FOI #16450

Olivencia, Mildred

From: murphyc@jbb.com
Sent: Tuesday, November 03, 2015 7:30 PM
To: Olivencia, Mildred
Cc: Torres-Rojas, Genara; Van Duyne, Sheree; Ng, Danny
Subject: Freedom of Information Online Request Form

Information:

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Required copies of the records: No

List of specific record(s):
A digital copy of the Port Authority of NY NJ Standard Technical Specifications for Divisions 15 mechanical and 16 electrical

THE PORT AUTHORITY OF NY & NJ

FOI Administrator

February 22, 2016

Mr. Charles Murphy
Jaros Baum & Bolles
80 Pine Street
12th Floor
New York, NY 10005

Re: Freedom of Information Reference No. 16450

Dear Mr. Murphy:

This is in response to your November 3, 2015 request, which has been processed under the Port Authority's Freedom of Information Code (the "Code", copy enclosed) for a digital copy of the Port Authority of NY NJ Standard Technical Specifications for Divisions 15 mechanical and 16 electrical.

Material responsive to your request can be found on the Port Authority's website at http://corpinfo.panynj.gov/documents/16450-o. Paper copies are available upon request.

Please refer to the above FOI reference number in any future correspondence relating to your request.

Very truly yours,

William Shalewitz
FOI Administrator

Enclosure

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DIVISION 15

SECTION 15310

SPRINKLER FIRE PROTECTION - PIPING AND APPURTENANCES

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies requirements of piping and appurtenances for automatic sprinkler fire protection systems.

B. Automatic sprinkler fire protection systems specified in this Section are:

1. Wet-Pipe System
2. Dry-Pipe System
3. Pre-Action System
4. Deluge System
5. Combined Dry-Pipe and Pre-Action System

C. Sprinkler water service installed under this Section ends at the building line unless otherwise shown on the contract Drawings. The continuation of the sprinkler water service is specified under Division 2 of the Specifications. Types of material and installation of the piping under this Section shall be compatible with types of material and installation specified under Division 2.

D. Trenching and backfilling required in conjunction with underground piping furnished under this Section shall be as specified in applicable Sections of Division 2 and shall be included as Work under this Section.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

New York City Building Code

New York City Board of Standards and Appeals

New Jersey Uniform Construction Code

The BOCA National Building Code

The BOCA National Fire Prevention Code

Municipal Water Company

American National Standards Institute (ANSI)

American Society for Testing and Materials (ASTM)

American Water works Association (AWWA)

Factory Mutual Engineering Corp. (FM)

Manufacturer Standardization Society of the Valves and Fittings Industry, Inc. (MSS)

National Fire Protection Association (NFPA)

National Electrical Manufacturers Association (NEMA)

Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. The sprinkler installation shall be designed in accordance with NFPA 13 and shall be either a pipe schedule system or a hydraulically designed system.

C. In buildings requiring specialized sprinkler systems, additional applicable standards as referenced in NFPA 13 shall be used for design, including but not limited to the following: NFPA 15, 16, 231, 231C, 231D and 409.

D. Sprinkler fire protection piping and appurtenances shall be UL listed, and approved by FM and those authorities having jurisdiction.

E. Design shall be based on water supply information as shown on the Contract Drawings or, if not shown, as determined by a water flow test by the Contractor.

1.03 QUALITY ASSURANCE

A. Fire protection piping and appurtenances, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Entities performing Work shall have experience on at least two projects involving complexities similar to those required under this Contract.

C. Contract Drawings, as well as this Specification indicate sprinkler fire protection piping appurtenances based on specific manufacturers' types and models. Appurtenances having equal physical and performance characteristics by other approved manufacturers may be considered, provided that deviations do not alter the design concepts or intended performances, as judged by the Engineer. The burden of proof of equality of sprinkler fire protection piping appurtenances is on Contractor.

D. Manufacturer Qualifications: Firms whose equipment, specialties and accessories are listed by product name and manufacturer in UL Fire Protection Equipment Directory and FM Approval Guide, and that conform to other requirements indicated.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Clean all pipe sections of foreign matter and cover ends with temporary sheet metal closures or plastic end caps of sufficient tightness to prevent entry of foreign matter prior to shipping to the construction site.

B. Store pipe, fittings, valves and other components at the construction site on pallets or raised platforms with suitable coverings satisfactory to the Engineer to protect them against damage and weather.

C. Inspect all pipe, fittings, valves and other components for damage before moving them from storage to the point of installation at the construction site.

1.05 SPARE PARTS

A. Provide a red, steel cabinet containing the following spare sprinkler heads with their respective installing wrenches:

1. Systems of up to 300 heads - 6 spares.
2. Systems of 300 to 1000 heads - 12 spares.
3. Systems of above 1000 heads - 24 spares.

Stock of spare sprinkler heads shall include all types and temperature ratings installed and shall not be less than six for each type and rating.

1.06 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 PIPE, FITTINGS, AND FLANGES

A. Provide pipe, fittings and flanges in accordance with the "PIPE, FITTINGS AND FLANGES SCHEDULE" specified below, including gaskets, bolts, nuts, washers and other pressure containing parts necessary for the complete installation of piping systems.

B. Nipples shall be extra-heavy shoulder type of same material as pipe; close nipples are not acceptable.

C. Unless otherwise shown on the Contract Drawings, piping connections to equipment shall be made up with unions for piping 2 inches and smaller and shall be flanged for piping 2-1/2 inches and larger.

D. Gasket for flanges shall be 1/16-inch thick (after compression), rubber or neoprene, full-faced, and punched bolt holes.

E. Provide insulating flanges, couplings or unions where brass or copper pipe connects to ferrous pipe material. Flanged connections shall be made with gaskets, sleeves and washers of dielectric material for complete insulation between flanges, bolts, nuts and washers.

F. Grooved Piping Mechanical Couplings

1. Couplings shall be complete with gaskets, bolts and nuts recommended by the manufacturer for the service. Use vandal proof nuts and bolts on vertical piping in stairs.

2. Couplings shall be Victaulic "Style 75" lightweight for system pressure not exceeding 400 psi (including shut-off pressure of fire pump and static street pressure of water main) and Victaulic "Style 77" couplings for system pressure exceeding 400 psi, or approved equal. Flush-seal gaskets shall be used for all dry and pre-action systems.

3. Couplings shall be manufactured by Victaulic Co. of America; Tyler Pipe Subsidiary, Tyler Corp./Gustin-Bacon Division; Gruvlock couplings by Grinnell; or approved equal.

Systems	Pipes	Fittings and Flanges
Wet-Pipe, Dry-Pipe, Deluge, Pre-Action, and Combined Dry-Pipe and Pre-Action Systems	Black Steel, ASTM A 795, A 53, or A 135, Schedule 40 (*)	A. Black Cast Iron, ANSI B16.4 or Malleable Iron, ANSI B16.3, 175 psi w.w.p., Threaded B. Companion Flanges, Cast Iron, ANSI B16.1, 125 lb. Class C. Ductile Iron, ASTM A 536, Roll-Grooved, Mechanical Type Couplings & Gaskets(*)
Any System where piping is subject to a corrosive environment or weather; Water-Motor Gong Piping; Piping between Siamese Connection and Check Valve and Automatic Ball Drip Drain	Galvanized Steel, ASTM A 795 or A 53, Schedule 40	Galvanized Cast Iron, ANSI B16.4 or Galvanized Malleable Iron, ANSI B16.3, 175 psi exposed to the w.w.p., Threaded
Drain Piping	Galvanized Steel, ASTM A 53, Schedule 40	Galvanized Cast Iron (Drainage), ANSI B16.12, 125 lb. Class, Threaded

(*) Schedule 10 or lightweight steel pipe in accordance with NFPA 13 may be used for piping 2-1/2 inches and larger unless otherwise noted on the Contract Drawings. Threaded or cut-grooved connections will not be permitted for this pipe.

2.02 VALVES

A. Control Valves

1. Valves

a. Valves shall be OS&Y, solid wedge gate valves with rising stem and wheel handles, rated for 175 psi w.w.p. Valves shall have gland followers in stuffing box and shall be repackable while open and under pressure.

b. Each valve shall be stamped with manufacturer's name and working pressure of the valve.

c. Valves, 2 inches and smaller, shall be threaded, bronze body.

d. Valves, 2-1/2 inches and larger, shall be flanged, iron body. Provide valved by-pass for valves 6 inches and larger.

e. Valves shall be manufactured by Crane Co., Walworth Co., Stockham Valves & Fittings, or approved equal.

2. Tamper Switches

a. Install tamper switches in accordance with manufacturer's recommendations.

b. Tamper switches shall monitor the control valves to detect and indicate when a valve has been closed.

c. Unless otherwise shown on the Contract Drawings, tamper switches shall be completely factory assembled and wired and shall be mounted on the control valve. The valve stem shall be prepared as required to accept the actuating roller rod. Switches shall be Potter Electric Signal Co. Model OSYS-U-1 or -2, or approved equal.

d. Wiring to control circuit shall be as specified in Division 16.

e. Tamper switches shall be manufactured by Potter Electric Signal Co., Fire Control Instruments Inc., or approved equal.

B. Drain and Test Valves

1. Valves shall be threaded, bronze, angle or globe type with composition disc, 175 psi w.w.p.

2. At system low points where drain piping does not extend to a drain receptacle, provide a threaded hose end adapter at the valve outlet.

3. For dry-pipe systems, provide drum-drip drains on all low points in the systems. Enclose drum-drips in cabinets as shown on the Contract Drawings. Provide heating for drum-drip cabinets as shown on the Contract Drawings. Provide the drum-drip drains in protected locations. Extend auxiliary drains from drum-drips to the drain shown on the Contract Drawings.

4. The numbers and locations of drum-drips shown on the Contract Drawings are minimum; actual installation requirements and quantities shall be determined by the Contractor based on approved working drawings.

5. Valves shall be manufactured by Crane Co., Walworth Co., Stockham Valves & Fittings, or approved equal.

C. Check Valves

1. Check valves shall be swing type with renewable composition disc, bronze seat ring, and bolted cover.

2. Valves, 2 inches and smaller, shall be threaded, bronze, 175 psi w.w.p.

3. Valves, 2-1/2 inches and larger, shall be flanged, iron body, 175 psi w.w.p., unless otherwise shown on the Contract Drawings.

4. Valves shall be manufactured by Crane Co., Walworth Co., Stockham Valve & Fittings, or approved equal.

D. Sprinkler System Automatic Valves

1. General

a. Size of automatic valve (except for deluge system deluge valves) shall be at least as large as the system riser and related to system demand and friction loss limitations in hydraulically designed systems.

b. Automatic valves shall be manufactured by Reliable Automatic Sprinkler Co. Inc., Star Sprinkler Corp., Viking Corp., or approved equal.

2. Wet-Pipe Alarm Valves

a. Alarm check valves shall be complete with all trimming including, but not limited to, retard chamber, water-motor gong, piping, fittings, electric alarm switch, drip cup, valves, pressure gauges, sight glass, etc.

b. Alarm valves shall be Reliable "Model E" with "Model E-1" trimmings, or approved equal.

3. Dry-Pipe System or Combined Dry-Pipe and Pre-Action System Dry-Pipe Valves

a. Dry-pipe valves shall be complete with all trimmings including, but not limited to, piping, fittings, electric alarm switch, priming chamber and fill lines, pressure gauge, and quick-opening devices as required by NFPA 13.

b. Dry-pipe valve shall be Reliable "Model A" for 2-1/2-inch size and "Model D" for 4- and 6-inch sizes, or approved equal. Provide "Model A-2" automatic air maintenance device or approved equal, when compressed air is supplied from the building air supply.

c. Provide an air compressor capable of filling the largest system to 40 psi within a period of 30 minutes, complete with Reliable "Model B-1" automatic air maintenance device, or approved equal.

4. Pre-Action System Deluge Valves

a. Deluge valve shall be complete with all trimming including, but not limited to, piping, valves, fittings, electric alarm switch, alarm gauges, pilot trim, etc.

b. Deluge valve shall be Reliable "Model A" for 2-1/2-inch size and "Model BX" with external reset for 4- and 6-inch sizes, or approved equal.

c. Provide a self-contained supervisory air compressor panel. The panel shall supply approximately 24 oz./square in. air pressure and sound an alarm when pressure drops below 16 oz./square in. Panel shall be Reliable "Model B", or approved equal.

d. Deluge system shall be controlled by an approved detection and actuation system (smoke, thermal, infrared, ultra-violet), as specified in Division 16.

5. Deluge System Deluge Valves

a. Deluge valves shall be of the differential type, depending upon water pressure in the diaphragm chamber to hold the clapper closed against the water supply pressure. The valve shall be Reliable "Model A" for 2 1/2-inch size and "Model BX" with external reset for 4- and 6-inch sizes, or approved equal.

b. The valve shall have approved trim and shall have actuation means shown on the Contract Drawings.

2.03 SIAMESE CONNECTIONS

A. Siamese connections shall be two-way type, having a brass body, with clapper valves, hose thread swivels and painted plugs as required by local code, with brass chains or breakable caps and shall be Potter-Roemer Series 5950 or 5953, or approved equal. Siamese connection escutcheon shall be lettered in accordance with code requirements. Threads shall conform to local fire department requirements.

B. Where automatic ball drip is shown on the Contract Drawings to extend to the exterior at the siamese connection location, the siamese connection escutcheon shall be modified with a sillcock flange. In lieu of a sillcock flange, a drain elbow may be provided.

C. Flush type siamese connection shall be Potter-Roemer Series 5020, or approved equal. Size and location of outlet shall be as shown on the Contract Drawings. Extra-heavy nipple extensions shall be installed to connect the yoke to the outside assembly.

D. Exposed type siamese connection shall be Potter-Roemer Series 5720 or 5730, or approved equal. Size and location of outlet shall be as shown on the Contract Drawings.

E. Finish of siamese connection assembly including escutcheon shall be polished brass unless otherwise shown on the Contract Drawings.

F. Siamese connections shall be manufactured by Potter-Roemer Inc., Elkhart Brass Manufacturing Co. Inc., or approved equal.

2.04 ALARM ACTUATING DEVICES

A. All water flow signal devices shall be of the pressure-activated type provided with sprinkler system automatic valve. Vane type water flow devices may be used in zoned sections of sprinkler systems.

B. All pressure operated water flow alarm devices and vane-type switches shall be installed in accordance with manufacturer's recommendations, be completely factory assembled, piped and wired to meet the field conditions. Wiring to control circuit shall be as specified in Division 16.

C. Water flow devices of the vane type shall have adjustable pneumatic retard to prevent alarm signals due to surges and two single-pole, double-throw microswitches. Water flow devices shall be Potter Electric Signal Co. switch Model VSR-F, or approved equal.

D. The vane type device shall be provided a minimum of 18 inches from any flange, elbow, check valve or other fitting to minimize water surges and flow turbulence.

E. Tamper switches are specified in 2.02 A.2.

2.05 SPRINKLER SERVICE BACKFLOW PREVENTER

Provide a backflow preventer on each sprinkler water service. The installation shall be in accordance with the regulations of the local authorities. Backflow preventer shall be one or combination of the following devices and as specified on the Contract Drawings:

A. Single detector check with by-pass meter.

B. Double detector check with by-pass meter.

C. Reduced pressure zone device.

2.06 SPRINKLER HEADS

A. Sprinkler heads shall have 1/2-inch orifice and ordinary temperature rating (160-165 degrees F), unless otherwise shown on the Contract Drawings.

B. Sprinkler heads in areas without hung ceiling shall be bronze, upright or pendent type, Reliable "Model G", or approved equal.

C. Sprinkler heads in hung ceilings, where shown on the Contract Drawings, shall be chrome-plated, flush pendent type, Reliable "Model B" with chrome-plated escutcheon, or approved equal.

D. Sprinkler heads in hung ceilings, where shown on the Contract Drawings, shall be chrome-plated, recessed type, Reliable "Model G", or approved equal.

E. Sprinkler heads in hung ceilings, where shown on the Contract Drawings, shall be chrome-plated, concealed type, Reliable "Model G1" or "Model G4", or approved equal.

F. Sprinkler heads for dry-pipe system provided in areas without hung ceilings shall be bronze, closed fusible link upright type, Reliable "Model G", or approved equal.

G. Sprinkler heads for dry-pipe system concealed within hung ceiling shall be chrome-plated, pendent dry type, Reliable "Model G3" with chrome-plated escutcheon, or approved equal.

H. Sprinkler heads for concealed sidewall locations shall be polished, chrome-plated bronze type, Reliable "Model ZX" with chrome-plated recessed escutcheon, or approved equal.

I. Sprinkler heads for exposed sidewall locations shall be polished, chrome-plated bronze type, Reliable "Model G" with "Type B" chrome-plated escutcheon, or approved equal.

J. Provide sprinkler guards, Reliable "Model C1 or C2" with a zinc finish or approved equal, for pendent and upright heads to be installed in areas where the sprinkler head is subject to damage.

K. Sprinkler heads and guards shall be manufactured by Reliable Automatic Sprinkler Co. Inc., Star Sprinkler Corp., Viking Corp., Central Sprinkler Corp. or approved equal.

2.07 ACCESSORIES

A. Automatic Ball Drips

For each siamese connection and wherever shown on the Contract Drawings, provide a Potter-Roemer Model 5982 automatic ball drip, or approved equal. Provide pipe discharge to exterior or a drain receptacle. Where static pressure at location requiring drainage exceeds the ball drip operating characteristics, a valved drain shall be used.

B. Pressure Gauges

Gauges shall have aluminum case, 4-1/2-inch diameter aluminum ring-bronze bourdon tube, stainless steel linkage, 1/2-inch bottom connection, black pointer, white face with black figures and segment range of 0-200 psi, 20 psi figure intervals, 2 psi intermediate graduations. Dial shall have red marker at 175 psi. Gauges shall be Dresser Industries Inc. "Ashcroft Series 1379", or approved equal.

C. Sight Glass

1. Where test connections connect to closed drains or spill to receptacles located remotely from test control valves, a sight test connection, having a smooth bore non-corrosive orifice giving a flow equivalent to one sprinkler, shall be provided.

2. Where sprinkler drain lines connect to closed drain lines or spill to receptacles located remotely from drain valve, a glass sight drain shall be provided.

D. Water-Motor Gong

Water-motor gong shall be provided for exterior building wall as required. Miscellaneous framing shall be installed to secure gong rigidly as required. Water-motor gong shall be a minimum of 10 inches in diameter and shall be mounted on the exterior wall in accordance with the manufacturer's recommendations. Water-motor gong shall be Reliable "Model C", or approved equal.

E. Pipe and Valve Identification

1. Adhesive Bands

a. Provide approved adhesive bands in sets of two, one identifying the piping system type and the second, the direction of flow. Sets shall be provided in quantities sufficient to accommodate the requirements of 3.05 A of this Section.

b. For 3-inch or larger pipe, the adhesive band identifying the piping system shall display the name of the service in white letters at least two inches high and the band indicating direction of flow shall display a white arrow of similar size. For 2-1/2 inch or smaller pipe, the letters and the arrow shall be white and shall be not less than one inch high. Bands shall have red backgrounds and shall conform to ANSI A13.1.

c. Adhesive bands shall be W.H. Brady Co. "Quik-Label", or approved equal.

2. Valve Tags, Charts and Schedules

a. Provide each valve with a 2-inch diameter 18 gauge brass tag with brass chain. Service designation shall be 1/4-inch high and valve number shall be 1/2-inch high, on two lines with service designation on the upper line, and valve number on the lower line. The characters shall be indented and filled with durable black compound.

b. Provide diagrammatic valve charts and schedules, using a valve numbering system which differentiates between classes of service and indicates floor level of valve location.

c. Tags shall conform to the numbers, locations, and uses listed in the valve charts and schedules.

d. Valve charts and schedules shall be mounted under glass in wood frames or aluminum self-closing frames.

e. Tags and the frames for valve charts and schedules shall be manufactured by Seton Name Plate Corp., or approved equal.

3. Identification Signs

a. Provide identification signs for all control valves, test valves, and system drain valves in accordance with NFPA 13. Identification signs shall be Reliable Style A and B, or approved equal.

b. On the outside of doors to rooms where control valves are located, provide suitable signs making note of such valve locations.

c. For hydraulically designed systems, a hydraulic calculation data sign shall be mounted at the system control valve assembly. The sign shall contain such data as design density, designed area of discharge, discharge rate, residual pressure available and pressure required.

F. Access Ladders

Control valves located seven feet or more above the finished floor shall be provided with a permanent steel access ladder. Ladder construction shall be approved by the Engineer.

G. Access Doors

Provide a complete list of all access doors required in finished walls, ceilings, partitions and any other area for access to all valves, water flow alarms, flushing connections, drains, etc., concealed behind such finished construction. Access doors shall be furnished and installed under other Sections.

2.08 PIPE HANGERS AND SUPPORTS

A. Design, fabricate and provide all pipe hangers and supports adequate to support and guide the piping, allow for forces imposed by expansion joints, satisfy structural and seismic requirements and maintain proper clearances with respect to adjacent piping, equipment and structures.

B. Provide hangers and supports, with beam clamps, restraints, supplemental steel, inserts, fish plates, mounting devices and similar items to support piping in alignment without sagging or interference, and to permit complete drainage and free expansion and contraction. Provide retaining straps when installing beam clamps or C clamps.

C. All hangers and supports shall be capable of screw adjustment after piping is erected and shall be provided with a locking nut (double nut) to prevent loss of adjustment.

D. Where required, provide anchors, sway bracing, blocking and steel to connect to structure to prevent excessive pipe movement that could cause damage due to expansion, contraction or thrust.

E. All pipe hangers, inserts, supports, supplemental steel, rods and components shall be galvanized.

F. Pipe hanger spacing, rod diameter, etc., shall be in accordance with the requirements of NFPA 13.

G. Support hangers from building steel framing wherever possible. Provide any additional miscellaneous steel supports between existing framing members as required. Do not support piping from other piping, ductwork and conduit.

H. Tabs in metal deck construction shall not be used to support piping.

I. Perforated band iron, strap iron or wire are not acceptable materials to be used and will not be approved.

J. Where required, provide supplemental channels and steel to support Work specified in this Section. Cut ends of steel shall be ground smooth, free from burrs and sprayed with a galvanized coating.

K. Where several pipes rest on a common trapeze, increase hanger rod diameter and decrease spacing in accordance with maximum and minimum pipe sizes, respectively.

L. Expansion anchors, self-drilling expansion shields, power driven studs and similar devices shall not be used, unless specifically approved by the Engineer.

M. Provide pipe restraints to prevent movement by an upward thrust in the pipe risers.

N. Support vertical piping at the lowest level, at each alternate level above and below offsets, and at the top of the riser by use of riser clamps. Provide additional intermediate support brackets, secured to structure, on piping utilizing gasket coupling joints.

O. Support horizontal piping as follows:

1. For piping 3 inches and smaller, support on adjustable swivel pipe rings or clevis type hangers.
2. For piping sizes of 4 to 8 inches, support on clevis type hangers.
3. For piping 10 inches and larger, support on trapeze hangers constructed of channel iron and hung from rod and insert assembly. Load calculations shall be performed.

P. Hanger system shall not penetrate waterproofing.

Q. If removal of existing fireproofing is required for installation purposes, such removal shall be performed by the Contractor and shall be kept to a minimum. The Contractor shall replace all removed fireproofing with new fireproofing to the satisfaction of the Engineer at no additional cost to the Authority.

R. Provide thrust restraint on underground piping entering the building through the floor or wall to serve the sprinkler systems.

S. Hangers and supports shall be manufactured by Grinnell Corp., Pipe Support Div.; Carpenter & Patterson Inc.; Michigan Hanger Co. Inc.; or approved equal.

2.09 SLEEVES, SEALS, AND ESCUTCHEONS

A. Piping passing through masonry or concrete walls and framed partitions shall have a trim opening cut no greater than necessary for the installation of a sleeve secured therein. Sleeve shall be 1/2 inch in diameter larger than the outside diameter of the pipe. Sleeve shall be flush with the finished wall or partition surface.

B. Sleeves through concrete floors for piping shall have the opening 1/2 inch in diameter larger than the outside diameter of the pipe passing through. Floor sleeves shall project one inch above floor slab.

C. Annular spaces between piping and sleeves shall be packed with mineral wool and sealed to retain the fire integrity of the walls, partitions, and floors with a non-hardening through-penetration firestops having F ratings compatible with the fire ratings of the barriers in which they are installed, per ASTM E 814. Firestop systems shall be UL approved, and shall be as manufactured by 3M, Bio Fireshield, Inc., General Electric Co., Dow Corning Corporation, or approved equal.

D. Sleeves in walls and floors shall be galvanized steel pipe, Schedule 40 for sizes up to 10 inches and 3/8-inch wall thickness for 12 inches and larger. Sleeves in partitions shall be 20-gauge galvanized sheet metal.

E. Piping in exposed areas, passing through walls, floors or ceilings shall be fitted with chromium-plated cast brass escutcheons with fastening set screws.

F. Piping passing through floor waterproofing membrane shall be provided with a 4-pound lead flashing or a 16-ounce copper flashing, each within an integral skirt or flange. Flashing shall be suitably formed, and the skirt or flange shall extend not less than 8 inches from the pipe and shall be set over the floor membrane in a solid coating of bituminous cement. The flashing shall extend up the pipe a minimum of 10 inches above the floor. The annular space between the flashing and the pipe shall be sealed watertight.

PART 3. EXECUTION

3.01 INSTALLATION

A. General

1. Install piping and appurtenances in accordance with manufacturers' installation procedures, requirements of NFPA 13, and as specified.

2. Coordinate piping installation with other Work to avoid interference. Coordinate as necessary to ensure that all hangers, supports, sleeves and other built-in devices are incorporated in forms or in masonry to avoid necessity of cutting finished structure.

3. All measurements, both horizontal and vertical, shall be based on established benchmarks. All Work shall agree with these established lines and levels. Verify all measurements at site and check the correctness of same as related to the Work.

4. Perform necessary cutting and patching in accordance with requirements specified in Division 2 Section entitled "CUTTING, PATCHING AND REMOVAL". All openings in existing slabs required for pipe penetrations shall be core drilled.

5. Electrical installation of appurtenances furnished under this Section shall be in accordance with requirements specified under Division 16.

6. Installation requirements for pipe hangers and supports and pipe penetration sleeves, seals and escutcheons are specified in 2.08 and 2.09, respectively.

B. Piping

1. Install piping as shown on the Contract Drawings and straight and direct as possible, forming right angles or parallel lines with building walls, neatly spaced, with risers plumb and true.

2. Sprinkler piping shall be installed so that the system can be drained.

3. Avoid tool marks and unnecessary pipe threads. Burrs formed when cutting pipe shall be removed by reaming. Before installing pipe, thoroughly clean the inside free of cutting and foreign matter. Cut all piping square and smooth and make up all joints to required limits.

4. Make changes in pipe size by the use of reducing fittings. Do not use reducing bushings except by approval of the Engineer.

5. Install piping so that no part thereof will interfere with doors, windows, heating, plumbing or electrical equipment. Coordinate Work specified in this Section with Work specified in other Sections to avoid any interference with potential effectiveness of the automatic sprinkler systems.

6. Provide protective pans under pipes passing over high voltage electric bus duct or switchgear equipment. Construct the pans of 18-gauge copper, suitably reinforced to prevent sagging. Turn the edges of the pans up to 6 inches on all sides with corners brazed to make the pans watertight. Support the pan with hangers and provide drainage clear of the electrical work.

7. Provide flushing connections for flushing scale and foreign material from sprinkler system in accordance with NFPA 13.

8. Before final piping connections are made to equipment and before sprinkler heads are installed, all piping shall be thoroughly blown out, rodded out, or washed out at least twice, in a manner as directed and approved by the Engineer, to remove all accumulation of dirt, chips or other deleterious materials. Make all temporary connections and furnish all appliances required for the purpose of cleaning.

C. Pipe Joints

1. Threaded joints shall be made up tight using pipe joint Teflon compound or tape, applied on the male threads only.

2. Roll-grooved pipe and fittings shall be clean and free from indentations, projections and tool marks in the area from pipe end to groove for proper gasket sealing. Provide a thin uniform coat of lubricant on the suitable gasket intended for specified service as recommended by the manufacturer. Place the gasket over one pipe end, align pipe ends and bring together, positioning the gasket between the groove on each pipe end. Assemble the housing over the gasket with housing key section engaging both grooves. The bolts shall be inserted, nuts started and uniformly tightened until the housing bolt pads are firmly seated together, metal to metal.

3. Flanged joints shall be made up square and tight with gaskets. Dip bolts and nuts in mixture of graphite and oil immediately prior to installation.

4. Joints between copper or brass and steel pipe shall be made by using a dielectric coupling.

3.02 FIELD TESTS

A. Notify the Engineer and those authorities which would have jurisdiction, at least 48 hours in advance of making the required tests, so that arrangements may be made for their presence to witness the tests.

B. Perform all tests prior to painting or concealing.

C. Isolate all equipment, controls and instruments from the piping system during the required tests.

D. Provide and install necessary equipment, instruments, hardware, temporary piping, vents, drains, and include necessary personnel required to perform all tests.

E. Perform hydrostatic tests for all sections of the piping systems installed under this Section, at not less than 200 psi pressure for two hours, or at 50 psi in excess of the maximum pressure, when the maximum pressure to be maintained in the system is in excess of 150 psi. The test pressure shall be read from a gauge located at the low elevation point of the individual system or portion of the system being tested.

F. Test dry-pipe system with air at 40 psi for 24 hours, prior to performing the hydrostatic tests specified in 3.02 E above. Permissible air leakage shall not exceed the value specified in NFPA 13.

G. Systems may be tested in sections, when directed by the Engineer, to permit construction to proceed. Testing on a section-by-section basis may be done with standard air pressure test. When the sprinkler system is completely installed, it shall be subjected to the hydrostatic test herein specified.

H. Test all components in the system including alarm devices and demonstrate that the equipment complies with the requirements and function for which they are intended. Testing through the Inspector's Test Connection shall be included to demonstrate that flow and time parameters are satisfied.

I. With the entire system under normal operating pressure, each control valve shall be opened and closed to demonstrate proper operation.

J. All tests shall conform to the requirements of NFPA 13. Records of all tests shall be made available for the Engineer's inspection, as required.

K. Should the tests reveal any leaks or deficiencies in piping installed under this Section, make necessary corrections immediately and flush, clean and retest the system for the Engineer's approval at no cost to the Authority.

L. Repair or replace any portion of the system installed under this Section that is damaged as a result of test operations at no cost to the Authority.

M. Where piping installed under this Section is connected to any existing system, such installed piping shall be isolated from the existing system during the performance of the required field tests, unless otherwise directed by the Engineer.

N. The Engineer reserves the right to direct the Contractor not to isolate the newly installed piping from the existing system during the performance of the required field tests. In such event, the Contractor shall correct any revealed leaks or other deficiencies within the first 20 feet of the existing system, measured in any direction from the point of connection with the newly installed piping, all as directed by the Engineer and at no additional cost to the Authority.

O. Dispose of water removed from pipelines in a manner that shall not cause damage to any property.

3.03 PROTECTION

As soon as sprinkler heads are in place, cover each head with a small paper bag of a UL approved type which shall be removed only after all painting is complete and then all heads shall be cleaned.

3.04 PAINTING

Upon completion of the installation, remove all protecting materials, thoroughly remove all scale and grease and leave in a clean condition for painting. Piping to be painted shall be as shown on the Contract Drawings. Painting shall be in accordance with the requirements of Division 9 Section entitled "PAINTING".

3.05 PIPE AND VALVE IDENTIFICATION

A. Pipe Identification

Affix sets of pipe adhesive bands specified in 2.07 E.1 where they can be easily read, with their long dimension parallel to the axis of the pipe and no more than 40 feet apart on a piping system.

At least one set of identifying bands shall be affixed in all occupied and unoccupied rooms as well as in all other spaces, such as hung ceilings or shafts, where piping may be viewed and the identity of the piping system cannot be readily ascertained.

B. Valve Tags

Securely fasten valve tags specified in 2.07 E.2 with approved brass chain.

END OF SECTION

SECTION 15310

SPRINKLER FIRE PROTECTION - PIPING AND APPURTENANCES

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Sprinkler Fire Protection Piping Shop Drawings

   Shop and coordination drawings shall be double line at a minimum of 3/8"=1'-0" scale.

2. Detailed shop drawings, including hydraulic calculations in accordance with the requirements of NFPA 13. The drawings shall include all partitions, lights, ceiling construction, sprinkler heads, piping, hanger locations, vertical and horizontal piping offsets, pipe elevations, room designations, control valves and water supply information. Shop drawings shall show the specific standards, codes and sections thereof which apply and the design hydraulic areas and parameters, and available water supply test results.

   a. Piping layout and installation drawings including, at a minimum, the following:

      (1) Plans, elevation, sections and riser diagram.

      (2) Hanger, support locations and details. Indicate methods of attachment to building structure.

      (3) Pipe elevations and dimensions from main piping runs to a reference point.

      (4) Penetrations through fire rated and other partitions.

      (5) Electrical wiring diagram showing connection of tamper switches and alarm devices.

      (6) Location for sprinkler heads and piping accessories, including valves and access ladders and doors.

   b. Piping coordination drawings showing plan views and sections, drawn to scale, on which all items are shown and coordinated with all Work of other Sections.

B. Product Data / Catalog Cuts

1. Piping and appurtenances.

2. Sprinkler pipe materials and schedule for each piping system.

3. Catalog cuts, including product performance data, for all items furnished under this Contract, including the following at a minimum:

   a. Sprinkler heads.

   b. Pipe, pipe fittings and flanges.

   c. Valves, including valve charts and schedules.

d. Tamper switches/alarm devices.

e. Siamese and other fire department connections.

f. Sprinkler service backflow preventer.

g. Adjustable pressure restricting devices.

h. Pressure gauges.

i. Pipe and valve tags identification bands.

j. Access ladders.

k. Access doors, including list of their locations.

l. Pipe hangers and supports, including schedule showing manufacturer's figure number, size, location and features of each required hanger and support.

m. Sleeves and escutcheons.

4. List of access doors and schedules.

C. Construction and Installation Procedures

1. Field test procedure.

D. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive information for the specific approved equipment; including approved shop drawings and catalog cuts, sequence of operation, test results, troubleshooting, maintenance requirements, spare parts lists, electrical/control devices and electrical/control wiring diagram(s).

E. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15310

SPRINKLER FIRE PROTECTION - PIPING AND APPURTENANCES

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(1.02 E)	Water supply information to be used for design.
(2.01 C)	Piping connections to equipment (other than union connections for 2" and smaller and flanged for 2 1/2" and larger).
(2.02 A.2.c)	Tamper switch wiring (other than specified).
(2.02 B.3)	Drum-drip details, including heating and auxiliary drains.
(2.02 B.4)	Numbers and locations of drum-drips.
(2.02 C.3)	Check valve rating(s) (other than 175 psi w.w.p.).
(2.02 D.5.b)	Deluge system deluge valve actuation means.
(2.03 B)	Automatic ball drip to extend to the exterior at a siamese connection.
(2.03 C)	Outlet size and location of flush type siamese connection.
(2.03 D)	Outlet size and location of exposed type siamese connection.
(2.03 E)	Finish of siamese connection assembly (other than polished brass).
(2.06 A)	Sprinkler head orifice sizes and temperature ratings (other than 1/2" and 160-165 degrees F rating).
(2.06 C)	Flush pendent type sprinklers in hung ceilings.
(2.06 D)	Recessed type sprinklers in hung ceilings.
(2.06 E)	Concealed type sprinklers in hung ceilings.
(2.07 A)	Automatic ball drip(s).
(3.01 B.1)	Piping layout.
(3.04)	Area required to be painted.

B. Other Items

1. Ensure that the Specifications include the following Section(s) referenced in this Section:

(3.01 A.4)	"CUTTING, PATCHING AND REMOVAL"
(3.04)	"PAINTING"

2. Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15311

DIESEL FIRE PUMPS AND ACCESSORY EQUIPMENT

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for diesel fire pumps and associated accessory equipment.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

New York City Building Code

New York City Board of Standards and Appeals

New Jersey Uniform Construction Code

The BOCA National Building Code

The BOCA National Fire Prevention Code

Antifriction Bearing Manufacturers Association (AFBMA)

American National Standards Institute (ANSI)

American Society for Testing and Materials (ASTM)

Hydraulic Institute (HI)

Factory Mutual Engineering Corporation (FM)

National Electrical Manufacturers Association (NEMA)

Nation Fire Protection Association (NFPA)

Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Design and performance requirements of fire pumps and jockey pumps shall be as specified in the Fire Pumps Schedules (hereinafter in this Section "Schedules") shown on the Contract Drawings.

C. The fire pumps, controllers and accessories shall be designed in accordance with NFPA 20 and NFPA 70, and shall be UL listed and approved by FM and those authorities having jurisdiction.

D. The jockey pump controllers shall be UL listed.

E. Each pump shall be designed to deliver rated capacity when operating at the rated net pressure (which excludes suction pressure) and the rated speed, as specified in the Schedules shown on the Contract Drawings.

F. The fire pump(s) shall deliver not less than 150 percent of rated capacity at a pressure not less than 65 percent of rated pressure. The head capacity curve for the pump shall rise steadily from design point of operation to pump shutoff. The pump shutoff pressure shall not exceed 120 percent of the rated pressure. Minimum suction pressure shall be positive.

G. The pump(s) shall be designed based on the minimum available NPSH specified in the Schedules shown on the Contract Drawings for satisfactory operation at 150 percent of rated capacity.

H. A pump, driver, and control equipment, and all necessary accessories shall be selected and assembled as a complete unit assembly by the pump manufacturer.

I. Impeller shall be statically and dynamically balanced.

1.03 QUALITY ASSURANCE

A. Fire pumps, jockey pumps and accessories, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Entities performing Work shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver pumps on factory-installed wooden skids and with lifting lugs; pack components in factory-fabricated protective containers.

B. Handle pumps and all accessories carefully to avoid damage to components, enclosures and finish.

C. Store pumps and all accessories in clean, dry spaces and protect them from weather.

D. Comply with manufacturer's rigging instructions for unloading pumps and moving them to final location for installation.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with requirements of this Section, furnish and install pumps, drivers (diesel engines and motors), and controllers of one of the following manufacturers, or approved equal:

Pumps

Peerless Pump, Sterling Fluid Products, Inc.

General Signal Corp./Aurora Pump

Patterson Pump Co. Subsidiary, Gorman-Rupp Co.

Fairbanks Morse Pump Division

Engines for Fire Pumps

Cummins Engine Co. Inc.

Clarke Detroit Diesel-Allison, Inc.

Caterpillar Inc

Motors for Jockey Pumps

General Electric Co.

Westinghouse Electric Corp.

Emerson Electric Co./US Electrical Motors Division

Continental Electric Co., Inc.

Controllers

Firetrol Inc./Fire Pump Control Division

General Electric Co.

Master Control Systems Inc.

Joslyn Clark Controls, Inc.

B. Controllers for the fire pumps and jockey pumps shall be of the same manufacturer.

2.02 MATERIALS

A. Materials for fire pumps and jockey pumps shall be as specified below:

Casing:	Cast iron
Impellers:	Cast bronze
Shaft:	Carbon (alloy) steel
Casing Rings:	Renewable bronze
Impeller Rings:	Bronze
Base Plate:	Carbon steel
Foundation Shims:	Carbon steel

2.03 CONSTRUCTION FEATURES

A. Fire Pumps and Jockey Pumps

1. Fire pumps shall be centrifugal, horizontally split case, double suction, single stage type.
2. Jockey pumps shall be centrifugal, horizontal, volute or turbine vane type.
3. Each type of pump (fire or jockey) shall be identical in construction and similar parts of the same type pumps shall be interchangeable.
4. The pumps shall be arranged to facilitate inspection and maintenance. Upper casing and inner assembly shall be readily removable without disturbing the driver or suction and discharge connections.
5. Provide renewable shaft sleeves at bearing points and stuffing boxes to prevent shaft wear.
6. Do not use full size impellers. Securely fasten impellers to the shaft to withstand all operating loads.
7. Impellers shall be of one-piece construction, and shall have renewable wearing rings. Renewable wearing rings shall be provided for the casings. Impellers shall be firmly secured to the shaft and retained against movement. Locking devices shall be sufficient to prevent loosening under all conditions of service.
8. Pressure casings shall be of such thickness to be suitable for maximum discharge and hydrostatic test pressures at pumping temperature, and with a minimum of 1/8-inch corrosion allowance.
9. Provide pump bearings in sufficient number and locate to ensure proper shaft alignment and minimize noise level. All pump bearings shall be oil lubricated.
10. Provide stuffing boxes, seals and packing glands as required, between fixed and rotating parts for minimum water leakage. Provide seal injection breakdown orifices as required to reduce pressure and to control injection flow.
11. Provide flanged flexible couplings to connect drivers and pump shafts.
12. Provide coupling guards for driver-pump couplings in accordance with OSHA requirements.
13. Provide each pump unit with a suitable mounting base designed to support the total weight of complete pump and driver and all imposed dynamic loads.
14. Provide foundation bolts and complete requirements for foundation bolting.
15. Provide foundation shims required for proper alignment and grouting in concrete.
16. Provide pumps with lifting lugs to facilitate handling during installation and maintenance.

B. Diesel Engines for Fire Pumps

Diesel engines shall be complete with all accessories to meet the requirements of NFPA 20, shall be designed for dual battery, automatic operation, and shall be capable of starting at an ambient room temperature of 45 degrees F. Each diesel engine shall be furnished with the following:

1. A complete, closed cooling system including all necessary pumps, heat exchanger, valves and piping.
2. Water piping from fire pump discharge to the closed cooling system heat exchanger with necessary valves, pressure regulator with strainer and by-pass and fittings.
3. Heavy duty, oil bath air cleaner.
4. Hydraulic governor for speed control.
5. Water-cooled exhaust manifold.
6. Jacket water immersion heater to operate at available voltage and maintain 120 degrees F jacket water temperature at all times when the engine is not running. The immersion heater shall have provisions for supervisory attachment for central station signal.
7. Jacket water-circulating pump.
8. A complete lubrication system including all necessary pumps, coolers, filters, valves and piping.
9. Fuel system including pump, injectors, primary and secondary filters, flexible connections, valves and piping.
10. A generator.
11. Two 12-volt dc, rubber case, lead acid, double insulated, heavy duty, dry charged batteries with electrolytic liquid in separate containers. Batteries shall be Exide "Hycap Heavy Duty" or approved equal and shall be mounted remotely from the engine. Two battery mounting frames, and two sets of battery cables shall be provided.
12. Instrument panel with manual throttle control, jacket water-temperature gauge, ammeter, tachometer, hour-meter, emergency shutdown control, high water temperature and low oil pressure alarm switches, lubricating oil pressure gauge.

C. Motors for Jockey Pumps

1. Each jockey pump shall be driven by a 3-phase, 60-cycle, drip proof, ball bearing, squirrel cage induction motor with horsepower, rpm, and voltage characteristics as specified in the Schedules shown on the Contract Drawings, constructed in accordance with applicable NEMA standards.
2. Provide motors in accordance with requirements specified in Division 15 Section entitled "MOTORS AND MOTOR CONTROLLERS". Select the motor characteristics, the motor mounting, and all accessories necessary to satisfy the requirements of the pump motor drive unit in all operating modes.
3. Provide motors with lifting lugs to facilitate handling during installation and maintenance.

D. Fire Pump Controllers

Each diesel engine controller (fire pump controller) shall include the following features:

1. Solid state, combined manual and automatic type with "Manual-Off-Automatic" selector switch.
2. NEMA Type 3R enclosure, rain tight, freestanding, formed sheet steel cabinet, arranged for installation with back against wall, with all operating devices, wiring and components accessible from the front. Where shown on the Contract Drawings, enclosure shall be NEMA Type 12 industrial use, dust tight and oil tight cabinet.
3. Integral dual battery charger.
4. Battery volt meters.
5. Pressure switch.
6. Manual stop feature.
7. Automatic weekly test timer.
8. Sequence starting.
9. 7-day system pressure recorder.
10. Alarms:
    a. Failure of engine to start automatically.
    b. Shutdown from overspeed.
    c. High jacket water temperature.
    d. Battery failure.
    e. Low fuel level.
    f. Low lubricating oil pressure.
    g. Failure of battery charger.
    h. Pump operating.
    i. Turning of controller to off or manual.
    j. Provide separate contacts for remote indication for each alarm h. and i.
    k. Provide common contacts for remote indication for alarms a through g.

E. Jockey Pump Controllers

1. The jockey pump controller shall enable the jockey pump to maintain system pressures to prevent unnecessary cycling of the fire pump and to satisfy NFPA 20 requirements.
2. The jockey pump controller shall be completely assembled, wired and tested at the manufacturer's plant.
3. The jockey pump controller shall incorporate a full voltage magnetic starter, fusible disconnect switch, "Hand-Off-Auto" selector switch, and a pressure switch with independent high and low settings, mounted within the controller. A circuit breaker may be substituted for a fusible disconnect switch, subject to approval of the Engineer.

4. A running period timer shall be provided, within the controller, to prevent too frequent automatic starting and stopping of the jockey pump. The timer shall be set to keep the jockey pump motor in operation for at least one minute and it shall be interwired with the pressure switch.

5. A pressure recorder associated with the jockey pump controller shall be provided.

6. The controller components shall be enclosed in a NEMA Type 2 drip-tight enclosure.

2.04 ACCESSORIES

A. Pressure Relief Valve for Fire Pumps

1. When specified in the Schedules shown on the Contract Drawings, provide a pressure relief valve to relieve excess pressure in a fire protection system. The valve shall maintain constant pressure in the system regardless of demand changes.

2. Size the valve in accordance with the requirements of NFPA 20. The valve shall have a rated working pressure of 175 psig and shall have a sufficient relieving capacity while limiting the pressure developed on the system side of the fire pump to 175 psig. Provide valve with a position indicator, factory-calibrated to measure flow rate. Spring loaded valve is not acceptable.

3. The valve shall be of the hydraulically-operated, pilot-controlled, diaphragm-type, globe or angle valve with flanged ends. It shall have a single, removable, Teflon-coated seat, a delrin-sleeved stem guide at both ends, and a resilient disc. No external packing glands shall be permitted and the diaphragm shall not be used as a seating surface. The pilot control shall be a direct-acting, adjustable, diaphragm-type valve designed for modulating service to permit flow when controlling pressure exceeds spring setting.

4. The valve shall be so set that it will relieve at pressures higher than the sum of rated net pump pressure and the maximum suction pressure.

B. Fire Pump Flow Measuring Devices for Fire Pump Test Line

1. Provide a manifold for hose lines to facilitate testing. Number and size of hose valves shall be in accordance with the requirements of NFPA 20 and approved for testing purposes.

2. A water measuring device shall be installed on the line leading to the test discharge manifold.

3. The water flow measuring device shall be venturi, diaphragm or orifice plate type, as shown on the Contract Drawings.

4. Flow measuring devices shall be equipped with fixed measurement indicating devices and all necessary appurtenances and accessories, and they shall be UL listed and FM approved.

C. Pressure Gauges

Provide a pressure gauge with range up to 200 psi at the pump suction and a pressure gauge with range from zero to 300 psi at the pump discharge. The gauges shall have Type 316 stainless steel bourdon tube, 4-1/2 inch flangeless Acaloy case, 1/4 inch bottom connection with helicoid cartridge snubber, black dial on white face, right-hand helicoid movement. Pressure gauges shall be Helicoid Type 440, manufactured by Helicoid Instruments, Bristol-Babcok, Inc. or approved equal. Each pressure gauge shall be provided with a shut-off cock to facilitate removal for maintenance.

D. Casing Relief Valve and Air Release Valve

Provide the pump with a 3/4 inch casing relief valve and an automatic air vent on the pump casing, each piped to the nearest drain.

E. Engine Mufflers

Provide engine mufflers. The muffler shall be in accordance with engine manufacturer's recommended model for the respective engine, and shall be installed as shown on the Contract Drawings.

F. Diesel Fuel Oil System

1. Each diesel shall be furnished with a UL listed fuel system and fuel tank of sufficient volume to permit continuous operation of the engine for a period in excess of 12 hours. The entire fuel system shall be installed to comply with requirements of the Local Code and to the requirements of NFPA 30 and 31.
2. The storage tank shall be fabricated from ¼-inch thick steel plate and shall be complete with vents, fill caps, tees, nipples, bushings, couplings, elbows, strainers, valves, conduit, piping, copper tubing and a tank gauge.
3. Provide Type "K" seamless copper tubing, flare fittings, adapters, approved metallic type flexible connections, and all necessary fuel oil specialties for fuel line connections between storage tank and engine.
4. Provide the tank with threaded outlets for vent, gauge, fill, overflow and suction lines. Suitable bushings shall be provided to accommodate the lines connected to the tank.
5. The exteriors of tank and fuel lines shall be cleaned of all loose rust, scale, grease, oil and other objectionable material and shall be given a prime coat.
6. The tank vent line shall be terminated with a flame arrester. The flame arrester shall be equipped with a conservation unit.
7. The fuel oil tank gauge shall be of the direct reading "Liquidometer" type (tank-mounted). Gauge installation requirements, as related to other tank interior piping, shall be checked for necessary clearances. If insufficient operating space exists, an alternate gauge shall be "Model 8680" as manufactured by Rockester Gauge, Inc., or approved equal.
8. The fuel oil tank shall be supported on welded pipe leg steel saddles.
9. The tank fill box shall have a cover marked "Diesel Fuel". Box shall be furnished complete with two wrenches and two cap gasket replacements.

10. The fuel storage system shall be equipped with a low fuel alarm. It shall provide visual and audible alarms at the controller and also send an alarm to a remote location.

11. The fuel storage tank shall be installed above ground or underground, as shown on the Contract Drawings.

12. A fuel storage tank installed underground shall be provided with a small "day"-type gravity tank equipped with a hand pump.

G. Nameplates

1. A corrosion resistant nameplate shall be permanently attached to fire pumps, fire pump motors and controllers.

2. Each pump shall be provided with a nameplate not less than 3 inches by 4 inches in size, made of corrosion-resistant metal, with easily readable letters and figures. The nameplate shall be securely attached to the pump baseplate, where it will be easily visible. Each nameplate shall bear the following information:

   a. Manufacturer's name.

   b. Manufacturer's model or type designation.

   c. Manufacturer's serial number.

   d. Rated capacity, in gpm at rated pressure, in psi.

   e. Rated speed, in rpm.

   f. Net pressure at shut-off, in psi.

   g. Net pressure, in psi at 150 percent of rated capacity, in gpm.

   h. Number of stages.

   i. Impeller diameter.

   j. Brake horsepower (BHP) at rated conditions.

   k. Maximum BHP required at rated speed at any capacity.

   l. UL/FM listings.

   The motors shall have information in accordance with NFPA 20 and NEMA Standard MG-1.

   The controllers shall have information relating to the manufacturer model number, UL/FM listings and complete electrical rating.

2.05 SHOP TESTS

A. General

1. Manufacturers' standard shop tests shall be performed on pumps, diesel engines, controllers and accessories, in conformance to the requirements of NFPA 20 and this Section.

2. All shop tests may be witnessed by the Engineer. Notify the Engineer 14 days in advance of scheduled tests.

B. Hydrostatic Tests

All pumps shall be hydrostatically tested at a pressure equivalent to twice the shut-off pressure but not less than 250 psig. The test pressure shall be held for a minimum of 15 minutes.

C. Diesel Engine Tests

Diesel engines shall be tested at the factory of the manufacturer and shall be demonstrated to deliver ten percent in excess of the maximum BHP at the pump to which it is to be connected. The speed at the load shaft for this test shall be held to within one percent of the rated speed of the pump. As a minimum, tests shall be conducted in accordance with the "Standard Practices for Stationary Diesel Engines" of the Diesel Engine Manufacturers Association. Engines shall be tested at the rated speed subsequent to the above operational test and shall include the determination of engine output, speed, fuel consumption, and efficiency at zero, twenty-five, fifty, seventy-five, and one hundred percent of full load.

D. Performance Tests

Each pump shall be performance tested with its own driver and shall meet the requirements specified in this Section.

E. Controller Tests

The controller manufacturer, prior to shipment, shall hook up and test the entire controller as a completed assembly. This test shall include each function required to be performed, such as remote alarms, automatic start with manual shutdown, pressure drop, manual start-up, etc.

F. Test Reports

Prepare copies of the pump and driver performance curves. The shipment of the pump and driver shall not be made until the certified curves have been approved by the Engineer.

PART 3. EXECUTION

3.01 INSTALLATION

A. The pump and the pump driver shall be supported on a steel bedplate and frame which shall be anchored to a reinforced concrete base required for each of the units furnished. The concrete base shall have its surface extended at least 3 inches beyond the edges of the bedplate.

B. The pump controllers shall be located as shown on the Contract Drawings and mounted on firm metal legs provided by the controller manufacturer.

C. The pump bedplate and frame shall be shimmed level with shims one inch above the concrete base before grouting into place.

D. The grout shall form a continuous solid support under the entire bearing area of the bedplate. Anchor bolts shall be cast integrally with the concrete base and accurately positioned by use of templates. Grout shall be an approved mixture. Concrete shall conform to the requirements of Division 3 Section entitled "PORTLAND CEMENT CONCRETE". The exposed surfaces of the base shall have a smooth even finish. After the grout has set with the shims or wedges in place, the anchor bolts shall be tightened to set the bases firmly upon the grout.

E. Recheck the alignment to ensure that no distortion has taken place during grouting. No piping will be allowed to be connected to the pumps until alignment and grouting have been approved by the Engineer. Any errors revealed shall be corrected.

3.02 FIELD TESTS

A. Upon completion of installation, perform field tests to establish the pump performance and mechanical smoothness of operation of the pump, the pump driver and controller as a unit. Said tests shall include testing of operation and calibration of all equipment, alarms, controls and other component parts of the water and fire systems. A copy of the manufacturer's certified shop pump test performance curve shall be available for comparison with the results of field tests.

B. Provide the services of a competent representative of the pump manufacturer to inspect the pump and controls during their installation, place them into operation and assist in performing field tests.

C. Notify the Engineer at least ten days before these tests are scheduled. Provide sufficient manpower and all necessary equipment to conduct tests, including measuring flow rates, pressures, temperatures and power consumption. After approval by the Engineer of the proposed time of tests, perform the tests in the presence of the Engineer and those authorities having jurisdiction.

D. Field tests shall meet all the requirements of NFPA 20 and shall demonstrate the following:

1. The pump and driver shafts shall be properly aligned so that there are no signs of heating at the pump and driver bearings.
2. The pump and driver bedplate shall be securely attached and grouted to the concrete foundations so that shaft alignment remains true under operating conditions.
3. Each pumping unit shall be able to discharge its rated capacity at its rated net pressure and rated speed without showing signs of excessive heating of bearings or driver.
4. At rated speed, the fire pump shall be able to discharge 150 percent of its rated capacity at 65 percent of its rated net pressure without excessive heating of bearings or driver.
5. Automatic pressure switch operation of controller shall start the pump at the specified pressure limits.
6. In installations where new pumps have been added to existing pumps, the complete pumping system shall be operated with all pumps, both new and existing, operating properly and automatically, due to pressure drop in water main and through the pressure controls and sequential starting installations.

7. The pumping system shall function properly with manual shutdown, after automatic operation.

8. The complete pumping system shall operate properly under manual start and stop procedures. Where applicable, the complete pumping system shall operate properly under all remote-starting arrangements.

9. Controller for pump shall be put through not less than 10 automatic and 10 manual operations.

10. Alarm transmissions of all types shall be tested, including pump running alarms, supervisory and tamper alarms, phase reversal, power loss and pump room temperature alarms and other alarms.

11. Each pump shall be operated for a test period of not less than one hour, total time.

E. Furnish necessary fuel oil for the fire pump tests. After approval of installation and testing by the Engineer, fill the tank to capacity with fuel oil. The diesel fuel oil shall be in accordance with ASTM Diesel Fuel Oil Classifications.

END OF SECTION

SECTION 15311

DIESEL FIRE PUMPS AND ACCESSORY EQUIPMENT

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Diesel Fire Pump Shop Drawings

   Shop and coordination drawings shall be double line at a minimum of 3/8"=1'-0" scale.

   a. Pump layout and installation drawings including, at a minimum, the following:

      (1) Dimensioned outline drawings of pumps, motors, controllers and accessories, including details of valving and piping arrangements and foundation layouts.

      (2) Plans, elevation, sections and riser diagram.

      (3) Hanger, support locations and details. Indicate methods of attachment to building structure.

      (4) Pipe elevations and dimensions from main piping runs to a reference point.

      (5) Penetrations through fire rated and other partitions.

      (6) Wiring diagram of controllers, control wiring and power wiring diagrams, coordinating all systems in an integrated arrangement.

      (7) Sequence of operations related to wiring diagram.

      (8) Location for fire pumps and jockey pumps accessories, including valves, piping and appurtenances.

   b. Coordination drawings showing plan views and sections, drawn to scale, on which all items are shown and coordinated with all Work of other Sections.

B. Product Data / Catalog Cuts

1. Catalog cuts, including product performance data, for all items furnished under this Contract, including the following at a minimum:

   a. Pump: Cut sheet with the performance characteristic curves certified by the manufacturer, and with information on impeller diameter that the casing will permit.

   b. Motors of jockey pumps.

   c. Test header and measuring devices.

   d. Fire pump and Jockey pump controllers and appurtenances.

   e. Fuel oil system.

   f. Pressure relief valve.

g. Casing relief valve and air release valves.

h. Indication of minimum and maximum flows and the minimum required NPSH at which each pump can operate continuously without causing damage.

2. Certified shop test results.

C. Construction and Installation Procedures

1. Field test procedure.

D. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive information for the specific approved equipment; including approved shop drawings and catalog cuts, sequence of operation, test results, troubleshooting, maintenance requirements, spare parts lists, electrical/control devices and electrical/control wiring diagram(s).

E. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15311

DIESEL FIRE PUMPS AND ACCESSORY EQUIPMENT

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

1. Contract Drawings

(2.03 D.2)	NEMA Type 12 enclosure in lieu of NEMA Type 3R.
(2.04 B.3)	Flow measuring devices (venturi, diaphragm, or orifice plate).
(3.02 B)	Location of controllers.

2. Fire Pumps Schedules (shown on the Contract Drawings)

(1.02 B & E)	Design and performance requirements of fire pumps and jockey pumps.
(1.02 G)	Minimum available NPSH.
(2.03 C.1)	Electrical characteristics for jockey pumps.
(2.04 A.1)	Pressure relief valve in the system.

B. Other Items

1. Ensure that the Specifications include the following Sections referenced in this Section:

(2.03 C.2)	"MOTORS AND MOTOR CONTROLLERS"
(3.01 D)	"PORTLAND CEMENT CONCRETE"

2. Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15312

ELECTRIC FIRE PUMPS AND ACCESSORY EQUIPMENT

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for electric fire pumps and associated accessory equipment.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

New York City Building Code

New York City Board of Standards and Appeals

New Jersey Uniform Construction Code

The BOCA National Building Code

The BOCA National Fire Prevention Code

Antifriction Bearing Manufacturers Association (AFBMA)

American National Standards Institute (ANSI)

American Society for Testing and Materials (ASTM)

Hydraulic Institute (HI)

Factory Mutual Engineering Corporation (FM)

National Electrical Manufacturers Association (NEMA)

National Fire Protection Association (NFPA)

Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Design and performance requirements of fire pumps and jockey pumps shall be as specified in the Fire Pumps Schedules (hereinafter in this Section "Schedules"), shown on the Contract Drawings.

C. The fire pumps, controllers and accessories shall be designed in accordance with NFPA 20 and NFPA 70, and shall be UL listed and approved by FM and those authorities having jurisdiction.

D. The jockey pump controllers shall be UL listed.

E. Each pump shall be designed to deliver rated capacity when operating at a rated net pressure (which excludes suction pressure) and rated speed, as specified in the Schedules.

F. The fire pump(s) shall deliver not less than 150 percent of rated capacity at a net pressure not less than 65 percent of rated pressure. The head-capacity curve for the pump shall rise steadily from design point of operation to pump shutoff. The pump shutoff pressure shall not exceed 120 percent of the rated pressure. Minimum suction pressure shall be positive.

G. The pump(s) shall be designed based on the minimum available NPSH specified in the Schedules shown on the Contract Drawings for satisfactory operation at 150 percent of rated capacity.

H. A pump, motor driver, and control equipment, and all necessary accessories shall be selected and assembled as a complete unit by the pump manufacturer.

I. Impeller shall be statically and dynamically balanced.

1.03 QUALITY ASSURANCE

A. Fire pumps, jockey pumps, and accessories, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Entities performing work shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver pumps on factory-installed wooden skids and with lifting lugs; pack components in factory-fabricated protective containers.

B. Handle pumps and all accessories carefully to avoid damage to components, enclosures and finish.

C. Store pumps and all accessories in clean, dry spaces and protect them from weather.

D. Comply with manufacturer's rigging instructions for unloading pumps and moving them to final location for installation.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with requirements of this Section, furnish and install pumps, motors and controllers of the following manufacturers, or approved equal:

1. Pumps

   Peerless Pump, Sterling Fluid Products, Inc.
   General Signal Corp./Aurora Pump
   Patterson Pump Co. Subsidiary, Gorman-Rupp Co.
   Fairbanks Morse Pump Division

2. Motors

   General Electric Co.
   Westinghouse Electric Corp.
   Emerson Electric Co./US Electrical Motors Division
   Continental Electric Co., Inc.

3. Controllers

   Continental Electric Co., Inc.
   Firetrol Inc./Fire Pump Control Division
   General Electric Co.
   Master Control Systems Inc.
   Joslyn Clark Controls, Inc.

B. Controllers for the fire pumps and jockey pumps shall be of the same manufacturers.

2.02 MATERIALS

Materials for the fire pumps and jockey pumps shall be as specified below:

Casing:	Cast iron
Impellers:	Cast bronze
Shaft:	Carbon (alloy) steel
Casing Rings:	Renewable bronze
Impeller Rings:	Bronze
Base Plate:	Carbon steel
Foundation Shims:	Carbon steel

2.03 CONSTRUCTION FEATURES

A. Fire Pumps and Jockey Pumps

1. Fire pumps shall be centrifugal, horizontally split case, double suction, single stage type.
2. Jockey pumps shall be centrifugal, horizontal, volute or turbine vane type.
3. Each type of pump (fire or jockey) shall be identical in construction and similar parts of the same type pumps shall be interchangeable.

4. The pumps shall be arranged to facilitate inspection and maintenance. Upper casing and inner assembly shall be readily removable without disturbing the motor or suction and discharge connections.

5. Provide renewable shaft sleeves at bearing points and stuffing boxes to prevent shaft wear.

6. Do not use full size impellers. Securely fasten impellers to the shaft to withstand all operating loads.

7. Impellers shall be of one-piece construction, and shall have renewable wearing rings. Renewable wearing rings shall be provided for the casings. Impellers shall be firmly secured to the shaft and retained against movement. Locking devices shall be sufficient to prevent loosening under all conditions of service.

8. Pressure casings shall be of such thickness to be suitable for maximum discharge and hydrostatic test pressures at pumping temperature, and with a minimum of 1/8 inch corrosion allowance.

9. Provide pumps bearings in sufficient number and locate to ensure proper shaft alignment and minimize noise level. All pump bearings shall be oil lubricated.

10. Provide stuffing boxes, seals, and packing glands as required, between fixed and rotating parts for minimum water leakage. Provide seal injection breakdown orifices as required to reduce pressure and to control injection flow.

11. Provide flanged flexible couplings to connect motor drivers and pump shafts.

12. Provide coupling guards for motor-pump couplings in accordance with OSHA requirements.

13. Provide each pump unit with a suitable mounting base designed to support the total weight of complete pump and motor driver and all imposed dynamic loads.

14. Provide foundation bolts and complete requirements for foundation bolting.

15. Provide foundation shims required for proper alignment and grouting in concrete.

16. Provide pumps with lifting lugs to facilitate handling during installation and maintenance.

B. Motors

1. Each pump shall be driven by a 3-phase, 60-cycle, drip proof, ball bearing, squirrel cage induction motor with horsepower, rpm, and voltage characteristics as specified in the Schedules shown on the Contract Drawings, constructed in accordance with applicable NEMA standards.

2. Provide motors in accordance with requirements specified in the Division 15 Section entitled "MOTORS AND MOTOR CONTROLLERS". Select the motor characteristics, the motor mounting, and all accessories necessary to satisfy the requirements of the pump motor drive unit in all operating modes.

3. Provide motors with lifting lugs to facilitate handling during installation and maintenance.

C. Fire Pump Controllers

1. The fire pump controller shall be completely assembled, wired and tested at the manufacturer's plant.

2. The controller shall be both manual and automatic in operations.

3. The motor starter in the controller shall be as shown on the Contract Drawings and shall be of the "Primary Resistance Reduced Voltage Starting" or "Full Voltage Starting" type.

4. The starter shall be energized automatically through action of the pressure regulator, or manually by means of a start button on the front of the enclosure. Under emergency conditions it shall be possible to close the starter mechanically through an externally operated handle provided with a latch-in device.

5. The controller shall include a combination isolating switch/circuit breaker, mechanically interlocked to operate with a single flange-mounted external handle. The interlocking shall be such that moving the handle from "OFF" to "ON" will sequence the isolating switch on first and then the circuit breaker. Also, moving the handle from "ON" to "OFF" will open the circuit breaker first and then the isolating switch. Isolating switch/circuit breaker shall be mechanically interlocked with the enclosure door so that entrance to the controller will not be allowed with the handle in the "ON" position, except by a hidden, tool-operated, defeater mechanism. The isolating switch/circuit breaker shall be capable of interrupting the motor locked rotor current without damage to the switch controller or operating personnel. The isolating switch/circuit breaker shall be capable of being padlocked in the "ON" and "OFF" position with up to three padlocks for installation and maintenance safety. The controller door shall have a locking type handle.

6. The controller shall have a minimum fault withstand rating in accordance with the requirements of NFPA 20.

7. The minimum fault withstand rating shall equal or exceed the maximum available fault current determined at the input terminals of the controller.

8. The circuit breaker shall be capable of being field tested to verify actual pick up, locked rotor, and instantaneous trip points after field installation without disturbing field line and load conductors.

9. The circuit breaker shall be appropriate for the motor in AC voltage and number of poles, and have a rating of at least 115 percent of the rated full load current of the motor. The breaker shall permit normal starting without tripping and shall provide stalled rotor protection and instantaneous short circuit protection. The interrupting capacity of the circuit breaker shall be in accordance with NFPA 20 and be appropriate for the maximum available fault current and incoming voltage.

10. The controller components shall be enclosed in a NEMA Type 3R enclosure, rain tight, free-standing, formed sheet steel cabinet, arranged for installation with back against the wall, with all operating devices, wiring and components accessible from the front. Where shown on the Contract Drawings, the controller components shall be enclosed in a NEMA Type 12 industrial use, dust-tight and oil-tight cabinet.

11. Provide alarm devices for "Power Available", "Pump Running", and "Phase Reversal" alarms which will transmit signals locally and to remote locations.

12. Provide a running period timer. The running period of the timer shall be set to prevent too frequent startings and stoppings of the motor. Timer shall be bypassed to permit an automatic start of the controller and continuous operation until manually stopped.

13. An automatic shutoff shall not be used for the fire pump, if it provides the "sole supply", according to NFPA 20.

14. Power transfer switches shall be provided for emergency power installations, with either emergency generators or emergency second power line from the local Utility. The automatic power transfer switch shall be an integral part of the fire pump controller, built in at the manufacturer's plant.

D. Jockey Pump Controllers

1. The jockey pump controller shall enable the jockey pump to maintain system pressures to prevent unnecessary cycling of the fire pump and to satisfy NFPA 20 requirements.

2. The jockey pump controller shall be completely assembled, wired and tested at the manufacturer's plant.

3. The jockey pump controller shall incorporate a full voltage magnetic starter, fusible disconnect switch, "Hand-Off-Auto" selector switch, and a pressure switch with independent high and low settings, mounted within the controller. A circuit breaker may be substituted for a fusible disconnect switch, subject to approval of the Engineer.

4. A running period timer shall be provided, within the controller, to prevent too frequent automatic starting and stopping of the jockey pump. The timer shall be set to keep the jockey pump motor in operation for at least one minute and it shall be interwired with the pressure switch.

5. A pressure recorder associated with the jockey pump controller shall be provided.

6. The controller components shall be enclosed in a NEMA Type 2 drip-tight enclosure.

2.04 ACCESSORIES

A. Pressure Relief Valve for Fire Pumps

1. When specified in the Schedules shown on the Contract Drawings, provide a pressure relief valve to relieve excess pressure in a fire protection system. The valve shall maintain constant pressure in the system regardless of demand changes.

2. Size the valve in accordance with the requirements of NFPA 20. The valve shall have a rated working pressure of 175 psig and shall have a sufficient relieving capacity while limiting the pressure developed on the system side of the fire pump to 175 psig. Provide valve with a position indicator, factory-calibrated to measure flow rate. Spring-loaded valve is not acceptable.

3. The valve shall be of the hydraulically-operated, pilot-controlled, diaphragm-type, globe or angle valve with flanged ends. It shall have a single, removable, Teflon-coated seat, a delrin-sleeved stem guide at both ends, and a resilient disc. No external packing glands shall be permitted and the diaphragm shall not be used as a seating surface. The pilot control shall be a direct-acting, adjustable, diaphragm-type valve designed for modulating service to permit flow when controlling pressure exceeds spring setting.

4. The valve shall be so set that it will relieve at pressures higher than the sum of rated net pump pressure and the maximum available suction pressure.

B. Fire Pump Flow Measuring Devices for Fire Pump Test Line

1. Provide a manifold for hose lines to facilitate testing. Number and size of hose valves shall be in accordance with the requirements of NFPA 20 and approved for testing purposes.

2. A water measuring device shall be installed on the line leading to the test discharge manifold.

3. The water flow measuring device shall be venturi, diaphragm or orifice plate type, as shown on the Contract Drawings.

4. Flow measuring devices shall be equipped with fixed measurement indicating devices and all necessary appurtenances and accessories and they shall be UL listed and FM approved.

C. Pressure Gauges

Provide a pressure gauge with range up to 200 psi at the pump suction and a pressure gauge with range from zero to 300 psi at the pump discharge. The gauges shall have Type 316 stainless steel bourdon tube, 4-1/2 inch flangeless Acaloy case, 1/4 inch bottom connection with helicoid cartridge snubber, black dial on white face, right-hand helicoid movement. Pressure gauges shall be Helicoid Type 440, manufactured by Helicoid Instruments, Bristol-Babcock, Inc. or approved equal. Each pressure gauge shall be provided with a shut-off cock to facilitate removal for maintenance.

D. Casing Relief Valve and Air Release Valve

The pump shall be provided with a 3/4 inch casing relief valve and an automatic air vent on the pump casing, each piped to the nearest drain.

E. Nameplates

A corrosion-resistant nameplate shall be permanently attached to fire pumps, fire pump motors and controllers.

Each pump shall be provided with a nameplate not less than 3 inches by 4 inches in size, made of corrosion-resistant metal, with easily readable letters and figures. The nameplate shall be securely attached to the pump baseplate, where it will be easily visible. Each nameplate shall bear the following information:

1. Manufacturer's name.

2. Manufacturer's model or type designation.

3. Manufacturer's serial number.

4. Rated capacity, in gpm at rated pressure, in psi.

5. Rated speed, in rpm.

6. Net pressure at shutoff, in psi.

7. Net pressure, in psi at 150 percent of rated capacity, in gpm.

8. Number of stages.

9. Impeller diameter.

10. Brake horsepower (BHP) at rated conditions.

11. Maximum BHP required at rated speed at any capacity.

12. UL/FM listings.

The motors shall have information in accordance with NFPA 20 and NEMA Standard MG-1.

The controllers shall have information relating to the manufacturer model number UL/FM listings and complete electrical rating.

2.05 SHOP TESTS

A. General

1. Manufacturers' standard shop tests shall be performed on pumps, motors, controllers and accessories, in conformance to the requirements of NFPA 20 and this Section.

2. All shop tests may be witnessed by the Engineer. Notify the Engineer 14 days in advance of scheduled tests.

B. Hydrostatic Tests

All pumps shall be hydrostatically tested at a pressure equivalent to twice the shutoff pressure but not less than 250 psig. The test pressure shall be held for a minimum of 15 minutes.

C. Performance Tests

Each pump shall be performance tested with its own motor and shall meet the requirements specified in this Section. The use of calibrated test motors is not allowed.

D. Controller Tests

The controller manufacturer, prior to shipment, shall hook up and test the entire controller as a completed assembly. This test shall include each function required to be performed, such as remote alarms, automatic start with manual shutdown, pressure drop, manual start-up, etc. Additionally, the controller manufacturer shall set the instantaneous and long time trips in the circuit breaker specified in C for fire pump controllers. The Contractor shall have the controller manufacturer test the circuit breaker at the above specified settings to ensure that the breaker trips within the time current requirements set forth.

E. Test Reports

Prepare copies of the pump and driver performance curves. The shipment of the pump and driver shall not be made until the certified curves have been approved by the Engineer.

PART 3. EXECUTION

3.01 INSTALLATION

A. The pump and the pump driver shall be supported on a steel bedplate and frame which shall be anchored to a reinforced concrete base required for each of the units furnished. The concrete base shall have its surface extended at least 3 inches beyond the edges of the bedplate.

B. The pump controllers shall be located as shown on the Contract Drawings and mounted on firm metal legs provided by the controller manufacturer.

C. The pump bedplate and frame shall be shimmed level with shims one inch above the concrete base before grouting into place.

D. The grout shall form a continuous solid support under the entire bearing area of the bedplate. Anchor bolts shall be cast integrally with the concrete base and accurately positioned by use of templates. Grout shall be an approved mixture. Concrete shall conform to the requirements of Division 3 Section entitled "PORTLAND CEMENT CONCRETE". The exposed surfaces of the base shall have a smooth even finish. After the grout has set with the shims or wedges in place, the anchor bolts shall be tightened to set the bases firmly upon the grout.

E. Recheck the alignment to ensure that no distortion has taken place during grouting. No piping will be allowed to be connected to the pumps until alignment and grouting have been approved by the Engineer. Any errors revealed shall be corrected.

3.02 FIELD TESTS

A. Upon completion of installation, perform field tests to establish the pump performance and mechanical smoothness of operation of the pump, motor and controller as a unit. Tests shall include testing of operation and calibration of all equipment, alarms, controls and other component parts of the water and fire systems. A copy of the manufacturer's certified shop pump test performance curve shall be available for comparison with the results of field tests.

B. Provide the services of a competent representative of the pump manufacturer to inspect the pump and controls during their installation, place them into operation and assist in performing field tests.

C. Notify the Engineer at least ten days before these tests are scheduled. Provide sufficient manpower and all necessary equipment to conduct tests, including measuring flow rates, pressures, temperatures and power consumption. After approval by the Engineer of the proposed time of tests, perform the tests in the presence of the Engineer and those authorities having jurisdiction.

D. Field tests shall meet all the requirements of NFPA 20 and shall demonstrate the following:

1. The pump and driver shafts shall be properly aligned so that there are no signs of heating at the pump and driver bearings.

2. The pump and driver bedplate shall be securely attached and grouted to the concrete foundations so that shaft alignment remains true under operating conditions.

3. Each pumping unit shall be able to discharge its rated capacity at its rated net pressure and rated speed without showing signs of excessive heating of bearings or driver.

4. At rated speed, the fire pump shall be able to discharge 150 percent of its rated capacity at 65 percent of its rated net pressure without excessive heating of bearings or driver.

5. Automatic pressure switch operation of controller shall start the pump at the specified pressure limits.

6. In installations where new pumps have been added to existing pumps, the complete pumping system shall be operated with all pumps, both new and existing, operating properly and automatically, due to pressure drop in water main and through the pressure controls and sequential starting installations.

7. The pumping system shall function properly with manual shutdown, after automatic operation.

8. The complete pumping system shall operate properly under manual start and stop procedures. Where applicable, the complete pumping system shall operate properly under all remote-starting arrangements.

9. Controller for pump shall be put through not less than 10 automatic and 10 manual operations.

10. Alarm transmissions of all types shall be tested, including pump running alarms, supervisory and tamper alarms, phase reversal, power loss and pump room temperature alarms and other alarms.

11. The pump motor shall not be energized until the pump has been rotated by hand to assure that it turns freely. Follow all instructions of the manufacturer's representative in checking out the pump before starting.

12. Each pump shall be operated for a test period of not less than one hour, total time.

END OF SECTION

SECTION 15312

ELECTRIC FIRE PUMP AND ACCESSORY EQUIPMENT

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Electric Fire Pump Shop Drawings

   Shop and coordination drawings shall be double line at a minimum of 3/8"=1'-0" scale.

   a. Piping layout and installation drawings including, at a minimum, the following:

      (1) Dimensioned outline drawings of pumps, motors, controllers and accessories, including details of valving and piping arrangements and foundation layouts.

      (2) Plans, elevation, sections and riser diagram.

      (3) Hanger, support locations and details. Indicate methods of attachment to building structure.

      (4) Pipe elevations and dimensions from main piping runs to a reference point.

      (5) Penetrations through fire rated and other partitions.

      (6) Wiring diagram of controllers, control wiring and power wiring diagrams, coordinating all systems in an integrated arrangement.

      (7) Sequence of operations related to wiring diagram.

      (8) Location for fire pumps and jockey pumps accessories, including valves, piping and appurtenances.

   b. Coordination drawings showing plan views and sections, drawn to scale, on which all items are shown and coordinated with all Work of other Sections.

B. Product Data / Catalog Cuts

1. Catalog cuts, including product performance data, for all items furnished under this Contract, including the following at a minimum:

   a. Pump: Cut sheet with the performance characteristic curves certified by the manufacturer, and with information on impeller diameter that the casing will permit.

   b. Motors of fire pumps and jockey pumps.

   c. Fire pump and jockey pump controllers and appurtenances.

   d. Test header and measuring devices.

   e. Pressure relief valve.

   f. Casing relief valve and air release valves.

g. Indication of minimum and maximum flows and the minimum required NPSH at which each pump can operate continuously without causing damage.

2. Certified shop test results.

C. Construction and Installation Procedures

1. Field test procedure.

D. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive information for the specific approved equipment; including approved shop drawings and catalog cuts, sequence of operation, test results, troubleshooting, maintenance requirements, spare parts lists, electrical/control devices and electrical/control wiring diagram(s).

E. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15312

ELECTRIC FIRE PUMPS AND ACCESSORY EQUIPMENT

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

1. Contract Drawings

(2.03 C.10)	NEMA Type 12 enclosure in lieu of NEMA Type 3R.
(2.04 B.3)	Flow measuring devices (venturi, diaphragm, or orifice plate).
(3.01 B)	Location of controllers.

2. Fire Pumps Schedules (shown on Contract Drawings)

(1.02 B&E)	Design and performance requirements of fire pumps and jockey pumps.
(1.02 G)	Minimum available NPSH.
(2.03 B.1)	Electrical characteristics for motors.
(2.04 A.1)	Pressure relief valve in the system.

B. Other Items

1. Ensure that the Specifications include the following Sections referenced in this Section:

(2.03 B.2)	"MOTORS AND MOTOR CONTROLLERS"
(3.01 D)	"PORTLAND CEMENT CONCRETE"

2. Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15375

FIRE STANDPIPE SYSTEM PIPING AND APPURTENANCES

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies requirements of piping and appurtenances for the fire standpipe systems.

B. Standpipe water service installed under this Section ends at the building line unless otherwise shown on the Contract Drawings. The continuation of the standpipe water service is specified under Division 2 of the Specifications. Types of material and installation of the piping under this Section shall be compatible with types of material and installation specified under Division 2.

C. Trenching and backfilling required in conjunction with underground piping furnished under this Section shall be as specified in applicable Sections of Division 2 and shall be included as Work under this Section.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, as though the Authority were a private corporation, and with the latest industry standards including, but not limited to, the entities listed below:

New York City Building Code
New Jersey Uniform Construction Code
Municipal Water Company
American National Standards Institute (ANSI)
American Society for Testing and Materials (ASTM)
American Water Works Association (AWWA)
Factory Mutual Engineering Corp. (FM)
National Fire Protection Association (NFPA)
Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. The fire standpipe system design shall be based on water supply information as shown on the Contract Drawings or, if not shown, as determined by a water flow test by the Contractor.

1.03 QUALITY ASSURANCE

A. Fire standpipe system piping and appurtenances, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Entities performing Work shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Clean all pipe sections of foreign matter and cover ends with temporary sheet metal closures or plastic end caps of sufficient tightness to prevent entry of foreign matter prior to shipping to the construction site.

B. Store pipe, fittings, valves and other components at the construction site on pallets or raised platforms with suitable coverings satisfactory to the Engineer to protect them against damage and weather.

C. Inspect all pipe, fittings, valves and other components for damage before moving them from storage to the point of installation at the construction site.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 PIPE, FITTINGS, AND FLANGES

A. Provide pipe, fittings, and flanges in accordance with the "Pipe, Fittings and Flanges Schedule" specified below, including gaskets, bolts, nuts, washers and other pressure containing parts necessary for the complete installation of piping systems.

B. Nipples shall be extra-heavy shoulder-type of same material as pipe; close nipples are not acceptable.

C. Gaskets for flanges shall be 1/16-inch thick (after compression), rubber or neoprene, full-faced, and punched bolt holes.

D. Grooved Piping Mechanical Couplings

1. Couplings shall be complete with gaskets, bolts and nuts recommended by the manufacturer for the service. Use vandal proof nuts and bolts on vertical piping in stairs.

2. Couplings shall be Victaulic "Style 75" lightweight for system pressure not exceeding 400 psi (including shutoff pressure of fire pump and static street pressure of water main) and Victaulic "Style 77" for system pressure exceeding 400 psi, or approved equal. Flush-seal gaskets shall be used on all dry standpipe system piping.

3. Couplings shall be manufactured by Victaulic Co. of America; Tyler Pipe Subsidiary, Tyler Corp./Gustin-Bacon Division; Gruvlock Couplings by Grinnell; or approved equal.

Pipe, Fittings and Flanges Schedule

Systems	Pipe	Fittings and Flanges
Wet Standpipe	Black Steel, ASTM A 795, A 53, or A 135, Schedule 40	A. Black Malleable Iron, ANSI B16.3 or Ductile Iron AWWA C110, 300 lb. Class, 500 psi w.w.p., Threaded B. Companion Flanges, Cast Iron, ANSI B16.1, 125 lb. Class C. Ductile Iron ASTM A 536, Grooved, Mechanical Type Couplings and Gaskets
Dry Standpipe, or piping subject to corrosion; Piping between Siamese connection and check Valve and Automatic Ball Drip Drain	Galvanized Steel, ASTM A 795 or A 53, Schedule 40	Same as for Wet Standpipe except all fittings and flanges shall be galvanized
Drain Piping	Galvanized Steel, ASTM or A 53, Schedule 40	Galvanized Cast Iron (Drainage), ANSI B16.12, 125 lb. Class, Threaded
Piping at Standpipe Water Meter Assembly	Galvanized Steel, ASTM or A 53, Schedule 40	Galvanized Cast Iron (Drainage), ANSI B16.1, 125 lb. Class, Flanged

2.02 VALVES

A. Control Valves

1. Valves

a. Valves shall be flanged, iron body, bronze mounted, OS&Y, solid wedge gate valves with rising stem and wheel handles, rated for 175 psi w.w.p., or as shown on the Contract Drawings. Valves shall have gland followers in stuffing box and shall be repackable while open and under pressure. Provide valved bypass around valves six inches and larger.

b. Valves shall be manufactured by Crane Co., Walworth Co., Stockham Valves & Fittings, or approved equal.

2. Tamper Switches

a. Provide tamper switches in accordance with manufacturer's recommendations.

b. Tamper switches shall monitor the control valves to detect and indicate when a valve has been closed.

c. Unless otherwise shown on the Contract Drawings, tamper switches shall be completely factory assembled and wired and shall be mounted on the control valve. The valve stem shall be prepared as required to accept the actuating roller rod. Switches shall be Potter Electric Signal Co. Model OSYS-U-1 or -2, or approved equal.

d. Wiring to control circuit shall be as specified in Division 16.

e. Tamper switches shall be manufactured by Potter Electric Signal Co., Fire Control Instruments Inc., or approved equal.

B. Drain Valves (Dry Systems)

1. Valves shall be threaded, bronze, angle or globe type with composition disc, 200 psi w.w.p, or as shown on the Contract Drawings.

2. At system low points where drain piping does not extend to a drain receptacle, provide a threaded hose end adapter at the valve outlet.

3. For dry standpipe system to be filled with compressed air, provide drum-drip drains on all low points in the systems. Enclose drum-drips in cabinets as shown on the Contract Drawings. Provide heating for drum-drip cabinets as shown on the Contract Drawings. Provide the drum-drip drains in protected locations. Extend auxiliary drains from drum-drips to the drain shown on the Contract Drawings.

4. The numbers and locations of drum-drips shown on the Contract Drawings are minimum; actual installation requirements and quantities shall be determined by the Contractor based on approved shop drawings.

5. Valves shall be manufactured by Crane Co., Walworth Co., Stockham Valves & Fittings, or approved equal.

C. Check Valves

1. Check valves shall be swing type, flanged, iron body, bronze mounted with renewable composition disc, bronze seat ring, and bolted cover, rated for 175 psi w.w.p., or as shown on the Contract Drawings.

2. Valves shall be manufactured by Crane Co., Walworth Co., Stockham Valve & Fittings, or approved equal.

D. Dry Standpipe System Automatic Valves

1. For dry fire standpipe system, activation shall occur through one of the applicable automatic valves specified below and as shown on the Contract Drawings:

a. Deluge valve shall be electrically operated, release type with manual trip device complete with all drains, accessories, and controls. Deluge valve shall be operational from electrically operated, remote control stations located at each hose rack. All drains shall be connected and discharged into the drain receptor. Valve shall be Star Sprinkler "Model D", or approved equal. Controls, switches, panels, alarms, etc. shall be as specified in Division 16.

b. Dry-pipe valve shall be of the differential type, only. The dry-pipe valve shall be furnished with bronze clapper and latch and shall be Star Sprinkler "Model A", or approved equal.

c. Provide opening device on all systems. The device shall be of the exhauster pattern, designed and installed so as to provide for a full 2 inches air release from the system and designed to operate upon a 2 psi differential pressure within 7 seconds after fully opening the standard test connections. Exhauster shall be Star Sprinkler "Model BB", or approved equal.

2. Automatic valves shall be manufactured by Reliable Automatic Sprinkler Co. Inc., Star Sprinkler Corp., Viking Corp., or approved equal.

2.03 SIAMESE CONNECTIONS

A. Siamese connections shall be two-way type, having a brass body, with clapper valves, hose thread swivels and red painted plugs, as required by local code. Provide the siamese connections with breakable caps, unless indicated otherwise on the Contract Drawings. Siamese connection escutcheon shall be lettered in accordance with code requirements. Threads shall conform to local fire department requirements.

B. Where automatic ball drip is shown on the Contract Drawings to extend to the exterior at the siamese connection location, the siamese connection escutcheon shall be modified with a sillcock flange. In lieu of a sillcock flange, a drain elbow may be provided.

C. Flush type siamese connection shall be Potter-Roemer Series 5020, or approved equal. Size and location of outlet shall be as shown on the Contract Drawings. Extra-heavy nipple extensions shall be installed to connect the yoke to the outside assembly.

D. Exposed type siamese connection shall be Potter-Roemer Series 5720 (back outlet) or 5730 (90° angle outlet) as shown on the Contract Drawings, or approved equal. Size and location of outlet shall be as shown on the Contract Drawings.

E. Finish of siamese connection assembly including escutcheon shall be polished brass, unless otherwise shown on the Contract Drawings.

F. Siamese connections shall be manufactured by Potter-Roemer Inc., Elkhart Brass Manufacturing Co. Inc., or approved equal.

2.04 FIRE LINE BACKFLOW PREVENTER

Provide a backflow preventer on the fire standpipe system water service. The installation shall be in accordance with the regulations of the local authorities. Backflow preventer shall be one or combination of the following devices and as specified on the Contract Drawings:

A. Single detector check with bypass meter.

B. Double detector check with bypass meter.

C. Reduced pressure zone device.

2.05 FIRE HOSE STATIONS

A. Fire standpipe equipment shall be manufactured by Potter-Roemer Inc., Elkhart Brass Manufacturing Co. Inc., or approved equal.

B. All the fire standpipe equipment numbers specified herein are those of Potter-Roemer Inc.

C. Hose Racks (2-1/2 inch Valve with 1-1/2 inch Hose)

At each hose station, exposed or in a hose cabinet, where shown on the Contract Drawings, provide a Figure (Fig.) 4075, 2-1/2 inch brass angle valve, complete with 2-1/2 inch brass rack supporting hose nipple, a Fig. 2810, 2-1/2 inch x 1-1/2 inch reducer, with 1-1/2 inch Fig. 2915, Polyflex synthetic fire hose (length of hose is shown on the Contract Drawings, in 25- or 50-foot sections); Fig. 2930, satin cast brass expansion ring couplings attached; Fig. 2960 adjustable fog nozzles of molded polycarbonate/Lexan plastic; Fig. 2794, all steel, red enameled hose rack with non-detachable sliding pins and spring clip nozzle holder and trigger mechanism; and Fig. 6057, Universal Spanner with brass chain.

D. Hose Racks (2-1/2 inch Valve with 2-1/2 inch Hose)

At each hose station, exposed or in a hose cabinet, where shown on the Contract Drawings, provide a Fig. 4075, 2-1/2 inch brass angle valve, complete with 2-1/2 inch brass rack supporting hose nipple, with 2-1/2 inch Fig. 2916, Polyflex synthetic fire hose (length of hose is shown on the Contract Drawings, in 25- or 50-foot sections); Fig. 2936, satin cast brass expansion ring couplings attached; Fig. 2961 adjustable fog nozzles of molded Polycarbonate/Lexan plastic; Fig. 2887, all steel, red enameled hose rack with non-detachable sliding pins and spring clip nozzle holder and trigger mechanism; and Fig. 6057, Universal Spanner with brass chain.

E. Hose Cabinets

Selection of hose cabinet shall be as shown on the Contract Drawings and shall conform to the applicable description specified below:

1. Hose Cabinets (Recessed/Space for Extinguisher)

   Cabinet for hose station and extinguisher shall be Fig. 1300 Series for 1-1/2 inch valve (Fig. 1400 Series for 2-1/2 inch valve), recessed cabinet with 20-gauge steel body and 18-gauge trim, having 20-gauge door of style "AW" Full Panel wire glass. Cabinet shall be white enamel inside and prime coated outside.

2. Hose Cabinets (Surface-Mounted/Space for Extinguisher)

   Cabinet for hose station and extinguisher shall be Fig. 1350 Series for 1-1/2 inch valve (Fig. 1450 Series for 2-1/2 inch valve), surface-mounted cabinet with 20-gauge steel body and trim, having 20-gauge door of style "AW" Full Panel wire glass. Cabinet shall be white enamel inside and prime coated outside.

3. Hose Cabinets (Recessed/No Space for Extinguisher)

   Cabinet for hose station shall be Fig. 1000 Series for 1-1/2 inch valve (Fig. 1100 Series for 2-1/2 inch valve), recessed cabinet with 20-gauge steel body and 18-gauge trim having 20-gauge door of style "DW" Duo Panel wire glass. Cabinet shall be white enamel inside and prime coated outside.

4. Hose Cabinets (Surface-Mounted/No Space for Extinguisher)

Cabinet for hose station shall be Fig. 1050 Series for 1-1/2 inch valve (Fig. 1150 Series for 2-1/2 inch valve), surface-mounted cabinet with 20-gauge steel body and trim, having 20-gauge door of style "DW" Duo Panel wire glass. Cabinet shall be white enamel inside and prime coated outside.

5. Valve Cabinets (2-1/2 inch Valve)

Hose valve cabinet for recessed or surface-mounted use shall be Fig. 1800 Series with 20-gauge steel body, 18-gauge trim having 20-gauge door of style "AW" Full Panel wire glass. Cabinets shall accommodate 2-1/2 inch angle valve with cap and chain and shall be white enamel inside and prime coated outside.

F. Adjustable Pressure Restricting Devices

Where shown on the Contract Drawings, provide Fig. 2765, 1-1/2 inch, or Fig. 2766, 2-1/2 inch, brass, suitable outlet pressure reducer where hydrostatic pressure exceeds 85 psi for 1-1/2 inch hose and 55 psi for 2-1/2 inch hose.

G. Fire Extinguisher Cabinets (All)

Fire extinguisher cabinet for recessed or surface-mounted use shall be Fig. 1700 Series with 22-gauge steel body, 18-gauge trim having tubular door of style "AW" Full Panel wire glass. Cabinet shall be of size to accommodate extinguisher type, as shown on the Contract Drawings, and shall be white enamel inside and prime coated outside.

H. Roof Manifolds

Size and position of roof manifold shall be as shown on the Contract Drawings and shall be Fig. 5890 Series vertical, or Fig. 5880 Series horizontal, complete with three Fig. 4065, 2-1/2 inch brass valves with Fig. 4625 brass caps and chains.

2.06 ACCESSORIES

A. Automatic Ball Drips

For each siamese connection and wherever shown on the Contract Drawings, provide a Potter-Roemer Model 5982 automatic ball drip, or approved equal. Provide pipe discharge to exterior or a drain receptacle. Where static pressure at location requiring drainage exceeds the ball drip operating characteristics, a valved drain shall be used.

B. Pressure Gauges

Gauges shall have aluminum case, 4-1/2 inch diameter aluminum ring-bronze bourdon tube, stainless steel linkage, 1/2 inch bottom connection, black pointer, white face with black figures and segment range of 0-200 psi, 20 psi figure intervals, 2 psi intermediate graduations. Dial shall have red marker at 175 psi. Gauges shall be Dresser Industries Inc. "Ashcroft Series 1379", or approved equal.

C. Pipe and Valve Identification

1. Adhesive Bands

a. Provide approved adhesive bands in sets of two, one identifying the piping system type and the second, the direction of flow. Sets shall be provided in quantities sufficient to accommodate the requirements of 3.04 A of this Section.

b. For 3-inch or larger pipe, the adhesive band identifying the piping system shall display the name of the service in white letters at least two inches high and the band indicating direction of flow shall display a white arrow of similar size. For 2-1/2 inch or smaller pipe, the letters and the arrow shall be white and shall be not less than one inch high. Bands shall have red backgrounds and shall conform to ANSI A 13.1.

c. Adhesive bands shall be W. H. Brady Co. "Quik-Label", or approved equal.

2. Valve Tags, Charts and Schedules

a. Provide each valve with a 2-inch diameter 18 gauge brass tag with brass chain. Service designation shall be 1/4-inch high and valve number shall be 1/2-inch high, on two lines with service designation on the upper line and valve number on the lower line. The characters shall be indented and filled with durable black compound.

b. Provide diagrammatic valve charts and schedules, using a valve numbering system which differentiates between classes of service and indicates floor level of valve location.

c. Tags shall conform to the numbers, locations and uses listed in the valve charts and schedules.

d. Valve charts and schedules shall be mounted under glass in wood frames or aluminum self-closing frames.

e. Tags and the frames for valve charts and schedules shall be manufactured by Seton Name Plate Corp., or approved equal.

3. Identification Signs

a. Provide identification signs for control valves. Identification signs shall be Reliable Style A and B, or approved equal.

b. On the outside of doors to rooms where control valves are located, provide suitable signs making note of such valve locations.

D. Access Ladders

Control valves located seven feet or more above the finished floor shall be provided with a permanent steel access ladder. Ladder construction shall be approved by the Engineer.

E. Access Doors

Provide a complete list of all access doors (including locations) that are required in finished walls, ceilings, partitions and any other areas for access to all valves and drains concealed behind such finished construction. Access doors shall be furnished and installed under appropriate Access Door Sections of Division 8.

2.07 PIPE HANGERS AND SUPPORTS

A. Design, fabricate and provide all pipe hangers and supports adequate to support and guide the piping, allow for forces imposed by expansion joints, satisfy structural requirements and maintain proper clearances with respect to adjacent piping, equipment and structures.

B. Provide hangers and supports, with beam clamps, restraints, supplemental steel, inserts, fish plates, mounting devices, and similar items to support piping in alignment without sagging or interference, and to permit complete drainage and free expansion and contraction.

C. All hangers and supports shall be capable of screw adjustment after piping is erected and shall be provided with a locking nut (double nut) to prevent loss of adjustment.

D. Where required, provide anchors, sway bracing, blocking and steel to connect to structure to prevent excessive pipe movement that could cause damage due to expansion, contraction or thrust.

E. All pipe hangers, inserts, supports, supplemental steel, rods and components shall be galvanized.

F. Support hangers from building steel framing wherever possible. Provide any additional miscellaneous steel supports between existing framing members as required. Do not support piping from other piping, ductwork and conduit.

G. Tabs in metal deck construction shall not be used to support piping.

H. Where required, provide supplemental channels and steel to support Work of this Section. Cut ends of steel shall be ground smooth, free from burrs and sprayed with a galvanized coating.

I. Where several pipes rest on a common trapeze, increase hanger rod diameter and decrease spacing in accordance with maximum and minimum pipe sizes, respectively.

J. Expansion anchors, self-drilling expansion shields, power driven studs and similar devices shall not be used, unless specifically approved by the Engineer.

K. Provide pipe restraints to prevent movement by an upward thrust in the pipe risers.

L. Support vertical piping at the lowest level, at each alternate level above and below offsets, and at the top of the riser by use of riser clamps. Provide additional intermediate support brackets, secured to structure, on piping utilizing gasket coupling joints.

M. Support horizontal piping as follows:

1. For piping sizes of 3 to 8 inches, support on clevis type hangers.
2. For piping 10 inches and larger, support on trapeze hangers constructed of channel iron and hung from rod and insert assembly. Load calculations shall be performed.

N. Hanger system shall not penetrate waterproofing.

O. If removal of existing fireproofing is required for installation purposes, such removal shall be performed by the Contractor and shall be kept to a minimum. The Contractor shall replace all removed fireproofing with new fireproofing to the satisfaction of the Engineer and at no additional cost to the Authority.

P. Unless otherwise specifically approved, hanger rod size and spacing shall be within the following limits:

Pipe Size	Maximum Hanger Spacing	Minimum Rod Size
2-1/2" to 3-1/2"	12 ft. o.c.	1/2"
4" and 5"	12 ft. o.c.	5/8"
6"	12 ft. o.c.	3/4"
8"	12 ft. o.c.	7/8"
10" and 12"	12 ft. o.c.	7/8"

Q. Provide thrust restraint on underground piping entering the building through the floor or wall to serve the fire standpipe systems.

R. Hangers and supports shall be manufactured by Grinnell Corp., Carpenter & Patterson Inc., Michigan Hanger Co. Inc., or approved equal.

2.08 SLEEVES, SEALS AND ESCUTCHEONS

A. Piping passing through masonry or concrete walls and framed partitions shall have a trim opening cut no greater than necessary for the installation of a sleeve secured therein. Sleeve shall be 1/2 inch in diameter larger than the outside diameter of the pipe. Sleeve shall be flush with the finished wall or partition surface.

B. Sleeves through concrete floors for piping shall have the opening 1/2 inch in diameter larger than the outside diameter of the pipe passing through. Floor sleeves shall project one inch above floor slab.

C. Pipe insulation shall be omitted at penetrations through fire-rated barriers. In all cases, pack the annular space between the pipe and sleeve with mineral wool. Additionally at penetrations through fire-rated barriers, seal the annular space to retain the fire rating integrity of the barrier with non-hardening through-penetration firestops having F-ratings compatible with fire ratings of the barriers in which they are installed, per ASTM, E 814. Firestop systems shall be UL-approved, and shall be as manufactured by 3M, Bio-fireshield, Inc., General Electric Co., Dow Corning Corp., or approved equal.

D. Sleeves in walls and floors shall be galvanized steel pipe, Schedule 40 for sizes up to 10 inches and 3/8-inch wall thickness for 12 inches and larger. Sleeves in partitions shall be 20-gauge galvanized sheet metal.

E. Piping in exposed areas, passing through walls, floors or ceilings shall be fitted with chromium-plated cast brass escutcheons with fastening set screws.

F. Piping passing through floor waterproofing membrane shall be provided with a 4-pound lead flashing or a 16-ounce copper flashing, each within an integral skirt or flange. Flashing shall be suitably formed, and the skirt or flange shall extend not less than 8 inches from the pipe and shall be set over the floor membrane in a solid coating of bituminous cement. The flashing shall extend up the pipe a minimum of 10 inches above the floor. The annular space between the flashing and the pipe shall be sealed watertight.

PART 3. EXECUTION

3.01 INSTALLATION

A. General

1. Install piping and appurtenances in accordance with manufacturers' installation procedures, requirements of NFPA 14, and as specified.

2. Coordinate piping installation with other Work to avoid interference. Coordinate as necessary to ensure that all hangers, supports, sleeves and other built-in devices are incorporated in forms or in masonry to avoid necessity of cutting finished structure.

3. All measurements, both horizontal and vertical, shall be based on established benchmarks. All Work shall agree with these established lines and levels. Verify all measurements at site and check the correctness of same as related to the Work.

4. Perform necessary cutting and patching in accordance with requirements specified in Division 2 Section entitled "CUTTING, PATCHING AND REMOVAL". All openings in existing slabs required for pipe penetrations shall be core drilled.

5. Electrical installation of appurtenances furnished under this Section shall be in accordance with requirements specified under Division 16.

6. Installation requirements for pipe hangers and supports and pipe penetration sleeves, seals, and escutcheons are specified in 2.07 and 2.08, respectively.

B. Piping

1. Install piping as shown on the Contract Drawings and straight and direct as possible, forming right angles or parallel lines with building walls, neatly spaced, with risers plumb and true.

2. Avoid tool marks and unnecessary pipe threads. Burrs formed when cutting pipe shall be removed by reaming. Before installing pipe, thoroughly clean the inside free of cutting and foreign matter. Cut all piping square and smooth and make up all joints to required limits.

3. Make changes in pipe size by the use of reducing fittings. Do not use reducing bushings except by approval of the Engineer.

4. Install piping so that no part thereof will interfere with doors, windows, heating, plumbing or electrical equipment. Coordinate Work specified in this Section with that specified in other Sections to avoid any interference with potential effectiveness of the fire standpipe systems.

5. Provide protective pans under pipes passing over high voltage electric bus duct or switchgear equipment. Construct the pans of 18-gauge copper, suitably reinforced to prevent sagging. Turn the edges of the pans up to 6 inches on all sides with corners brazed to make the pans watertight. Support the pan with hangers and provide drainage clear of the electrical work.

6. Dry systems shall be installed so that the system can be drained.

7. All piping shall be thoroughly blown out, rodded out, or washed out at least twice, in a manner as directed and approved by the Engineer, to remove all accumulation of dirt, chips or other deleterious materials. Make all temporary connections and furnish all appliances required for the purpose of cleaning.

C. Pipe Joints

1. Threaded joints shall be made up tight using pipe joint Teflon compound or tape, applied on the male threads only.

2. Grooved pipe and fittings shall be clean and free from indentations, projections and tool marks in the area from pipe end to groove for proper gasket sealing. Provide a thin uniform coat of lubricant on the suitable gasket intended for specified service as recommended by the manufacturer. Place the gasket over one pipe end, align pipe ends and bring together, positioning the gasket between the groove on each pipe end. Assemble the housing over the gasket with housing key section engaging both grooves. The bolts shall be inserted, nuts started and uniformly tightened until the housing bolt pads are firmly seated together, metal to metal.

3. Flanged joints shall be made up square and tight with gaskets. Dip bolts and nuts in mixture of graphite and oil immediately prior to installation.

4. Joints between copper or brass and steel pipe shall be made by using a dielectric coupling.

3.02 FIELD TESTS

A. Notify the Engineer and those authorities having jurisdiction, at least 48 hours in advance of making the required tests, so that arrangements may be made for their presence to witness the tests.

B. Perform all tests prior to painting or concealing.

C. Isolate all equipment, controls and instruments from the piping system during the required tests.

D. Provide and install necessary equipment, instruments, hardware, temporary piping, vents, drains, and include necessary personnel required to perform all tests.

E. Perform hydrostatic tests for all sections of the piping systems (except siamese connections), at not less than 200 psi pressure for two hours, or at 50 psi in excess of the maximum pressure, when the maximum pressure to be maintained in the system is in excess of 150 psi. Test pressure for siamese connections shall not be less than 300 psi. The test pressure shall be read from a gauge located at the low elevation point of the individual system or portion of the system being tested.

F. Test dry-pipe systems with air at 40 psi for 24 hours, prior to performing the hydrostatic tests specified in 3.02 E above. Permissible air leakage shall not exceed the value specified in NFPA 14.

G. Set the adjustable pressure reducing devices according to the manufacturer's instructions to produce flows at the required rate and pressure in accordance with the applicable code requirements, as if this Contract were being performed for a private corporation. A written record shall be furnished to the Engineer of all settings throughout the system.

H. With the entire system under normal operating pressure, each control valve shall be opened and closed to demonstrate proper operation.

I. All tests shall conform to the requirements of NFPA 14. Records of all tests shall be made available for the Engineer's inspection, as required.

J. Should the tests reveal any leaks or deficiencies in piping installed under this Section, make necessary corrections immediately and flush, clean and retest the system for the Engineer's approval at no additional cost to the Authority.

K. Repair or replace any portion of the system installed under this Section that is damaged as a result of test operations at no additional cost to the Authority.

L. Where piping installed under this Section is connected to any existing system, such installed piping shall be isolated from the existing system during the performance of the required field tests, unless otherwise directed by the Engineer.

M. The Engineer reserves the right to direct the Contractor not to isolate the newly-installed piping from the existing system during the performance of the required field tests. In such event, the Contractor shall correct any revealed leaks or other deficiencies within the first 20 feet of the existing system, measured in any direction from the point of connection with the newly installed piping, all as directed by the Engineer and at no additional cost to the Authority.

N. Dispose of water removed from pipelines in a manner that shall not cause damage to any property.

3.03 PAINTING

Upon completion of the installation, remove all protecting materials, thoroughly remove all scale and grease and leave in a clean condition for painting. Piping to be painted shall be as shown on the Contract Drawings. Painting shall be in accordance with the requirements of Division 9 Section entitled "PAINTING".

3.04 PIPE AND VALVE IDENTIFICATION

A. Pipe Identification

1. Affix sets of pipe adhesive bands specified in 2.06 C.1 where they can be easily read, with their long dimension parallel to the axis of the pipe and no more than 40 feet apart on a piping system.

2. At least one set of identifying bands shall be affixed in all occupied and unoccupied rooms as well as in all other spaces, such as hung ceilings or shafts, where piping may be viewed and the identity of the piping system cannot be readily ascertained.

B. Valve Tags

Securely fasten valve tags specified in 2.06 C.2 with approved brass chain.

END OF SECTION

SECTION 15375

FIRE STANDPIPE SYSTEM PIPING AND APPURTENANCES

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Fire Standpipe Shop Drawings

   Shop and coordination drawings shall be double line at a minimum of 3/8"=1'-0" scale.

   a. Piping layout and installation drawings including, at a minimum, the following:

      (1) Plans, elevation, sections and riser diagram.

      (2) Hanger, support locations and details. Indicate methods of attachment to building structure.

      (3) Pipe elevations and dimensions from main piping runs to a reference point.

      (4) Penetrations through fire rated and other partitions.

      (5) Electrical wiring diagram showing connection of tamper switches and alarm devices.

      (6) Location for piping accessories, including valves and access ladders and doors.

   b. Piping coordination drawings showing plan views and sections, drawn to scale, on which all items are shown and coordinated with all Work of other Sections.

B. Product Data / Catalog Cuts

1. Standpipe piping and appurtenances.

2. Standpipe material and schedule.

3. Catalog cuts, including product performance data, for all items furnished under this Contract, including the following at a minimum:

   a. Pipe, pipe fittings and flanges,

   b. Valves, including valve charts and schedules.

   c. Tamper switches/alarm devices.

   d. Siamese and other fire department connections.

   e. Fire line backflow preventer.

   f. Fire hose stations.

   g. Adjustable pressure restricting devices.

   h. Automatic ball drips.

i. Pressure gauges.

j. Pipe and valve tags identification bands.

k. Access ladders.

l. Access doors, including list of their locations.

m. Hangers and supports, including schedule showing manufacturer's figure number, size, location and features of each required hanger and support.

n. Sleeves and escutcheons.

4. List of access doors and schedules.

C. Construction and Installation Procedures

1. Field test procedure.

D. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive information for the specific approved equipment; including approved shop drawings and catalog cuts, sequence of operation, test results, troubleshooting, maintenance requirements, spare parts lists, electrical/control devices and electrical/control wiring diagram(s).

E. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15375

FIRE STANDPIPE SYSTEM
PIPING AND APPURTENANCES

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(1.01 B)	End of standpipe water service other than at the building line.
(1.02 B)	Water supply information to be used for fire standpipe system design.
(2.02 A.1.a)	Control valve requirements other than as specified.
(2.02 A.2.c)	Tamper switch requirements, if other than specified.
(2.02 B.1)	Dry system drain valves other than as specified.
(2.02 B.3)	Drum-drip details, including heating and auxiliary drains.
(2.02 B.4)	Numbers and locations of drum-drips.
(2.02 C.1)	Check valve requirements, if other than specified.
(2.02 D.1)	Dry system automatic valves requirements, if other than specified.
(2.03 A)	Siamese protective covers if other than breakable caps.
(2.03 B)	Where automatic ball drip is to extend to the exterior at a siamese connection location.
(2.03 C)	Outlet size and location of flush type siamese connection.
(2.03 D)	Outlet type, size and location of exposed type siamese connection.
(2.03 E)	Finish of siamese connection assembly, if other than polished brass.
(2.04)	Backflow preventer type.
(2.05 C)	Locations of hose racks with 2-1/2 inch valve and 1-1/2 inch hose and lengths of hoses.
(2.05 D)	Locations of hose racks with 2-1/2 inch valve and 2-1/2 inch hose and lengths of hoses.
(2.05 E)	Hose cabinet types.
(2.05 F)	Size of adjustable pressure restricting devices.
(2.05 G)	Extinguisher type.
(2.05 H)	Size and position of roof manifold.
(2.06 A)	Automatic ball drip locations.
(3.01 B.1)	Piping layout.
(3.03)	Piping to be painted.

B. Other Items

1. Ensure that the Specifications include the following Section(s) referenced in this Section:

(2.06 E)	"ACCESS DOORS" Sections

(3.01 A.4) "CUTTING, PATCHING AND REMOVAL"

(3.03) "PAINTING"

2. Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15410

PLUMBING PIPING AND APPURTENANCES

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies requirements for domestic water service piping, storm and sanitary sewer piping, and appurtenances.

B. Domestic water service and storm and sanitary sewers installed under this Section end at the building line unless otherwise shown on the Contract Drawings. The continuation of the domestic water service and storm and sanitary sewers is specified under Division 2 of the Specifications. Types of material and installation of the piping under this Section shall be compatible with types of material and installation specified under Division 2.

C. Trenching and backfilling required in conjunction with underground piping furnished under this Section shall be as specified in applicable Sections of Division 2 and shall be included as Work under this Section.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

New York City Building Code

New Jersey Uniform Construction Code

Municipal Water Company

American National Standards Institute (ANSI)

American Society for Testing and Materials (ASTM)

American Society of Mechanical Engineers (ASME)

Cast Iron Soil Pipe Institute (CISPI)

American Water Works Association (AWWA)

In addition, specific provisions cited herein shall govern for the associated specific application.

1.03 QUALITY ASSURANCE

A. Plumbing piping and appurtenances, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Entities performing the Work of this Section shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Clean all pipe sections of foreign matter and cover ends with temporary sheet metal closures or plastic end caps of sufficient tightness to prevent entry of foreign matter prior to shipping to the construction site.

B. Store pipe, fittings, valves and other components at the construction site on pallets or raised platforms with suitable coverings satisfactory to the Engineer to protect them against damage and weather.

C. Inspect all pipe, fittings, valves and other components for damage before moving them from storage to the point of installation at the construction site.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 PIPE, FITTINGS, AND FLANGES

A. Unless otherwise shown on the Contract Drawings, provide pipe (and tube), fittings and flanges in accordance with the "Pipe, Fittings, and Flanges Schedule" specified below, including gaskets, bolts, nuts, washers and other pressure containing parts necessary for the complete installation of piping systems.

B. Nipples shall be extra-heavy shoulder type. No close nipples shall be used. All nipples shall have designation mark of the manufacturer and shall conform to ASTM pipe specifications for system served.

C. Gaskets for flanges shall be 1/16-inch thick (after compression) rubber or neoprene, full-faced, and punched bolt holes.

D. Unions shall be malleable iron, threaded, conforming to ANSI B16.39.

Pipe, Fittings and Flanges Schedule

Systems	Pipe	Fitting and Flanges
Storm & Sanitary Drainage & Vent (underground)	Cast Iron, ASTM A 74, Service Weight Hub & Spigot Type	Cast Iron, ASTM A 74, Service Weight Hub & Spigot Type; caulked or compression type joints
Storm & Sanitary Drainage & Vent (above ground and underground)	Cast Iron, CISPI-301, ASTM A888, Service Weight Hubless Type	Cast Iron, CISPI-301, ASTM A 888, Service Weight, Hubless Type
Storm & Sanitary Pump Discharge	Galvanized Steel, ASTM A 53, Schedule 40	Galvanized Malleable Iron, ANSI B16.3, 150 lb. Class, Threaded
Sanitary Indirect Drainage	Galvanized Steel, ASTM A 53, Schedule 40	Galvanized Cast Iron (Drainage), ANSI B16.12, 125 lb. Class, Threaded
Domestic Water	Copper Tubing, ASTM B 88, Type L, Drawn, Nominal Wall	Cast Bronze, ANSI B16.18, Same Wall as Tube, Solder Joints
Domestic Water at Meter Assembly (3 inches and larger)	Galvanized Steel, ASTM A 53, Schedule 40	Galvanized Cast Iron, ANSI B16.1, 125 lb. Class, Flanged (Companion)

2.02 VALVES

A. General

1. Provide types of valves as and where shown on the Contract Drawings.
2. All gate and globe valves shall be the products of one manufacturer.
3. Valves shall be of one of the following manufacturers, or approved equal:
   a. Stockham Valves and Fittings.
   b. Crane Co.
   c. Walworth Co.
   d. NIBCO Inc.

B. Gate Valves

1. For piping 2 inches and smaller: Class 125, bronze body, screw-in bonnet, rising stem, solid wedge, approved equal of Stockham Fig. B-122 (threaded ends), or Fig. B-109 (soldered ends).
2. For piping 2-1/2 inches and 3 inches
   a. Class 125, iron body, bolted bonnet, rising stem, solid wedge, bronze mounted, flanged ends, similar to Stockham Fig. G-623, or approved equal.
   b. Class 150, bronze body, screw-in bonnet, rising stem, solid wedge, threaded ends, similar to Stockham Fig. B-122, or approved equal.

3. For piping 4 inches and larger: Class 125, iron body, bolted bonnet, solid wedge, bronze mounted, OS&Y, flanged ends, similar to Stockham Fig. G-623, or approved equal.

C. Globe Valves

Class 150, bronze body, screw-in bonnet, rising stem, integral seat, renewable disc, approved equal of Stockham Fig. B-22 (threaded ends), or Fig. B-24 (soldered ends).

D. Drain Valves

Class 125, gate valve, bronze body, screw-in bonnet, non-rising stem, solid wedge, threaded ends on inlet side of valve and hose end thread with cap and chain on the outlet side, similar to NIBCO Fig. T-113-HC, or approved equal.

E. Check Valves

1. For pipe 2 inches and smaller: Class 125, bronze body, horizontal swing, renewable disc, approved equal of Stockham Fig. B-321 (threaded ends), or Fig. B-319 (soldered ends).

2. For piping 2-1/2 inches and larger: Class 125, iron body, bronze mounted, bolted bonnet, horizontal swing, renewable seat, flanged ends, similar to Stockham Fig. G-931, or approved equal.

3. Ball Valves

For piping 1 inch and smaller: Class 150, bronze body, full port, bronze trim, approved equal of Stockham Fig. S-216 BRRT (threaded ends) or Fig. S-216 BRRS (soldered ends).

2.03 ACCESSORIES

A. Pipe and Valve Identification

1. Adhesive Bands

a. Provide approved adhesive bands in sets of two, one identifying the piping system type and the second, the direction of flow. Sets shall be provided in quantities sufficient to accommodate the requirements of 3.04 A of this Section.

b. For 3-inch or larger pipe, the adhesive band identifying the piping system shall display the name of the service in letters at least two inches high and the band indicating direction of flow shall display an arrow of similar size. For 2-1/2 inch or smaller pipe, the letters and the arrow shall be not less than one inch high. Bands shall be in colors and shall conform to ANSI A13.1.

c. Adhesive bands shall be W.H. Brady Co. "Quik-Label", or approved equal.

2. Valve Tags, Charts and Schedules

a. Provide each valve with a 2-inch diameter 18 gauge brass tag with brass chain. Service designation shall be 1/4-inch high and valve number shall be 1/2-inch high, on two lines with service designation on the upper line, and valve number on the lower line. The characters shall be indented and filled with durable black compound.

b. Provide diagrammatic valve charts and schedules, using a valve numbering system that differentiates between classes of service and indicates floor level of valve location.

c. Tags shall conform to the numbers, locations, and uses listed in the valve charts and schedules.

d. Valve charts and schedules shall be mounted under glass in wood frames or aluminum self-closing frames.

e. Tags and the frames for valve charts and schedules shall be manufactured by Seton Name Plate Corp., or approved equal.

B. Access Doors

Provide a complete list of all access doors required in finished walls, ceilings, partitions and any other areas for access to all valves concealed behind such finished construction. Access doors will be furnished and installed under other Sections.

2.04 PIPE HANGERS AND SUPPORTS

A. Design, fabricate and provide all pipe hangers and supports adequate to support and guide the piping, allow for forces imposed by expansion joints, satisfy structural requirements and maintain proper clearances with respect to adjacent piping, equipment and structures.

B. Hangers and supports shall include guides, anchors, stops, restraints, welded attachments, insulation shields, saddle strands, stays, braces, bolts, nuts, washers, expansion bolts, pipe clamps, beam clamps, and supplementary structural steel for pipe hangers and supports.

C. Keep the different types of hangers to a minimum. Provide clevis type hangers for sizes 3 inches and above.

D. Suspend hangers from beam clamps, brackets, fish plates, inserts or other approved means. Furnish and install any additional miscellaneous steel supports between building framing members as may be required. The installation of "C" clamps on beams must include retaining straps to prevent separation of beam and clamp.

E. Copper plate all hangers that will be in direct contact with brass or copper tubing.

F. Support vertical piping with steel riser clamps. Additional intermediate support brackets, secured to the structure, shall be installed on piping utilizing gasket or coupling joints in accordance with the manufacturer's recommendations.

G. Trapeze type hangers of steel construction, with hold-down U-bolts, may be used for two or more pipes which have a uniform slope throughout.

H. Base hanger loads on weight of pipe supported, weight of insulation covering and weight of fluid being transported.

I. When loads between supports can be expected to cause a sag in the pipe in excess of 1/4 inch, reduce spacing as necessary to stay within such a limit.

J. Provide and install on all supporting rods, a forged steel turnbuckle with top and bottom lockouts having a vertical adjustment of 6 inches, minimum.

K. All pipe hangers, rods, supports, insulation shields, clamps, and other associated components shall be galvanized.

L. Do not hang piping from other piping and ductwork, except for small water branches in pipe enclosures behind toilet rooms or as approved by the Engineer.

M. Vertical pipes shall be supported on every floor and at intervals between floors so that no more than 10 feet of pipe is unsupported.

N. Provide protection shields for all insulated piping at all points of support. Shields shall be 12 inches long, galvanized steel plate with a radius suitable for the required applications, including insulation.

O. Tabs in metal deck construction shall not be used to support pipe or equipment.

P. Provide pipe anchors where necessary to restrain forces due to thermal expansion and contraction of pipe.

Q. Anchors shall be adequately designed to rigidly oppose forces acting on them and shall be embedded in structural concrete or connected to the building structural steel framework.

R. Provide pipe guides where necessary to confine movement along the centerline of the pipe due to thermal expansion and contraction between anchors. Guides shall be adequately designed and placed, generally between 20 to 30 feet on centers and an equal distance from the expansion loop.

S. Expansion anchors, self-drilling expansion shields, power driven studs and similar devices shall not be used, unless specifically approved by the Engineer.

T. Unless otherwise specifically approved, hanger rod size and spacing shall be within the following limits:

1. Steel Pipe

Pipe Size	Maximum Hanger Spacing	Minimum Rod Size
1/2" to 1"	8 ft. o.c.	3/8"
1-1/4" to 2"	10 ft. o.c.	3/8"
2-1/2" to 3-1/2"	12 ft. o.c.	1/2"
4" and 5"	12 ft. o.c.	5/8"
6"	12 ft. o.c.	3/4"
8"	12 ft. o.c.	7/8"
10" and 12"	12 ft. o.c.	7/8"

2. Copper Tube

Pipe Size	Maximum Hanger Spacing	Minimum Rod Size
1/2" to 1-1/4"	6 ft. o.c.	3/8"
1-1/2" and 2"	8 ft. o.c.	3/8"
2-1/2" to 3-1/2"	10 ft. o.c.	5/8"

3. Cast Iron Soil Pipe (No-Hub)

Supports for horizontal or vertical no-hub pipe shall be on each side of every stainless steel coupling except for spaces behind toilet rooms or where many fittings are installed at one location. At these points, support every 5'-0" o.c. and on as many fittings as necessary so that no more than one fitting shall be without a hanger in any 5'-0" space. Rod size shall be the same as for steel pipe above for corresponding pipe size.

4. Cast Iron Soil Pipe (Hub and Spigot)

a. Support vertical piping at base and at each story height but in no case at intervals greater than 20 feet.

b. Support horizontal piping at 5-foot intervals and behind every hub except for spaces behind toilet rooms or where many fittings are installed at one location. At these points, support every 5'-0" o.c. and on as many fittings as necessary so that no more than one fitting shall be without a hanger in any 5'-0" space. Rod size shall be the same as for steel pipe above for corresponding pipe size.

5. Base of Cast Iron Stacks

Bases of cast iron stacks shall be supported on concrete, on brick laid in cement mortar, by metal bracket attached to the building construction, or by equivalent methods. All stacks shall be anchored so as to relieve the load from the base of the stack.

U. Hangers and supports shall be manufactured by Grinnell Corp., Carpenter & Patterson Inc., Michigan Hanger Co. Inc., or approved equal.

2.05 SLEEVES, SEALS, AND ESCUTCHEONS

A. Pipe Penetration through Walls, Partitions and Floors

1. Piping passing through masonry or concrete walls and framed partitions shall have a trim opening cut no greater than necessary for the installation of a sleeve secured therein. Sleeve shall be 1/2 inch in diameter larger than the diameter of the insulated pipe. Sleeve shall be flush with the finished wall or partition surface.

2. Sleeves through concrete floors for piping shall have the opening 1/2 inch in diameter larger than the diameter of the insulated pipe passing through. Floor sleeves shall project one inch above floor slab.

3. Pipe insulation shall be omitted at penetrations through fire-rated barriers. In all cases pack the annular space between the pipe (whether insulated or uninsulated) and sleeve with mineral wool. Additionally, at penetrations through fire-rated barriers seal the annular space to retain the fire integrity of the fire-rated barrier with nonhardening through-penetration firestops having F-ratings, compatible with the fire ratings of the barriers in which they are installed, per ASTM E 814. Firestop systems shall be UL-approved, and shall be as manufactured by 3M, Bio Fireshield, Inc., General Electric Company, Dow Corning Corporation, or approved equal.

4. Sleeves in walls and floors shall be galvanized steel pipe, Schedule 40 for sizes up to 10 inches and 3/8-inch wall thickness for 12 inches and larger. Sleeves in partitions shall be 20-gauge galvanized sheet metal.

5. Piping in exposed areas, passing through walls, floors or ceilings shall be fitted with chromium-plated cast brass escutcheons with fastening set screws.

6. Piping passing through floor waterproofing membrane shall be provided with a 4-pound lead flashing or a 16-ounce copper flashing, each within an integral skirt or flange. Flashing shall be suitably formed, and the skirt or flange shall extend not less than 8 inches from the pipe and shall be set over the floor membrane in a solid coating of bituminous cement. The flashing shall extend up the pipe a minimum of 10 inches above the floor. The annular space between the flashing and the pipe shall be sealed watertight.

7. Piping passing through roof construction shall be provided with counterflashing, consisting of steel rainhood secured all around the pipe and overlapping the flashing.

B. Pipe Penetration through Exterior Foundation and Pit Walls

1. General

a. All penetrations for piping through perimeter foundation walls and subgrade pit walls shall be provided with the pipe sleeves and seals as shown on the Contract Drawings.

b. Sleeves shall be Schedule 40 for sizes up to 10 inches and 3/8-inch wall thickness for sizes 12 inches and larger. All pipe sleeves shall be galvanized steel, set into foundation walls with anchors and water stop plates.

2. Lead-Oakum Seals

Where "Lead-Oakum" seal is shown on the Contract Drawing, the annular space between the pipe and the sleeve shall be made watertight by caulking with oakum and poured lead, edged and trimmed.

3. Interlocking Modular Seals (Link-Seal)

a. Where "Link Seal" is shown on the Contract Drawings, seal shall be modular mechanical type, consisting of interlocking sealing element links shaped to continuously fill the annular space between the pipe and the sleeve. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and nut. After the seal assembly is positioned in the sleeve, tightening of the bolts shall cause the sealing elements to expand and provide a watertight seal between the pipe and the sleeved opening. The seal shall provide electrical insulation between the pipe and wall.

b. The inside diameter of each wall sleeve shall be sized as recommended by the manufacturer to fit the pipe, seal, and any coating or insulation to ensure a watertight joint.

c. Install sleeves and seals in accordance with the seal manufacturer's instructions to provide a watertight installation.

d. Seals for perimeter foundation wall penetrations shall be two individual sealing units in tandem unless otherwise shown on the Contract Drawings. Single sealing unit shall be used for pit wall penetration unless otherwise shown on the Contract Drawings.

e. Seals shall be Thunderline Corp. "Link-Seal", or approved equal.

PART 3. EXECUTION

3.01 INSTALLATION

A. General

1. Install piping and appurtenances in accordance with manufacturers' installation procedures, applicable codes and standards, and as specified.

2. Coordinate piping installation with other Work to avoid interference. Coordinate as necessary to ensure that all hangers, supports, sleeves and other built-in devices are incorporated in forms or in masonry to avoid necessity of cutting finished structure.

3. All measurements, both horizontal and vertical, shall be based on established benchmarks. All Work shall agree with these established lines and levels. Verify all measurements at site and check the correctness of same as related to the Work.

4. Perform necessary cutting and patching in accordance with requirements specified in Division 2 Section entitled "CUTTING, PATCHING AND REMOVAL". All openings in existing slabs required for pipe penetrations shall be core drilled.

5. Installation requirements for pipe hangers and supports and pipe penetration sleeves, seals, and escutcheons are specified in 2.04 and 2.05, respectively.

B. Piping

1. Install piping as shown on the Contract Drawings and straight and direct as possible, forming right angles or parallel lines with building walls, neatly spaced, with risers plumb and true.

2. Piping shall pitch back toward system drain valve and any installed low points or pockets shall have a hose end drain valve.

3. Avoid tool marks and unnecessary pipe threads. Burrs formed when cutting pipe shall be removed by reaming. Before installing pipe, thoroughly clean the inside, free of cuttings and foreign matter. Cut all piping square and smooth and make up all joints to required limits.

4. Erect all piping to obtain sufficient flexibility to prevent excessive stresses in materials and excessive bending moments at joints or connections.

5. Make changes in pipe size by the use of reducing fittings. Do not use reducing bushings except by approval of the Engineer. Do not use close or shoulder nipples.

6. Arrange water piping so that system can be completely drained. Where lines are purposely pitched for drainage, a uniform grade shall be maintained. Lines shall be so supported as to prevent pocketing of water. No lines shall have pockets due to changes in elevation unless proper provisions for draining are made.

7. Installed piping shall not interfere with the operation or accessibility of doors and windows; shall not encroach on aisles, passageways and equipment; and shall not interfere with the servicing or maintenance of any equipment. Adjacent pipelines shall be grouped in the same horizontal or vertical plane.

C. Pipe Joints

1. Threaded Joints

   Make up threaded joints tight using pipe joint Teflon compound or tape, applied on the male thread only.

2. Flanged Joints

   Make up flanged joints square and tight with gaskets. Dip bolts and nuts in mixture of graphite and oil immediately prior to installation.

3. Soldered Joints

   a. Cut ends of tubing square and remove all burrs. Clean inside and outside of tubing with steel wool.

   b. Make joints with non-corrosive paste flux and 95 per cent tin and 5 per cent antimony solder. Cored or lead-containing solder is not permitted.

   c. Remove excess solder while still in plastic state.

   d. Leave a fillet at the wall of the fitting.

   e. Prior to silver soldering, remove the internal parts of all valves or other devices to be installed directly in line.

4. Caulked Joints

   For cast iron pipe with hub, pack hub firmly with hemp or picked oakum and fill with molten lead, using a minimum of twelve ounces of lead for each inch of pipe size per joint and to a one-inch minimum depth. After the lead has cooled, the joints shall be thoroughly caulked, using approved caulking irons, faced smooth and made tight without the use of putty, paint or cement.

5. Compression Joints

   Make compression joint with ASTM C564 neoprene rubber gaskets and lubricant. Gaskets shall match class of pipe and fittings. Make joints in accordance with recommendations of CISPI.

6. Cast Iron No-Hub Joints

No-hub cast iron pipe joint shall be of a coupling type. Each joint shall consist of 2 spigot ends of pipe or fitting, and a sealing sleeve assembly, consisting of a stainless steel shield over a neoprene gasket, held together by stainless steel clamps. The gasket shall be slid over the ends of the two pipes to be joined, then the shield and clamps shall be placed over the gasket. The entire coupling shall be held firmly together by the clamps, by alternately turning the screws to 100-115 in.-lb. torque. Couplings shall be "Clamp-All" type manufactured by Clamp-All Corp., or Husky SD Series 4000 type manufactured by Anaheim Foundry Company, or approved equal.

3.02 FIELD TESTS

A. General

1. Perform tests as herein specified on the various piping systems or portions thereof prior to backfilling, painting, concealing or insulating.
2. Notify the Engineer and those authorities having jurisdiction, at least 48 hours in advance of making the required tests, so that arrangements may be made for their presence to witness the tests.
3. Provide and install all equipment and devices required in connection with tests. Provide all necessary materials, supplies, labor and power for the tests.
4. Should the tests reveal any leaks or deficiencies in piping installed under this Section, make the necessary repairs immediately, or, if required by the Engineer, replace defective work with new work without additional cost to the Authority. Repeat tests as directed until the entire installation is proven satisfactory. No temporary method of repairing leaks will be permitted.
5. Where piping installed under this Section is connected to any existing system, such installed piping shall be isolated from the existing system during the performance of the required field tests, unless otherwise directed by the Engineer.
6. The Engineer reserves the right to direct the Contractor not to isolate the newly-installed piping from the existing system during the performance of the required field tests. In such event, the Contractor shall correct any revealed leaks or other deficiencies within the first 20 feet of the existing system, measured in any direction from the point of connection with the newly installed piping, all as directed by the Engineer and at no additional cost to the Authority.
7. Dispose of water removed from pipelines in a manner that will not cause damage to any property.
8. Provide and install the required air vents in the piping system tested.
9. All equipment, including water coolers, and all controls and instruments shall be isolated from the piping system during test, as well as during cleaning, disinfecting and flushing procedures.

B. Hydrostatic Tests

1. Storm and Sanitary Drainage and Vent

a. Tightly close all openings in the entire system and fill it with water to the point of overflow above the roof. The water level shall be maintained for one hour.

b. When piping is tested in sections, test piping with a pressure equivalent to a 10-foot water head. The water level shall be maintained for one hour.

c. For piping added, relocated or replaced on existing systems, install a test tee at the lowest elevation of each added, relocated or replaced piece of pipe and fill it with water to overflow level of next highest fixture outlet or drain. The water level shall be maintained for one hour.

2. Domestic Water

a. Cap or plug all outlets, apply a hydrostatic pressure of 125 psi and sustain such pressure for one hour.

b. For piping added, relocated or replaced on existing systems, apply a hydrostatic pressure of 50 psi above the existing system pressure for one hour.

C. Cleaning and Disinfecting

The potable water system shall be disinfected prior to use by a method of disinfection in accordance with the applicable code.

3.03 PAINTING

Upon completion of the installation, remove all protecting materials, thoroughly remove all scale and grease and leave in a clean condition for painting. Piping to be painted shall be as shown on the Contract Drawings. Painting shall be in accordance with the requirements of Division 9 Section entitled "PAINTING".

3.04 PIPE AND VALVE IDENTIFICATION

A. Pipe Identification

Affix sets of pipe adhesive bands specified in 2.03 A.1 where they can be easily read, with their long dimension parallel to the axis of the pipe and no more than 40 feet apart on a piping system. At least one set of identifying bands shall be affixed in all occupied and unoccupied rooms as well as in all other spaces, such as hung ceilings or shafts, where piping may be viewed and the identity of the piping system cannot be readily ascertained. A set of such bands shall be affixed at each branch and riser takeoff; adjacent to each valve; at each pipe passage through floor and ceiling construction; at each capped line; and at each pipe passage to an underground area.

B. Valve Tags

Securely fasten valve tags specified in 2.03 A.2 with approved brass chain.

END OF SECTION

SECTION 15410

PLUMBING PIPING AND APPURTENANCES

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Piping Shop Drawings

   Shop and coordination drawings shall be double line at a minimum of 3/8"=1'-0" scale.

   a. Piping layout and installation drawings including, at a minimum, the following:

      (1) Plans, elevation, sections and riser diagram.

      (2) Hanger, support locations and details. Indicate methods of attachment to building structure.

      (3) Pipe elevations and dimensions from main piping runs to a reference point.

      (4) Penetrations through fire rated and other partitions.

      (5) Location for piping accessories, including valves and access doors.

   b. Piping coordination drawings showing plan views and sections, drawn to scale, on which all items are shown and coordinated with all Work of other Sections.

B. Product Data / Catalog Cuts

1. Catalog cuts, including product performance data, for all items furnished under this Contract, including the following at a minimum:

   a. Pipe, pipe fittings and flanges including piping materials and schedule for each piping system.

   b. Valves, including valve charts and schedules.

   c. Hangers and supports, including schedule showing manufacturer's figure number, size, location and features of each required hanger and support.

   d. Sleeves and escutcheons.

   e. Pipe and valve tags identification bands.

2. List of access doors and schedules.

C. Construction and Installation Procedures

1. Field hydrostatic test procedure.

D. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive information for the specific approved equipment; including approved shop drawings and catalog cuts, sequence of operation, test results, troubleshooting, maintenance requirements, spare parts lists, electrical/control devices and electrical/control wiring diagram(s).

E. Site Inspection Reports

1. Field hydrostatic test results.

END OF APPENDIX "A"

SECTION 15410

PLUMBING PIPING AND APPURTENANCES

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.01 A)	Piping requirements other than specified in the Schedule.
(2.02 A.1)	Types of valves (gate, globe, drain, check or ball).
(2.05 B.1.a)	Exterior foundation and pit wall penetration details.
(2.05 B.2)	"Lead-Oakum" seal.
(2.05 B.3.a)	"Link-Seal".
(2.05 B.3.d)	Tandem sealing and single sealing.
(3.03 B.1)	Piping layouts.
(3.03)	Piping to be painted under other Section(s) of the Specifications.

B. Other Items

1. Ensure that the Specifications include the following Section(s) referenced in this Section:

(3.01 A.4)	"CUTTING, PATCHING AND REMOVAL"
(3.03)	"PAINTING"

2. Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15430

PLUMBING SPECIALTIES

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for plumbing specialties.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below:

American National Standards Institute (ANSI)
American Society of Mechanical Engineers (ASME)
American Society of Sanitary Engineering (ASSE)
American Society for Testing and Materials (ASTM)
Plumbing and Drainage Institute (PDI)

In addition, specific provisions cited herein shall govern for the associated specific application.

1.03 QUALITY ASSURANCE

A. Plumbing specialties of the types and sizes required shall have performed satisfactorily for purposes similar to those intended herein, for not less than three years.

B. Entities performing the work of this Section shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.04 DELIVERY, STORAGE, AND HANDLING

A. All specialties shall be factory-cleaned, wrapped and packaged in boxes prior to shipping to construction site.

B. Store specialties in clean, dry spaces and protect them from weather.

C. Prior to installation, inspect specialties for damage.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 DRAINS

A. General

1. Drains shall be of types and sizes shown on the Contract Drawings.
2. Special type drains other than those specified in 2.01 B and C below shall be provided as shown on the Contract Drawings.
3. Floor drains shall be provided with vandal proof grates in all areas except mechanical equipment rooms.
4. Drains shall be manufactured by Jay R. Smith Manufacturing Co., Josam Manufacturing Co., Zurn Industries Inc., Tyler Pipe Industries Inc./Wade Division, or approved equal.

B. Floor Drains

1. Toilet Rooms and Finished Areas

   Floor drains shall have cast iron body, with flashing collar, round top with nickel bronze adjustable strainer head; Jay R. Smith No. 2005-A or 2010-A, or approved equal.

2. Mechanical Equipment Rooms

   Floor drains shall have cast iron body, with flashing collar, round cast iron grate and slotted sediment bucket; Jay R. Smith No. 2230, or approved equal.

3. Drains receiving indirect waste shall be fitted with a cast iron funnel; Jay R. Smith No. 3581, or approved equal.

C. Roof Drains

1. Roof drains shall have cast iron body with adjustable extension sleeve, flashing collar and cast iron dome. Provide sump receiver and underdeck clamp for all roofs except poured-in place installations. Drain shall be Jay R. Smith No. 1015, or approved equal.
2. Install roof drains with 6-lb. lead flashing extending 12 inches beyond the outside diameter of the roof drain. Coordinate the installation with other affected Work.

2.02 VENT FLASHING COUPLINGS

A. Where shown on the Contract Drawings, provide cast iron, threaded (upper end) counterflashing sleeves; Jay R. Smith No. 1750, or approved equal.

B. Vents extending through roof shall be flashed watertight. Flashing shall be 6-lb. lead extending not less than 12 inches around the perimeter of the pipe, outside the barrel and terminate 12 inches above the roof with the vent flashing couplings specified above.

2.03 CLEANOUTS

A. Use "Y" (and "TY") fittings for cleanouts; full size "Y" for piping up to 4 inches and not less than 4-inch "Y" outlets for piping 5 inches and larger.

B. Provide cleanouts for storm and sanitary piping at bases of stacks, at changes in direction of horizontal piping, and at 50-foot intervals, minimum, on horizontal runs.

C. Floor cleanout deckplates shall be the following, or approved equal:

1. Unfinished areas: Jay R. Smith No. 4226.
2. Finished areas: Jay R. Smith No. 4026.
3. Tiled areas: Jay R. Smith No. 4146.
4. Carpeted areas: Jay R. Smith No. 4026-Y (with carpet marker).

D. Toilet room wall cleanouts shall be cast iron caulk ferrule and cast iron head seal plug with stainless steel cover and center screw; Jay R. Smith No. 4402, or approved equal.

E. Cleanouts at changes of direction of above-floor piping shall be cast iron caulk ferrule with straight threaded, tapered bronze plug; Jay R. Smith No. 4420, or approved equal.

F. All cleanout plugs shall be lubricated with graphite before installation.

G. Cleanouts shall be manufactured by Jay R. Smith Manufacturing Co., Josam Manufacturing Co., Zurn Industries Inc., Tyler Pipe Industries Inc./Wade Division, or approved equal.

2.04 FRESH AIR INLETS

A. Where shown on the Contract Drawings, provide fresh air inlets of perforated wall plate with pipe expander type securing device and spanner type tamperproof locking device; Jay R. Smith No. 9005, or approved equal.

B. Finish of plate shall be polished bronze, unless otherwise shown on the Contract Drawings.

2.05 DOMESTIC WATER METERS

Provide water meter(s) of the type and size(s) shown on the Contract Drawings. The meter shall be set horizontally, dial facing upward not more than three feet above floor, properly supported, and installed in accordance with the regulations of the local municipal water company.

2.06 STRAINERS

Where shown on the Contract Drawings, provide strainers of "Y" type with tapped blowdown connections, 150 psi w.w.p., bronze body, and bronze screens. Strainers shall be manufactured by Spirax Sarco Inc., Mueller Steam Specialty Co./MUESSCO, or approved equal.

2.07 GAUGES

A. Provide pressure gauges on water main, at pressure reducing valve assemblies and at other locations shown on the Contract Drawings.

B. Gauges shall be of bronze bourdon tube material, with 4-1/2-inch dial face and aluminum case and shall have a range of 160 psi with an accuracy of 0.5 percent of the scale range. Each gauge shall be provided with a snubber and cock. Pressure gauges shall be Weiss Instruments Inc. "Series UG-1", or approved equal.

2.08 THERMOMETERS

A. Provide thermometers on inlets and outlets of water heaters and circulating pumps, and where shown on the Contract Drawings.

B. Thermometers shall be of "red reading" Mercury, industrial glass type with V-shaped cast aluminum case, adjustable angle face, and stainless steel extension necks to suit insulation thickness, having a 9-inch long scale and a temperature range of 20 degrees F to 180 degrees F with an accuracy of one per cent of the scale range. Thermometers shall be provided with immersion bulb and separable socket. Thermometers shall be Weiss "Vari-Angle Industrial Thermometers", or approved equal.

2.09 AIR CHAMBERS

A. Provide full pipe size, 12-inch high air chambers at each plumbing fixture domestic water supply connection.

B. Provide full pipe size, 24-inch high air chambers at the top of each domestic water riser.

2.10 WATER HAMMER ARRESTORS

A. Provide water hammer arrestors adjacent to all equipment where quick-closing valves are provided and at other locations shown on the Contract Drawings.

B. Sizes and installation procedures of water hammer arrestors shall be in accordance with PDI Standards.

C. Water hammer arrestors shall be Jay R. Smith "Series 5000", or approved equal.

2.11 AIR RELIEF VALVES

A. Provide automatic air relief valves at high points in hot water piping and where shown on the Contract Drawings, with 3/4 inch threaded inlet; class 150 cast iron body and cap; valve, float, leverage and valve seat and compressed non-asbestos gasket. Pipe drain from relief valves shall spill over to adjacent floor drain, mop sink, or as shown on the Contract Drawings.

B. Relief valves shall be Taco Air Vent, Model 409, or approved equal.

2.12 NON-FREEZE WALL HYDRANTS

Where shown on the Contract Drawings, provide non-freeze wall hydrants, key operated with 3/4-inch, threaded inlets. Hydrant shall be all-bronze nickel-plated with hose connection, integral vacuum breaker, and stainless steel box with full 180 deg door opening, nickel-bronze face. Hydrants shall be Jay R. Smith No. 5509 QT, or approved equal.

2.13 HOSE BIBBS

Where shown on the Contract Drawings, provide Woodford Manufacturing Co. Model 24 C hose bibbs, or approved equal. Finish shall be rough brass in mechanical or non-finished spaces, and polished chrome-plated in all finished areas. Provide matching finish vacuum breakers at each hose bibb.

2.14 VACUUM BREAKERS

Vacuum breakers shall be bronze body, chrome-plated Watts Regulator Co. Model No. 288A-C, or approved equal. Check valve shall be provided at the outlet side of vacuum breaker.

2.15 BACKFLOW PREVENTERS

A. Where shown on the Contract Drawings, provide backflow preventers to prevent the backflow of contaminated water into the potable water supply. Each backflow preventer shall be a complete assembly, including tight-closing shutoff valves before and after the device, and shall be protected by a strainer. The design shall include test cocks and a pressure-differential relief valve located between two positive seating check valves. The device shall meet the requirements of ASSE Standards.

B. Backflow preventers shall be of a size shown on the Contract Drawings and shall be CMB Industries/FEBCO Division Model No. 825, Watts Regulator Co. Model No. 909, or approved equal.

2.16 DIELECTRIC FITTINGS

Connections between ferrous and non-ferrous pipe or equipment connections shall be made using isolating union or flange joints as manufactured by Watts Regulator Company, Series 3000, or approved equal.

PART 3. EXECUTION

3.01 INSTALLATION

Install plumbing specialties in accordance with the manufacturers' installation instructions.

3.02 PROTECTION

Upon completion of the installation, remove all protective materials and thoroughly clean all specialties to the satisfaction of the Engineer.

END OF SECTION

SECTION 15430

PLUMBING SPECIALTIES

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Product Data / Catalog Cuts

1. Plumbing Specialties

a. Catalog cuts, including product performance data, dimensions, components, weights and assembly details, for each item furnished under this Contract, including the following at a minimum:

(1) Drain, floor and roof.

(2) Vent flashing coupling.

(3) Cleanouts.

(4) Fresh air inlets.

(5) Domestic water meters.

(6) Backflow prevention devices.

(7) Strainers.

(8) Gauges.

(9) Thermometers.

(10) Air chambers.

(11) Water hammers arrestors.

(12) Air relief valves.

(13) Non-freeze wall hydrants.

(14) Hose bibs.

(15) Vacuum breakers.

(16) Dielectric fittings.

B. Construction and Installation Procedures

1. Field test procedure.

C. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive information for the specific approved equipment; including approved shop drawings and catalog cuts, sequence of operation, test results, troubleshooting, maintenance requirements, spare parts lists, electrical/control devices and electrical/control wiring diagram(s).

D. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15430

PLUMBING SPECIALTIES

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.01 A.1)	Types and sizes of floor and roof drains.
(2.01 A.2)	Special types of floor and roof drains other than those specified.
(2.02 A)	Vent flashing couplings.
(2.04 A)	Fresh air inlets.
(2.04 B)	Fresh air inlet wall plate finish if other than polished bronze.
(2.05)	Domestic water meter type and size(s).
(2.06)	Strainers.
(2.07 A)	Pressure gauges if other than at the water main and pressure reducing valve assembly.
(2.08 A)	Thermometers if other than at inlets and outlets of water heaters and pumps.
(2.10A)	Water hammer arrestors if other than at equipment with quick-closing valves.
(2.11 A)	Relief valve locations if other than at high points in hot water piping and pipe drain spill-over locations if other than to floor drain or mop sink.
(2.12)	Non-freeze wall hydrants.
(2.13)	Hose bibs.
(2.15 A)	Locations of backflow preventers.
(2.15 B)	Sizes of backflow preventers.

B. Other Items

Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15440

PLUMBING FIXTURES

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies requirements for plumbing fixtures.

B. Types of plumbing fixtures specified in this Section are:

1. Water Closets (WC).
2. Water Closets for Disabled (HC WC).
3. Urinals (UR).
4. Urinals for Disabled (HC UR).
5. Lavatories (LAV).
6. Lavatories for Disabled (HC LAV).
7. Counter Top Lavatories.
8. Service Sinks (SS).
9. Mop Receptors (MR).
10. Sinks (SK).
11. Electric Water Coolers (EWC).
12. Electric Water Coolers for Disabled (HC EWC).
13. Showers (SHR).
14. Jail Cell Fixtures.
15. Stainless Steel plumbing fixtures.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

Federal Specifications

New York City Building Code

New Jersey Uniform Construction code

American National Standards Institute (ANSI)

Air Conditioning and Refrigeration Institute (ARI)

American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)

American Society of Sanitary Engineers (ASSE)

American Society for Testing and Materials (ASTM)

American Society of Mechanical Engineers (ASME)

Underwriters Laboratories Inc. (UL)

National Electrical Code (NEC)

In addition, specific provisions cited herein shall govern for the associated specific application.

1.03 QUALITY ASSURANCE

A. Plumbing fixtures, of types, styles and configurations required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Entities performing the work of this Section shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver plumbing fixtures individually wrapped in factory-fabricated containers.

B. Handle plumbing fixtures carefully to prevent breakage and chipping and scoring of fixture finish.

C. Store plumbing fixtures in a dry location, and preferably on elevated platforms.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, furnish and install plumbing fixtures of one of the following manufacturers, or an approved equal:

A. Plumbing Fixtures and Trim (WC, HC WC, UR, HC UR, LAV, HC LAV, SS, Counter Top Lavatories)

American Standard Inc./US Plumbing Products
Crane Plumbing
Eljer
Kohler Co.

B. Plumbing Trim (Brassware)

American Standard Inc.
Chicago Faucet Co.
Delta Faucet Co., Div. of Masco Corp.
Moen Group; Stanadyne Corp.

C. Flush Valves

Coyne & Delany Co.
Sloan Valve Co.

D. Fixture Seats

Sperzel Industries Inc.
Sanderson Plumbing Product Inc./Beneke Div.
Olsonite Corp.

E. Electric Water Coolers

Elkay Manufacturing Co.
Halsey Taylor
Haws Drinking Faucet Co.
Sunroc Corp.

F. Service Sinks

Kohler Co.
Elkay Manufacturing Co.
American Standard Inc.
Crane Plumbing
Stern-Williams Co., Inc.

G. Sinks

Acorn Engineering Co.
American Standard Inc.
Elkay Manufacturing Co.
Just Manufacturing Co.

H. Mop and Shower Receptors

Stern-Williams Co. Inc.
Crane Plumbing

I. Showers and Trim

American Standard Inc.
Bradley Corp.
Kohler Co.
Leonard Valve Co.
Moen Group; Stanadyne Corp.
Powers Process Controls

J. Fixture Supports

J.R. Smith Manufacturing Co.
Josam Co.
Tyler Pipe/Wade Div.
Zurn Industries Inc./Hydromechanics Div.

K. Jail Cell Fixtures

Acorn Engineering Co.
Bradley Corp.

2.02 MATERIALS

A. Exposed surfaces which exhibit pitting, seam marks, roller marks, foundry sand holes, stains, discoloration or other surface imperfections on finished fixtures shall not be used.

B. Where fitting, trim and accessories are exposed or semi-exposed, provide bright chrome-plated fixtures. Provide copper or brass where not exposed. All exposed piping, fittings, valves, stops, traps, escutcheons, washers, nuts, etc. shall be chromium-plated with polish finish. All exposed aerators, nuts, bolts, trim, handles, etc., installed on any fixture for use by the general public, shall be made vandalproof.

C. Stainless steel sheets shall conform to ASTM A 167, for type specified in 2.03 and shall be of hardest workable temper.

D. Vitreous china shall be high quality, free from fire cracks, spots, blisters, pinholes and specks. Glaze exposed surfaces, and test for crazing resistance in accordance with ASTM C 554.

E. Fiberglass shall conform to ANSI Z 124.2, smooth surfaced, with color selected by the Engineer.

2.03 CONSTRUCTION FEATURES

A. General

1. Provide factory-fabricated fixtures of types and styles shown on the Contract Drawings. For each type fixture, provide fixture manufacturer's trim, carrier, seats, valves, etc., as required for complete unit. All fixtures of the same type shall be furnished by the same manufacturer.

2. Unless otherwise specified herein, comply with applicable Federal Specification WW-P-541 Series sections pertaining to plumbing fixtures, fittings, trim metals and finishes. Comply with requirements of WW-P-541 Series relative to quality of ware, glazing, enamel, composition and finish of metals, air gaps, and vacuum breakers, even though some plumbing fixtures specified in this Section are not specified in WW-P-541 Series.

3. Plumbing Fixtures shown on Contract Drawings and specified herein are based on specific descriptions, manufacturers, and model numbers. Other manufacturers of these products will be considered acceptable if approved as equal by the Engineer.

B. Water Closets (WC)

Kohler K-4330 "Kingston Lite" white vitreous china, 1.5 gallon flush, elongated bowl, wall hung, siphon jet flushing, 1-1/2-inch top spud; K-4670, white collar, "LUSTRA" solid plastic seat, with open front with concealed stainless steel check hinge. Connect with exposed Sloan Royal No. 111 low consumption (LC), quiet action, chrome, water conserving flush valve complete with non-hold-open, nickel-silver handle, screw driver angle stop with protecting cap, vacuum breaker, 1-1/2-inch outlet spud coupling with flange and cast brass wall escutcheon with set screw. Adjustable closet fitting and support shall be floor-bolted, block base type.

C. Water Closets for Disabled (HC WC)

Same as specified in 2.03 B above except that the rim height shall be set at 19 inches above finished floor.

D. Urinals (UR)

Kohler K-4960-T "Bardon Lite", white vitreous china washout urinal, less than 1 gpf, with extended shields, integral flush spreader, 3/4 inch top spud, outlet connection threaded 2 inches inside with bolts, washers, hangers and removable beehive strainer. Connect with exposed Sloan Royal No. 186-1, low consumption (LC), quiet action, chrome, water conserving flush valve, complete with screw drive angle stop with protecting cap, vacuum breaker, non-hold-open, nickel-silver handle, 3/4 inch outlet spud coupling with flange and cast brass wall escutcheon with set screw. Supports shall be floor-bolted, block base type.

E. Urinals for Disabled (HC UR) (or Juvenile)

Kohler K-5024-T "Darfield-Lite", white vitreous china washout urinal, less than 1 gpf, elongated lip, 3/4 inch top spud, 1-1/2 inch outlet, wall hanger, removable strainer, tailpiece, K-9200 "P" trap, and fitted with flush valve as specified in 2.03 D above.

F. Lavatories (LAV)

Kohler K-2054 "Jamestown", 20 inch by 18 inch, white vitreous china, front overflow lavatory, drilled for concealed carrier arms; pair K-7622 1/4 inch threaded offset tailpieces; pair K-7601 3/8 inch threaded supplies with loose key angle stops, reducers and cast brass escutcheons with set screws; K-9010, 1-1/4-inch by 1-1/2-inch cast brass "P" trap with cleanout, slip inlet, threaded outlet; K-9015 1-1/2 inch by 6 inch trap nipple, and cast brass escutcheon with set screw; K-7715 drain assembly with perforated strainer. Faucet shall be Delta Model 501 lever handle chrome faucet, less lift rod and waste and fitted with a vandalproof flow regulator spout aerator, limiting the flow to a maximum of 1/2 gpm. Support shall be floor-bolted, block base type.

G. Lavatories for Disabled (HC LAV)

Kohler K-2054 "Jamestown" (20-inch by 18-inch) or Kohler K-12636 "Morningside" (20 inch by 27 inch), white vitreous china, as shown on the Contract Drawings; front overflow lavatory, drilled for concealed carrier arms; K-13885 drain plug assembly with integral perforated grid; pair K-7622 1/4 inch threaded offset tailpieces; pair K-13711 3/8-inch threaded extended supplies with loose key angle stops, reducers and cast brass escutcheons with set screws; K-9010, 1-1/4 inch by 1-1/2 inch cast brass "P" trap with cleanout, slip inlet, threaded outlet; K-9015 1-1/2 inch by 6 inch trap nipple, and cast brass escutcheon with set screw. Faucet shall be gooseneck, chromed, K-13358 with 4 inch handles, 3/4 gpm flow regulated spout aerator and 1/2 inch threaded inlets and coupling nuts on 4 inch centers. Support shall be floor-bolted, block base type.

H. Counter Top Lavatories

Kohler K-2195 "Pennington", 20-inch by 17-inch, white vitreous china, front overflow, self-rimming; pair K-7622 1/4-inch threaded offset tailpieces; pair K-7601 3/8-inch threaded supplies with loose key angle stops, reducers and cast brass escutcheons with set screws; K-9010 1-1/4-inch by 1-1/2-inch cast brass "P" trap with cleanout, slip inlet, threaded outlet; K-9015 1-1/2-inch by 6-inch trap nipple, and cast brass escutcheon with set screw; K-7715 drain assembly with perforated strainer. Faucet shall be Delta Model 501, lever handle chrome faucet, less lift rod and waste and fitted with a vandalproof flow regulator spout aerator, limiting the flow to a maximum of 1/2 gpm.

I. Service Sinks (SS)

Kohler K-6718 "Bannon", 22 inch by 18 inch, enameled cast iron, plain back, wall hanger; K-8936 stainless steel rim guard; K-6673 "P" trap, standard with strainer; K-8904 wall-mounted chrome faucet with loose key stops in shank and vacuum breaker.

J. Mop Receptors (MR)

Precast terrazzo receptor shall be Elfin by Stern-Williams, or approved equal, with 3 inch, integrally cast, chrome-plated brass drain connection, 6-inch high by 36 inch by 24 inch (unless otherwise shown on the Contract Drawings) made of marble chips cast in gray portland cement to produce a minimum compressive strength of 3,000 psi at 28 days. Exposed edges and tops of curbs shall be fitted with 18 gauge, integrally cast, Type 302 stainless steel guard. The supply fitting shall be Kohler K-8904 wall-mounted chrome faucet with loose key stops in shank and vacuum breaker.

K. Sinks (SK)

Elkay "Lustertone", size and model as shown on the Contract Drawings, 18 gauge, Type 302 stainless steel, self-rimming counter top sink. Sink shall be fitted with Elkay LK-4100 faucet, LK-35 crumb cup strainer, "P" trap and loose key angle stops.

L. Electric Water Coolers (EWC)

Elkay Model EWA-8, surface-mounted, having a cooling capacity of 8.9 gallons per hour from 80 degrees F inlet water to 50 degrees F drinking water at room temperature of 90 degrees F. Water coolers shall comply with requirements of UL 399, ARI Standard 1010, and ASHRAE Standard 18.

M. Electric Water Coolers for Disabled (HC EWC)

Elkay Model EHFSA-8, surface-mounted, wheel chair level model, having a cooling capacity of 8 gallons per hour from 80 degrees F inlet water to 50 degrees F drinking water at room temperature of 90 degrees F.

N. Showers (SHR)

Shower floor receptor shall be precast terrazzo 36-inch by 36- inch with 2 inch brass, integrally cast drain connection and stainless steel strainer plate. Receptor shall be Stern-Williams "Trieste" Model 54. Terrazzo shall be made of black and white marble chips cast in white portland cement to produce a compressive strength of not less than 3000 psi at 28 days. The shower shall be fitted with a Powers P902H-J-1 shower unit, with pressure-balancing mixing valve, integral service stops and 2 gpm flow restrictor in shower head.

O. Jail Cell Fixtures

Acorn Model 1420 Lav/Toilet combination fixture, angled or offset as shown on the Contract Drawings, fabricated from 14 gauge Type 304 stainless steel, integrally reinforced. Construction shall be seamless welded, and exposed surfaces shall have a satin finish. It shall include, but not be limited to a lavatory bowl in a rectangle countertop, cabinet, toilet bowl, integral seat, trap and trap enclosure. Countertop shall be a minimum 12-inch by 20-inch with integral rectangular lavatory and an air-circulating self-draining dish. Toilet shall be blowout jet type, with an elongated bowl, a self-draining crevice-free flushing rim, and an integral contoured seat with a sanitary high polish finish. Toilet trap shall be capable of passing a 2-5/8-inch diameter ball, and shall be fully enclosed. Cabinet interior shall be sound-deadened with a vermin-proof and fire-resistant material. Fixture shall be capable of withstanding a load of 5,000 pounds without permanent damage. Provide the following with the fixture:

1. Acorn Penal-Trol single temperature lavatory valve (Acorn Option 01);
2. Acorn standard fast lavatory drain, with integral P-trap (Acorn PT) and a thru-wall extension with cleanout (Acorn LW2);
3. Fully-recessed toilet tissue holder (Acorn PH);
4. Acorn flush valve (Acorn FV) with push-button mounted backsplash. Valve shall be complete with vacuum breaker and push button. All exposed parts shall be chrome-plated. Provide a brass thru-wall flushing connection (Acorn FVT);

5. Acorn standard gasketed waste (Acorn GW) plus a yoke assembly to connect to a 3 -inch or 4-inch no-hub waste line (Acorn YA3 or YA4, respectively) as indicated on Contract Drawings.

P. Stainless Steel Plumbing Fixtures

1. Water Closets

Acorn Model No. 2105, wall hung, top supply toilet, siphon jet type, made with Type 304 stainless steel, elongated bowl, Acorn HS hinged white plastic seat, Acorn FV flush valve with vacuum breaker. Toilet shall be seamless welded, and exposed surfaces shall have a satin finish. Toilet trap shall pass 2-5/8-inch diameter ball and be fully enclosed. Toilet waste outlet shall be gasketed waste. Adjustable closet fitting and support shall be floor-bolted, block base type.

2. Urinals

Acorn Model No. 2167, wall hung, Type 304 stainless steel urinal. Top supply washout type, Acorn FV flush valve with a vacuum breaker and push button, Acorn FVC stainless steel vandalproof cover and "P" trap. Support shall be floor-bolted, block base type.

3. Lavatories

Acorn Model No. 1951, wall hung, 18-inch by 18-inch rectangular lavatory, with 14 inch by 12 inch by 6-inch deep bowl. Fixture shall be fabricated from Type 304 stainless steel. Construction shall be seamless welded, with satin-finish exterior. Lavatory deck shall have an integral air-circulating, self draining soap dish. Provide deck-mounted valve assembly (Acorn CSS), grid strainer (Acorn GT), chrome-plated brass supply with stop, "P" trap (Acorn TT). Manufacturer shall furnish a wall mounting bracket. Support shall be floor-bolted, block base type.

4. Drinking Fountains

Acorn Model No. 1670-1 front access drinking fountain, fabricated from Type 304 stainless steel. Construction shall be seamless welded, with satin-finish exterior. Cabinet bottom shall be removable and secured with tamper-resistant screws. Cabinet interior shall be sound-deadened with fire-resistant material. Fixture shall be furnished complete with bubbler, self-closing valve, a removable P-trap, a fast drain, and mounting hardware.

PART 3. EXECUTION

3.01 EXAMINATION

Examine roughing-in work of potable water and waste piping systems to verify actual locations of piping connections prior to installing fixtures; examine floors and substrates, and conditions under which fixture installation is to be accomplished. For electrical water coolers, coordinate field electrical wiring requirements specified in Division 16 Sections of the Specifications. Do not proceed with installation of fixtures until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install plumbing fixtures in locations shown on the Contract Drawings, in accordance with manufacturers' installation procedures.

B. Unless otherwise shown on the Contract Drawings, fixtures shall be installed at the following heights:

1. Water Closets (WC): Rim height shall be 15 inches above finished floor (AFF).
2. Water Closet for Disabled (HC WC): Rim height shall be 19 inches AFF.
3. Lavatories (LAV): Top of basin shall be 31 inches AFF.
4. Lavatories for Disabled (HC LAV): Bottom of apron shall be 29 inches AFF with 17 inches clear depth underneath. Install trap parallel with back wall. Insulate water supplies and trap.
5. Urinals (UR): Rim height shall be 24 inches AFF.
6. Urinals for the Disabled (HC UR): Rim height shall be 17 inches AFF with supply handle a maximum of 44 inches AFF.
7. Electric Water Coolers
   a. Electric Water Coolers (EWC): Rim height shall be 40 inches AFF.
   b. Electric Water Coolers for Disabled (HC EWC): Bottom of apron shall be 27 inches AFF with 17 inches clear depth underneath.
8. Shower: Bottom of shower head to floor shall be:
   a. 65 inches for male shower;
   b. 60 inches for female shower.
9. All other fixtures shall be installed in accordance with manufacturers' recommendations.

C. Grout or caulk area where fixture surfaces rest against wall or floor surfaces with Keene White Plaster or silicone caulking.

D. Fasten plumbing fixtures securely to supports or building structures. Ensure that fixtures are level and plumb. Secure supply lines behind or within wall construction so as to be rigid and not subject to pull or push movements.

E. Clean plumbing fixtures, trim and strainers of dirt and debris upon completion of installation.

F. Protect installed fixtures from damage during remainder of construction period.

3.03 FIELD TESTS

Upon completion of installation of fixtures and after the piping test specified in another Section of these Specifications is completed, operate the fixtures to demonstrate proper performance to the satisfaction of the Engineer.

3.04 ADJUSTMENTS

Adjust water pressure at drinking fountains, faucets, shower valves, and flush valves to assure proper performance in accordance with the manufacturers' recommendations and to the satisfaction of the Engineer.

END OF SECTION

SECTION 15440

PLUMBING FIXTURES

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Plumbing Fixtures Shop Drawings

   Shop and coordination drawings shall be double line at a minimum of 3/8"=1'-0" scale.

   a. Shop drawings indicating dimensions, roughing-in requirements, and method of assembly of components and anchorage, including the following at a minimum:

      (1) Plans, elevation and sections.

      (2) Anchorage locations and details. Indicate methods of attachment to building structure.

      (3) Location for plumbing fixtures accessories, including valves.

   b. Electrical wiring diagrams for electrical power supply.

   c. Coordination drawings showing plan views and sections, drawn to scale, on which all items are shown and coordinated with all Work of other Sections.

B. Product Data / Catalog Cuts

1. Plumbing Fixtures and Accessories

   a. Catalog cuts, including product performance data, for each item furnished under this Contract, including the following at a minimum:

      (1) Water closets.

      (2) Urinals.

      (3) Lavatories.

      (4) Counter top lavatories.

      (5) Service sinks.

      (6) Mop receptors.

      (7) Electric water coolers.

      (8) Showers.

      (9) Jail cell fixtures.

      (10) Stainless steel plumbing fixtures.

      (11) Electric water coolers.

(12) Drinking fountains and appurtenances.

C. Construction and Installation Procedures

1. Field test procedure.

D. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive information for the specific approved equipment; including approved shop drawings and catalog cuts, sequence of operation, test results, troubleshooting, maintenance requirements, spare parts lists, electrical/control devices and electrical/control wiring diagram(s).

E. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15440

PLUMBING FIXTURES

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.03 A.1)	Types and styles of fixtures.
(2.03 G)	Lavatories for disabled ("20 inch by 18 inch" or "20 inch by 27 inch" china).
(2.03 J)	Receptor size (other than specified).
(2.03 K)	Size and model number of sink.
(2.03 O)	Angled or offset Lav/Toilet combination fixture.
(2.03 O.5)	3-inch or 4-inch no-hub waste line.
(3.02 A)	Locations of plumbing fixtures.
(3.02 B)	Fixture mounting heights other than specified.

B. Other Items

Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15451

LIFT STATIONS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for lift stations.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

American National Standards Institute (ANSI)
American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)
American Society of Mechanical Engineers (ASME)
American Society for Testing and Materials (ASTM)
Hydraulic Institute (HI)
National Electrical Manufacturer's Association (NEMA)
National Electrical Code (NEC)
Sump and Sewage Pump Manufacturers Association (SSPMA)
Sheet Metal and Air-Conditioning Contractors National Association (SHACNA)
Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Design and performance requirements of Lift Station pumps shall be as specified in the Lift Station pump Schedules shown on Contract Drawings.

1.03 QUALITY ASSURANCE

A. Lift Station piping, appurtenances and pumps, of sizes and capacities required, shall be of a type and capacity satisfactorily used for purposes similar to those intended herein, for not less than three years.

B. Entities performing the Work of this Section shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver pumps and components in factory-fabricated protective packaging.

B. Handle pumps and components carefully to prevent breaking, denting and scoring.

C. Store pumps and components in clean, dry spaces and protect them from weather.

D. Comply with the manufacturer's rigging instructions for unloading pumps and moving them to final location for installation.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 PIPE, FITTINGS, AND FLANGES

A. Provide pipe, fittings and flanges in accordance with the "Pipe, Fittings and Flanges Schedule" below, unless otherwise shown on the Contract Drawings, including gaskets, bolts, nuts, washers and other pressure containing parts necessary for the complete installation of piping systems.

B. Nipples shall be extra-heavy shoulder-type. No close nipples shall be used.

C. Gaskets for flanges shall be 1/16-inch thick (after compression) rubber or neoprene, full-faced, and punched, bolt holes.

Pipe, Fittings and Flanges Schedule

Systems	Pipe	Fittings and Flanges
Pump Discharge	Galvanized Steel, ASTM A 53, Schedule 40	Galvanized Ductile Iron, ANSI B-16.5 150 Class, Flanged
Vent	Galvanized Steel, ASTM A 53, Schedule 40	Galvanized Malleable Iron, ANSI B16.3, 150 Class, Threaded

2.02 VALVES

A. General

Valves shall be of one of the following manufacturers, or approved equal:

Walworth Co
Crane Co.
Stockham Valves and Fittings
Nibco Valve Co.

B. Gate Valves

Gate valves shall be of the outside screw and yoke type and shall be capable of operating at a working pressure of 125 pounds per square inch. Valves shall have iron bodies, bonnets and yokes. Valves shall be provided with rising stems. The wedges shall be bronze-faced. Valves shall be of the flanged type and shall be Figure F-617-0, as manufactured by the Nibco Valve Co., or approved equal.

C. Check Valves

Check valves shall be iron body, swing check valves capable of operating at a working pressure of 125 pounds per square inch. They shall be bronze-faced and provided with renewable discs for cold water service. Valves shall be of the flanged type and shall be Fig. F-918, as manufactured by the Nibco Valve Company, or approved equal.

2.03 PUMPS

A. General

1. Pumps shall be of sizes, arrangements (simplex, duplex or triplex), service (sewage pump or sump pump), and capacities specified in the Schedules shown on the Contract Drawings.

2. Impellers shall be dynamically balanced, non-clog type. When utilized for sewage pumping service, impellers shall be capable of passing a minimum of 2-1/2 inch diameter solids. When utilized for sump pumping service, the pumps shall be provided with integral inlet strainers.

3. Pumps shall be of one of the following manufacturers, or approved equal:

   Weil Pump Co.
   Flygt Corp.
   Paco Pumps
   General Signal Corp./Aurora Pump

4. Pump materials shall be the following:

Casing:	Cast iron
Impellers:	Cast iron (high strength) or bronze
Shaft:	Stainless steel
Motor Cover (shell):	Cast iron
Slide Rail Guide Bars:	Galvanized steel
Strainers (Sump Pumps):	Cast iron or galvanized steel

B. Construction Features

1. Motors

   a. Provide each pump with submersible motor having electrical characteristics specified in the Schedules on the Contract Drawings.

   b. The motor shall be suitable for continuous duty and shall have built-in thermal overload protection.

c. Motor shall be of an air filled design. Oil filled motor shells will not be considered equal. Motor shall be housed in a watertight shell suitable for submersible conditions, and shall have Class F insulation.

d. Additional requirements for motors shall be in accordance with requirements specified in Division 15 Section entitled "MOTORS and MOTOR CONTROLLERS". Select the motor characteristics, the motor mountings and all accessories necessary to satisfy the requirements of the pump motor drive unit in all operating modes.

2. Removable Lift Type Pumps

a. If "Removable Lift" (Quick Removal) type pumps are specified in the Schedules on the Contract Drawings, the installation shall include additional appurtenances as described below.

b. The design shall be such that the pumps will be automatically connected to the discharge piping when lowered into place. The pumps shall be easily removable for inspection or service, requiring no bolts, nuts, or other fastenings to be removed for this purpose, nor shall they require personnel to enter the wet pit. The pumps shall be fitted with a stainless steel chain from each pump, of adequate strength and length to raise the pumps for inspection and removal.

c. The installation shall include a separate base plate, incorporating a stationary discharge elbow to receive the discharge when the pump is lowered into place. The receiving edge of the discharge elbow shall be fitted with a non-sparking material to prevent spark ignition during pump installation and removal.

d. Furnish and install two guide bars for each pump to permit raising and lowering. Guide bars shall be of 2-inch galvanized steel pipe of adequate length to extend from the lower guide holders mounted on the access frame.

e. Access cover shall be installed for each pump, complete with hinged and flush locking mechanism, upper guide holder and level sensor cable holder. Frame shall be provided with sliding nut rails to attach the accessories required. Lower guide bar holders shall be integral with the discharge connection. The guide bars shall not support any portion of the weight of the pumps. Doors shall be of skid proof design. Access covers shall be coordinated with the pumps and supplied by the pump manufacturer, with materials, sizes and numbers as noted on the Contract Drawings.

3. Control System

a. Provide a motor control panel in a single enclosure with a hinged door of NEMA enclosure type as shown on the Contract Drawings. Mount or install the panel where shown on the Contract Drawings.

b. For single pump installations, the control equipment shall consist of an automatic, heavy-duty, float switch to start and stop the ejector. The motor control panel shall contain a disconnect switch, magnetic motor starter with overload protection and "Hand-off-Automatic" selector switch.

c. For duplex or triplex pump installations, the control equipment shall consist of submersible mercury float switches. Each switch shall be hermetically sealed in a corrosion resistant float and mounted on a stainless steel pipe with wall bracket. The switches shall be arranged to provide pumps off, one pump operation along with alternation, and pump emergency protection and high water alarm condition, all as shown on the Contract Drawings. The motor control panel shall contain fusible disconnect switches with lockout handles through cover, magnetic across-the-line starters with 3-phase, overload and low voltage protection, running lights, automatic electric alternator, "Hand-Off-Automatic" selector switches, overload reset buttons, numbered and wired terminal strip, high water alarm bell, light and silencing button.

4. Explosionproof Installation

a. If "Explosionproof" type pumps are specified in the Schedules on the Contract Drawings, the installation shall include additional appurtenances as described below.

b. Motors shall be UL listed for Class 1, Group D hazardous locations.

c. The pump control system shall include an intrinsically safe pilot circuit for each mercury float switch to reduce the power to the float switch to a level incapable of releasing sufficient electrical or thermal energy to ignite explosive gases.

5. Provide submersible rated cables to all electrical devices that will be submerged. Submersible cables shall be long enough to reach from the submerged electrical device to the proper terminations in the pump motor controller without splicing.

2.04 PIPE SUPPORTS AND SLEEVES

A. Piping shall be supported with extra heavy galvanized pipe clamps and offset pipe clamps.

B. Sleeves

All penetrations through the lift station walls, floors and roof shall be provided with sleeves and seals with installation and sizes as recommended by the manufacturer.

1. Sleeves

Sleeves shall be "Link-Seal Wall Sleeves", galvanized, seamless steel, Schedule 40 (STD weight) pipe with full circle, continuously welded, water stop plate and anchor sleeve.

2. Seals

a. Seals shall be modular mechanical type, consisting of interlocking sealing element links shaped to continuously fill the annular space between the pipe and the sleeve. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and nut. After the seal assembly is positioned in the sleeve, tightening of the bolts shall cause the sealing elements to expand and provide a watertight seal between the pipe and the sleeved opening. The seal shall provide electrical insulation between the pipe and wall.

b. Pressure plate, bolts and sealing elements shall be Type "C" standards service.

3. Seals and sleeves shall be Thunderline Corp. "Link-Seal", or approved equal.

2.05 EXHAUST FAN

A. If indicated on the Contract Drawings, furnish and install an exhaust fan as specified herein below.

B. Exhaust fan shall be of forward-curve wheel, direct drive, centrifugal type.

C. The exhaust fan shall be of arrangement and size as shown on the Contract Drawings.

D. Materials for the exhaust fan shall be as follows, unless indicated otherwise on the Contract Drawings:

Housing:	Gray Iron Casting
Wheel:	Galvanized Steel
Hub:	Cast Iron

E. Exhaust fan performance shall be as indicated on the Contract Drawings.

F. Where indicated on the Contract Drawings, the exhaust fan shall be Type B, spark-resistant construction with a non-sparking wheel, and explosion-proof motors.

G. Exhaust fan accessories shall include a galvanized steel inlet screen.

H. Exhaust fan operation shall be controlled as follows:

1. The fan shall be interlocked with the lift pump controls, and shall operate automatically whenever any one pump goes into operation. The fan motor starter shall be provided with a "Run" indication lamp.

2. The pit shall be provided with a 120 volt weatherproof light fixture operated by a weatherproof "On-Off" manual switch. When in the "On" position, the switch shall put on the light, and shall also manually operate the fan, bypassing the fan/pump automatic operation interlock. The "On-Off" switch shall be as specified in Division 16 of this Specification.

3. Provide fan with weatherproof disconnect switch.

4. If "explosionproof" pumps are specified in the Schedules on the Contract Drawings, provide explosionproof light fixture and explosionproof "On-Off" light switch and fan disconnect switch. Wiring and conduit shall be in accordance with the NEC and with all applicable codes for installation in "Hazardous Locations".

2.06 SHOP TESTS

A. Pump

1. General

a. Manufacturer's standard shop tests shall be performed on motors, controllers and appurtenances in conformance to the requirements of this Section.

b. All shop tests may be witnessed by the Engineer. Notify the Engineer 14 days in advance of scheduled tests.

2. Performance Tests

Each pump shall be performance tested in accordance with the procedures of the Hydraulic Institute Standards.

PART 3. EXECUTION

3.01 INSTALLATION

A. General

1. Install pumps in locations shown on the Contract Drawings, and in accordance with the manufacturer's installation procedures.
2. Provide a gate valve and check valve on the discharge of each pump.
3. Field install all electrical devices furnished under this Section.
4. Verify that electrical wiring installation is in accordance with Engineer-approved manufacturer's submittal and in accordance with installation requirements of Division 16 of these Specifications.
5. Clean the pit of all construction debris before putting the system into operation.

B. Piping

1. Install piping as shown on the Contract Drawings, and as straight and direct as possible, forming right angles or parallel lines with walls.
2. Avoid tool marks and unnecessary pipe threads. Burrs formed when cutting pipe shall be removed by reaming. Before installing pipe, thoroughly clean the inside, so that it is free of cuttings and foreign matter. Cut all piping square and smooth and make up all joints to required limits.
3. Erect all piping to obtain sufficient flexibility to prevent excessive stresses in materials and excessive bending moments at joints or connections.
4. Make changes in pipe size by the use of reducing fittings. Do not use reducing bushings except with the prior approval by the Engineer. Do not use close or shoulder nipples.

C. Pipe Joint

1. Flanged Joints

Make up square and tight with gaskets 1/16-inch thick full flat faced. Dip bolts and nuts in mixture of graphite and oil immediately prior to installation. The first flange inside the pit wall on the pump discharge shall be anchored to the wall using two 7/8-inch diameter rods anchored in the concrete and passing through flange bolt holes, with a washer and nut on each side of the flange on each rod.

2. Threaded Joints

Make up threaded joints tight without caulking or the use of any filler except approved pipe joint teflon compound or tape, which shall be applied on the male threads only. All burrs or cuttings on threaded joints shall be removed prior to making up the joints.

D. All cut threads on galvanized steel pipe, shall be coated with cold galvanizing compound. Application shall be as recommended by the manufacturer.

3.02 FIELD ADJUSTMENTS

A. Check alignment. Where necessary, readjust slide rail guide bars, and realign shafts of motors and pumps within tolerances recommended by manufacturer and in presence of the manufacturer's service representative.

B. Lubricate pumps before operation.

3.03 FIELD TESTS

A. General

1. The Contractor shall arrange for the services of a competent representative of the pump manufacturer to inspect the pumps and controls during installation and to assist in placing them in operation and in the performance of the field tests.

2. All field tests of the pump system and associated piping shall be conducted in the presence of the Engineer. Notify the Engineer forty-eight hours prior to any field tests of the pump system and associated piping.

B. Piping

1. Upon completion of the pump discharge piping installed under this Section, the Contractor shall test such piping to a pressure equal to 50 psi at the highest elevation of the pump discharge piping for a period of one hour.

2. Leaks or other defects shall be corrected with the defective material repaired or replaced as directed by the Engineer.

C. Pumps

1. Upon completion of the pump system installation, perform field tests to establish the performance and mechanical smoothness of operation of each pump, and its motor and controller, all as a unit. Such tests shall include testing of operation, and calibration of all equipment, alarms, controls and other component parts of the system. A copy of the manufacturer's certified shop test pump performance curve shall be available for comparison with the results of field tests.

2. Defects shall be corrected with the defective products repaired or replaced as directed by the Engineer.

D. Upon the completion of any required adjustments or repairs, repeat tests until the system is approved by the Engineer.

END OF SECTION

SECTION 15451

LIFT STATIONS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Lift Station Shop Drawings

   Shop and coordination drawings shall be double line at a minimum of 3/8"=1'-0" scale.

   a. Pump layout and installation drawings, including the following at a minimum:

      (1) Plans, elevation and sections.

      (2) Hanger, support locations and details. Indicate methods of attachment to building structure.

      (3) Pipe elevations and dimensions from main piping runs to a reference point.

      (4) Location for pumping accessories, including valves and control panels.

   b. Electrical wiring diagrams for electrical power supply, interlock and pump controls. Differentiate between portions of wiring that are factory installed and portions that are field installed.

   c. Coordination drawings showing plan views and sections, drawn to scale, on which all items are shown and coordinated with all Work of other Sections.

B. Product Data / Catalog Cuts

1. Lift Station Pump and Accessories

   a. Catalog cuts, including product performance data for all items furnished under this Contract, including the following at a minimum:

      (1) Pump: Catalog cut sheets and performance characteristic curves with design/duty points clearly indicated.

      (2) Pipe, fittings and flanges.

      (3) Valves.

      (4) Pipe supports.

      (5) Pump motors .

      (6) Sleeves and sealing elements.

      (7) Pump control panel and appurtenances.

      (8) Exhaust fans.

(9) Access doors and appurtenances.

b. Certified shop test reports.

C. Construction and Installation Procedures

1. Field test procedure.

D. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive information for the specific approved equipment; including approved shop drawings and catalog cuts, sequence of operation, test results, troubleshooting, maintenance requirements, spare parts lists, electrical/control devices and electrical/control wiring diagram(s).

E. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15451

LIFT STATIONS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

1. Contract Drawings

(2.01 A)	Piping and appurtenances not in accordance with "SCHEDULE - PIPE, FITTINGS AND FLANGES"
(2.03 B.2.e)	Access door materials, sizes and numbers. Coordination of access door with pump.
(2.03 B.3.a)	NEMA enclosure type and location of motor control panel.
(2.03 B.3.c)	Arrangement of pump operating switches.
(2.05 A)	Exhaust fan - required.
(2.05 C)	Exhaust fan arrangement, size and installation.
(2.05 D)	Exhaust fan materials other than those specified.
(2.05 E)	Exhaust fan performance.
(2.05 F)	Spark-resistant construction of exhaust fan - required.
(3.01 A.1)	Locations of pumps.
(3.01 B.1)	Piping installation.

2. Schedules (shown on the Contract Drawings)

(1.02 B)	Design and performance requirements of lift station pumps.
(2.03 A.1)	Pumps sizes and arrangements (simplex, duplex, triplex).
(2.03 B.1.a)	Electrical characteristics of pumps.
(2.03 B.2.a)	"Removable Lift" type pumps - required.
(2.03 B.4.a)	"Explosionproof" type pumps - required.
(2.05 H.3)	"Explosionproof" lighting fixture and on-off switch - required.

B. Other Items

1. Ensure that the specifications include the following sections referenced in this Section:

(2.03 B.1.d)	MOTOR AND MOTOR CONTROLLERS
(2.05 H.2)	Division 16 specifications for "On-Off" switch for light and manual operation of fan.
(3.01 A.4)	Division 16 electrical wiring installation requirements*

*Coordinate with Electrical staff.

2. Modify Appendix "A" - Submittals per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15452

ELEVATOR PIT SUMP PUMPS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for elevator pit sump pumps.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards, including, but not limited to the entities listed below.

American Society for Testing and Materials (ASTM)
Hydraulic Institute (HI)
National Electrical Code (NEC)
National Electrical Manufacturers Association (NEMA)
Sump and Sewage Pump Manufacturers Association (SSPMA)
Underwriters Laboratories (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

1.03 QUALITY ASSURANCE

Elevator sump pumps, of types, materials and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver pumps and components in factory-fabricated protective packaging.

B. Handle pumps and components carefully to prevent breaking, denting and scoring.

C. Store pumps and components in clean, dry spaces and protect them from weather.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with the requirements of this Section, furnish and install elevator pit sump pumps of one of the following manufacturers, or approved equal:

Weil Pump Co.
Paco Pump
Aurora Pumps

2.02 MATERIALS

Materials for elevator pit sump pumps shall be as specified below:

Casing:	Cast iron
Impellers:	Bronze
Shaft (pump and motor):	Steel
Motor Cover (shell):	Cast iron
Strainer:	Perforated steel plate

2.03 CONSTRUCTION FEATURES

A. Pumps shall be submersible type.

B. Unless otherwise shown on the Contract Drawings, each pump shall deliver 45 gpm at 16 feet of water head (total dynamic head) when operating at 1750 rpm.

C. Pump impellers shall be dynamically balanced, semi-open type, and bearings shall be factory-sealed, grease-lubricated ball type.

D. Provide ceramic face mechanical seal with stainless steel, graphite, and Buna-N components.

E. Pumps shall be provided with suction strainers and 1-1/4-inch NPT discharges.

F. Unless otherwise shown on the Contract Drawings, motors shall be 1/3 HP, 1750 rpm, single phase, 115-volt, hermetically-sealed capacitor start with built-in overload protection.

G. Automatic start and stop of pump shall be provided by a differential mercury float switch, bracket-mounted on the motor housing. Provide pump with power cord and "piggy back" combination, grounded, plug and receptacle. Length of power cord shall be as required.

H. Pumps shall be Weil Pump Co. Series 1400, or approved equal.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install pumps in locations shown on the Contract Drawings, in accordance with manufacturer's installation procedures.

B. Provide a gate valve and check valve on the discharge of each pump.

C. Verify that electrical wiring installation is in accordance with Engineer-approved submittal.

D. Clean the pump pit of all construction debris before putting the system into operation.

3.02 FIELD TESTS

Operate pumps after the installation has been completed to verify that pumps, float switches, valves, etc. are in working order. Operate pumps in accordance with manufacturer's instructions.

END OF SECTION

SECTION 15452

ELEVATOR PIT SUMP PUMPS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Elevator Pit Sump Pump Shop Drawings

   Shop and coordination drawings shall be double line at a minimum of 3/8"=1'-0" scale.

   a. Pump layout and installation drawings, including the following at a minimum::

      (1) Plans, elevation and sections.

      (2) Hanger, support locations and details. Indicate methods of attachment to building structure.

      (3) Pipe elevations and dimensions from main piping runs to a reference point.

      (4) Location for pumping accessories, including valves and control panels.

   b. Electrical wiring diagrams for electrical power supply, including receptacle requirements, interlock and pump controls. Differentiate between portions of wiring that are factory installed and portions that are field installed.

   c. Coordination drawings showing plan views and sections, drawn to scale, on which all items are shown and coordinated with all Work of other Sections.

B. Product Data / Catalog Cuts

1. Elevator Pit Sump Pump and Accessories

   a. Catalog cuts, including product performance data, for all items furnished under this Contract, including the following at a minimum:

      (1) Pump: Catalog cut sheets and performance characteristic curves with design/duty points clearly indicated.

      (2) Pipe, pipe fittings and flanges.

      (3) Valves.

      (4) Pump motors.

      (5) Sleeves and sealing elements.

      (6) Pump control panel and appurtenances.

   b. Certified shop test reports.

C. Construction and Installation Procedures

1. Field test procedure.

D. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive information for the specific approved equipment; including approved shop drawings and catalog cuts, sequence of operation, test results, troubleshooting, maintenance requirements, spare parts lists, electrical/control devices and electrical/control wiring diagram(s).

E. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15452

ELEVATOR PIT SUMP PUMPS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.03 B)	Pump capacity, if other than specified.
(2.03 F)	Motor characteristics, if other than specified.
(3.01 A)	Pump locations.

B. Other Items

Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15453

SUBMERSIBLE SEWAGE EJECTORS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for submersible sewage ejectors.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

American Society for Testing and Materials (ASTM)
American Society of Mechanical Engineers (ASME)
Hydraulic Institute (HI)
National Electrical Manufacturers Association (NEMA)
National Electrical Code (NEC)
Sump and Sewage Pump Manufacturers Association (SSPMA)
Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Design and performance requirements of submersible sewage ejectors shall be as specified in the Schedules shown on the Contract Drawings.

1.03 QUALITY ASSURANCE

Submersible sewage ejectors, of sizes and capacities required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver ejectors and components in factory-fabricated protective packaging.

B. Handle ejectors and components carefully to prevent breaking, denting and scoring.

C. Store ejectors and components in clean, dry spaces and protect them from weather.

D. Comply with manufacturer's rigging instructions for unloading ejectors and moving them to final location for installation.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with the requirements of this Section, furnish and install submersible sewage ejectors of one of the following manufacturers, or approved equal:

Weil Pump Co.
Flygt Corp.
General Signal Corp./Aurora Pump
Federal Pump Corp.
Paco Pumps

2.02 MATERIALS

Materials for submersible sewage ejectors shall be as specified below.

Casing:	Cast iron
Impellers:	Cast iron (high strength) or bronze
Shaft:	Stainless steel
Motor Cover (shell):	Cast iron
Slide Rail Guide Bars:	Galvanized steel

2.03 CONSTRUCTION FEATURES

A. Ejectors

1. Ejectors shall be of sizes, arrangements (simplex or duplex), and capacities specified in the Schedules and as shown on the Contract Drawings.
2. Impellers shall be dynamically balanced, and shall be, non-clog type, capable of passing a minimum of 2-1/2-inch diameter solids.
3. Provide tandem mechanical shaft seals, with permanent oil lubrication by means of sealed oil-reservoir.

B. Motors

1. Provide each ejector with submersible motor having electrical characteristics specified in the Schedules shown on the Contract Drawings. Motor shall be close-coupled to the ejector.
2. The motor shall be suitable for continuous duty and shall have built-in thermal overload protection.
3. Motor shall be of an air filled design. Oil filled motor shells will not be considered equal. Motor shall be housed in a watertight shell suitable for submersible conditions, and shall have Class F insulation.

4. Additional provisions for motor shall be in accordance with requirements specified in Division 15 Section entitled "MOTORS and MOTOR CONTROLLERS". Select the motor characteristics, the motor mountings, and all accessories necessary to satisfy the requirements of the ejector motor drive unit in all operating modes.

C. Removable Lift Type Submersible Ejectors

1. If "Removable Lift" (Quick Removal) type ejectors are specified in the Schedules shown on the Contract Drawings, the installation shall include additional appurtenances as described below.

2. The design shall be such that the ejectors will be automatically connected to the discharge piping when lowered into place. The ejectors shall be easily removable for inspection or service, requiring no bolts, nuts, or other fastenings to be removed for this purpose, nor need personnel to enter the ejector pit. The ejectors shall be fitted with a stainless steel chain from each ejector, of adequate strength and length to raise the ejector for inspection and removal.

3. The installation shall include a separate base plate, incorporating a stationary discharge elbow to receive the discharge when the ejector is lowered into place. The receiving edge of the discharge elbow shall be fitted with a non-sparking material to prevent spark ignition during ejector installation and removal.

4. Furnish and install two guide bars for each ejector to permit raising and lowering the ejector. Guide bars shall be of two-inch galvanized steel pipe of adequate length to extend from the lower guide holders mounted on the access frame.

5. Access cover shall be installed for each ejector, complete with hinged and flush locking mechanism, upper guide holder and level sensor cable holder. Frame shall be provided with sliding nut rails to attach the accessories required. Lower guide bar holders shall be integral with the discharge connection. The guide bars shall not support any portion of the weight of the ejector. Doors shall be of skid proof design.

D. Control System

1. Provide a motor control panel in a single enclosure with a hinged door of NEMA enclosure type as shown on the Contract Drawings. Mount the panel where shown on the Contract Drawings.

2. For single ejector installations, the control equipment shall consist of an automatic, heavy-duty, float switch to start and stop the ejector. The motor control panel shall contain a disconnect switch, magnetic motor starter with overload protection and "Hand-Off-Automatic" selector switch.

3. For duplex ejector installations, the control equipment shall consist of four submersible mercury float switches. Each switch shall be hermetically sealed in a corrosion resistant float and mounted on a stainless steel pipe with wall bracket. The switches shall be arranged to provide ejectors off, one ejector operation along with alternation, two ejector emergency protection and high water alarm condition. The motor control panel shall contain two fusible disconnect switches with lockout handles through cover, two magnetic across-the-line starters with 3-phase, overload and low voltage protection, two ejector running lights, one automatic electric alternator, two "Hand-Off-Automatic" selector switches, two overload reset buttons, one numbered and wired terminal strip, high water alarm bell, light and silencing button.

E. Basin

Provide a cast iron basin (unless other material is shown on the Contract Drawings), complete with sewage inlet fitting and steel basin cover. The cover shall be provided with openings as required for ejector discharge piping, access with cover, vents and controls. All connections penetrating the cover shall be made gas tight. The basin shall be provided with a cement anchor flange. Size of basin shall be as shown on the Contract Drawings.

F. Explosionproof Installation

1. If "Explosionproof" type ejectors are specified in the Schedules shown on the Contract Drawings, the installation shall include additional appurtenances as described below.

2. Motors shall be UL listed for Class 1, Group D hazardous locations.

3. The ejector control system shall include an intrinsically safe pilot circuit for each mercury float switch to reduce the power to the float switch to a level incapable of releasing sufficient electrical or thermal energy to ignite explosive gases.

G. Provide submersible rated cables to all electrical devices that will be submerged. Submersible cables shall be long enough to reach from the submerged electrical device to the proper terminations in the ejector motor controller without splicing.

2.04 SHOP TESTS

A. General

1. Manufacturer's standard shop tests shall be performed on ejectors, motors, controllers, and appurtenances in conformance to the requirements of this Section.

2. All shop tests may be witnessed by the Engineer. Notify the Engineer 14 days in advance of scheduled tests.

B. Performance Tests

Each ejector shall be performance tested in accordance with the procedures of the Hydraulic Institute Standards.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install ejectors in locations shown on the Contract Drawings, in accordance with manufacturer's installation procedures. Alignment of the "Removable Lift" type ejectors during installation shall be in strict adherence to manufacturer's instructions.

B. Provide a gate valve and check valve on the discharge of each ejector.

C. Set cover over basin and fasten to top flange of basin so that cover is flush with finish floor, as applicable.

D. Field install all electrical devices furnished under this Section.

E. Verify that electrical wiring installation is in accordance with Engineer-approved submittal and in accordance with installation requirements of Division 16.

F. Clean the basin of all construction debris before putting the system into operation.

3.02 FIELD ADJUSTMENTS

A. Check alignment. Where necessary, readjust the slide rail guide bars, and realign shafts of motors and ejectors within tolerances recommended by ejector manufacturer and in presence of the manufacturer's service representative.

B. Lubricate ejectors before operation.

3.03 FIELD TESTS

Operate ejectors after the installation has been completed to verify that ejectors, float switches, alarms, valves, etc. are in working order. Operate ejectors in accordance with manufacturer's instructions.

END OF SECTION

SECTION 15453

SUBMERSIBLE SEWAGE EJECTORS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Submersible Sewage Ejector Shop Drawings

   Shop and coordination drawings shall be double line at a minimum of 3/8"=1'-0" scale.

   a. Pump layout and installation drawings including, at a minimum, the following:

      (1) Plans, elevation and sections.

      (2) Hanger, support locations and details. Indicate methods of attachment to building structure.

      (3) Pipe elevations and dimensions from main piping runs to a reference point.

      (4) Location for pumping accessories, including valves and control panels.

   b. Electrical wiring diagrams for electrical power supply, interlock and pump controls. Differentiate between portions of wiring that are factory installed and portions that are field installed.

   c. Coordination drawings showing plan views and sections, drawn to scale, on which all items are shown and coordinated with all Work of other Sections.

B. Product Data / Catalog Cuts

1. Submersible Sewage Ejector Pump and Accessories

   a. Catalog cuts, including product performance data for all items furnished under this Contract, including the following at a minimum:

      (1) Pump: Catalog cut sheets and performance characteristic curves with design/duty points clearly indicated.

      (2) Pipe, pipe fittings and flanges.

      (3) Valves.

      (4) Basin and cover.

      (5) Pump motors.

      (6) Pump control panel and appurtenances.

   b. Certified shop test reports.

C. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive information for the specific approved equipment; including approved shop drawings and catalog cuts, sequence of operation, test results, troubleshooting, maintenance requirements, spare parts lists, electrical/control devices and electrical/control wiring diagram(s).

D. Construction and Installation Procedures

1. Field test procedure.

E. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15453

SUBMERSIBLE SEWAGE EJECTORS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text.

1. Contract Drawings

(2.03 A.1)	Arrangements of ejectors.
(2.03 D.1)	NEMA enclosure type and installation location of the motor control panel.
(2.03 E)	Other than cast iron basin specified and size of basin.
(3.01 A)	Ejector installation locations.

2. Schedules (shown on the Contract Drawings)

(1.02 B)	Design and performance requirements of ejectors (overall).
(2.03 A.1)	Sizes and capacities.
(2.03 B.1)	Electrical characteristics.
(2.03 C.1)	"Removable Lift" type ejectors.
(2.03 F.1)	"Explosionproof" ejectors.

B. Other Items

1. Ensure that the Specifications include the following Sections referenced in this Section:

(2.03 B.4)	"MOTORS AND MOTOR CONTROLLERS"
(3.01 E)	Division 16 electrical wiring installation requirements

2. Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15454

VERTICAL SEWAGE EJECTORS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for vertical sewage ejectors.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

American Society for Testing and Materials (ASTM)

American Society of Mechanical Engineers (ASME)

Hydraulic Institute (HI)

National Electrical Manufacturers Association (NEMA)

National Electrical Code (NEC)

Sump and Sewage Pump Manufacturers Association (SSPMA)

Underwriters Laboratories, Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Design and performance requirements of vertical sewage ejectors shall be as specified in the Schedules shown on the Contract Drawings.

1.03 QUALITY ASSURANCE

Vertical sewage ejectors, of sizes and capacities required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver ejectors and components in factory-fabricated protective packaging.

B. Handle ejectors and components carefully to prevent breaking, denting and scoring.

C. Store ejectors and components in clean, dry spaces and protect them from weather.

D. Comply with manufacturer's rigging instructions for unloading ejectors and moving them to final location for installation.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with the requirements of this Section, furnish and install vertical sewage ejectors of one of the following manufacturers, or approved equal:

Federal Pump Corp
Flygt Corp.
General Signal Corp./Aurora Pump
Paco Pumps
Weil Pump Co.

2.02 MATERIALS

Materials for vertical sewage ejectors shall be as specified below.

Casing:	Cast iron
Impellers:	Cast iron (high strength) or bronze
Shaft:	Steel

2.03 CONSTRUCTION FEATURES

A. Ejectors

1. Ejectors shall be of sizes, arrangements (simplex or duplex), and capacities specified in the Schedules and as shown on the Contract Drawings.
2. Impellers shall be dynamically balanced and shall be non-clog type, capable of passing a minimum of 2-1/2-inch diameter solids.
3. Provide bearings (casing, guide, and thrust) in sufficient numbers and locate them to ensure proper shaft alignment and minimize noise level. All bearings shall be grease lubricated.
4. Casing and discharge nozzle shall be in a one-piece, symmetrical casting.
5. Each ejector shall be connected directly to the driver motor with a flexible coupling and mounted on a heavy floor plate.
6. Provide stuffing box with packing, designed for minimum water leakage.
7. Provide discharge pipe above the ejector floor plate.

B. Motors

1. Provide each ejector with motor having electrical characteristics specified in the Schedules shown on the Contract Drawings.

2. Provide motors in accordance with requirements specified in Division 15 Section entitled "MOTORS AND MOTOR CONTROLLERS". Select the motor characteristics, the motor mountings, and all accessories necessary to satisfy the requirements of the ejector-motor drive unit in all operating modes.

C. Control System

1. Provide a motor control panel in a single enclosure with a hinged door of NEMA enclosure type as shown on the Contract Drawings. Mount the panel where shown on the Contract Drawings.

2. For single ejector installations, the control equipment shall consist of an automatic, heavy-duty, float switch to start and stop the ejector. The motor control panel shall contain a disconnect switch, magnetic motor starter with overload protection and "Hand-Off-Automatic" selector switch.

3. For duplex ejector installations, the control equipment shall consist of four submersible mercury float switches. Each switch shall be hermetically sealed in a corrosion resistant float and mounted on a stainless steel pipe with wall bracket. The switches shall be arranged to provide ejectors off, one ejector operation along with alternation, two ejector emergency protection and high water alarm condition. The motor control panel shall contain two fusible disconnect switches with lockout handles through cover, two magnetic across-the-line starters with 3-phase, overload and low voltage protection, two ejector running lights, one automatic electric alternator, two "Hand-Off-Automatic" selector switches, two overload reset buttons, one numbered and wired terminal strip, high water alarm bell, light and silencing button.

D. Basin

Provide a cast iron basin (unless other material is shown on the Contract Drawings), complete with sewage inlet fitting and steel basin cover. The cover shall be provided with openings as required for ejectors, access with cover, vents and controls. All connections penetrating the cover shall be made gas tight. The basin shall be provided with a cement anchor flange. Size of basin shall be as shown on the Contract Drawings.

2.04 SHOP TESTS

A. General

1. Manufacturer's standard shop tests shall be performed on ejectors, motors, controllers and appurtenances in conformance to the requirements of this Section.

2. All shop tests may be witnessed by the Engineer. Notify the Engineer 14 days in advance of scheduled tests.

B. Performance Tests

Each ejector shall be performance tested in accordance with the procedures of the Hydraulic Institute Standards.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install ejectors in locations shown on the Contract Drawings, in accordance with manufacturers' installation procedures.

B. Provide a gate valve and check valve on the discharge of each ejector.

C. Set cover over basin and fasten to top flange of basin so that cover is flush with finish floor, as applicable.

D. Field install all electrical devices furnished under this Section.

E. Verify that electrical wiring installation is in accordance with Engineer-approved manufacturer's submittal and in accordance with installation requirements of Division 16.

F. Clean the basin of all construction debris before putting the system into operation.

3.02 FIELD ADJUSTMENTS

A. Check alignment, and where necessary, realign shafts of motors and ejectors within tolerances recommended by ejector manufacturer, and in presence of the manufacturer's service representative.

B. Lubricate ejectors before operation.

3.03 FIELD TESTS

Operate ejectors after the installation has been completed to verify that ejectors, float switches, alarms, valves etc. are in working order. Operate ejectors in accordance with manufacturer's instructions.

END OF SECTION

SECTION 15454

VERTICAL SEWAGE EJECTORS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Vertical Sewage Ejector Shop Drawings

   Shop and coordination drawings shall be double line at a minimum of 3/8"=1'-0" scale.

   a. Pump layout and installation drawings, including the following at a minimum:

      (1) Plans, elevation and sections.

      (2) Hanger, support locations and details. Indicate methods of attachment to building structure.

      (3) Pipe elevations and dimensions from main piping runs to a reference point.

      (4) Location for pumping accessories, including valves and control panels.

   b. Electrical wiring diagrams for electrical power supply, interlock and pump controls. Differentiate between portions of wiring that are factory installed and portions that are field installed.

   c. Coordination drawings showing plan views and sections, drawn to scale, on which all items are shown and coordinated with all Work of other Sections.

B. Product Data / Catalog Cuts

1. Vertical Sewage Ejector Pump and Accessories

   a. Catalog cuts, including product performance data for all items furnished under this Contract, including the following at a minimum:

      (1) Pump: Catalog cut sheets and performance characteristic curves with design/duty points clearly indicated.

      (2) Pipe, pipe fittings and flanges.

      (3) Valves.

      (4) Hangers and supports.

      (5) Basin and cover.

      (6) Pump motors.

      (7) Pump control panel and appurtenances.

   b. Certified shop test reports.

C. Construction and Installation Procedures

1. Field test procedure.

D. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive information for the specific approved equipment; including approved shop drawings and catalog cuts, sequence of operation, test results, troubleshooting, maintenance requirements, spare parts lists, electrical/control devices and electrical/control wiring diagram(s).

E. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15454

VERTICAL SEWAGE EJECTORS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

1. Contract Drawings

(2.03 A.1)	Arrangements of ejectors
(2.03 C.1)	NEMA enclosure type and installation location of the motor control panel
(2.03 D)	Other than cast iron basin specified and size of basin
(3.01 A)	Ejector installation locations

2. Schedules (Shown on the Contract Drawings)

(1.02 B)	Design and performance requirements of ejectors (overall)
(2.03 A.1)	Sizes and capacities
(2.03 B.1)	Electrical characteristics

B. Other Items

1. Ensure that the Specifications include the following Section(s) referenced in this Section:

(2.03 B.2)	"MOTORS AND MOTOR CONTROLLERS"
(3.01 E)	Division 16 electrical wiring installation requirements

2. Modify Appendix A "Submittal Requirements" as per Project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15455

SUBMERSIBLE SUMP PUMPS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for submersible sump pumps.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

American Society for Testing and Materials (ASTM)

American Society of Mechanical Engineers (ASME)

Hydraulic Institute (HI)

National Electrical Manufacturers Association (NEMA)

National Electrical Code (NEC)

Sump and Sewage Pump Manufacturers Association (SSPMA)

Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Design and performance requirements of submersible sump pumps shall be as specified in the Schedules shown on the Contract Drawings.

1.03 QUALITY ASSURANCE

Submersible sump pumps, of sizes and capacities required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver pumps and components in factory-fabricated protective packaging.

B. Handle pumps and components carefully to prevent breaking, denting and scoring.

C. Store pumps and components in clean, dry spaces and protect them from weather.

D. Comply with manufacturer's rigging instructions for unloading pumps and moving them to final location for installation.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with the requirements of this Section, furnish and install submersible sump pumps of one of the following manufacturers, or approved equal:

Federal Pump Corp.
Flygt Corp.
General Signal Corp./Aurora Pump
Paco Pumps
Weil Pump Co.

2.02 MATERIALS

Materials for submersible sump pumps shall be as specified below:

Casing:	Cast iron
Impellers:	Cast iron (high strength) or bronze
Shaft:	Stainless steel
Motor Cover (shell):	Cast iron
Strainers:	Cast iron or galvanized steel

2.03 CONSTRUCTION FEATURES

A. Pumps

1. Pumps shall be of sizes, arrangements (simplex or duplex), and capacities specified in the Schedules and as shown on the Contract Drawings.

2. Impellers shall be dynamically balanced, and shall be semi-open, non-clog type. Provide suction strainers.

3. Provide mechanical shaft seals, with permanent oil lubrication by means of sealed oil-reservoir.

B. Motors

1. Provide each pump with submersible motor having electric characteristics specified in the Schedules shown on the Contract Drawings. Motor shall be close-coupled to the pump.

2. The motor shall be suitable for continuous duty and shall have built-in thermal overload protection.

3. Motor shall be of an air filled design. Oil filled motor shells will not be considered equal. Motor shall be housed in a watertight shell suitable for submersible conditions, and shall have Class F insulation.

4. Additional provisions for motor shall be in accordance with requirements specified in Division 15 Section entitled "MOTORS AND MOTOR CONTROLLERS". Select the motor characteristics, the motor mountings, and all accessories necessary to satisfy the requirements of the pump motor drive unit in all operating modes.

C. Control System

1. Provide a motor control panel in a single enclosure with a hinged door of NEMA enclosure type as shown on the Contract Drawings. Mount the panel where shown on the Contract Drawings.

2. For single pump installations, the control equipment shall consist of an automatic, heavy-duty, float switch to start and stop the pump. The motor control panel shall contain a disconnect switch, magnetic motor starter with overload protection and "Hand-Off- Automatic" selector switch.

3. For duplex pump installations, the control equipment shall consist of four submersible mercury float switches. Each switch shall be hermetically sealed in a corrosion resistant float and mounted on a stainless steel pipe with wall bracket. The switches shall be arranged to provide pumps off, one pump operation along with alternation, two pump emergency protection and high water alarm condition. The motor control panel shall contain two fusible disconnect switches with lockout handles through cover, two magnetic across-the-line starters with 3-phase, overload and low voltage protection, two pump running lights, one automatic electric alternator, two "Hand-Off-Automatic" selector switches, two overload reset buttons, one numbered and wired terminal strip, high water alarm bell, light and silencing button.

D. Basin

Provide a cast iron basin (unless other material is shown on the Contract Drawings), complete with drain inlet fitting and steel basin cover. The cover shall be provided with openings as required for pump discharge piping, access with cover, vents and controls. The basin shall be provided with a cement anchor flange. Size of basin shall be as shown on the Contract Drawings.

E. Explosionproof Installation

1. If "Explosionproof" type pumps are specified in the Schedules shown on the Contract Drawings, the installation shall include additional appurtenances as described below.

2. Motors shall be UL listed for Class 1, Group D hazardous locations.

3. The pump control system shall include an intrinsically safe pilot circuit for each mercury float switch to reduce the power to the float switch to a level incapable of releasing sufficient electrical or thermal energy to ignite explosive gases.

F. Provide submersible rated cables to all electrical devices that will be submerged. Submersible cables shall be long enough to reach from the submerged electrical device to the proper terminations in the sump pump motor controller without splicing.

2.04 SHOP TESTS

A. General

1. Manufacturer's standard shop tests shall be performed on pumps, motors, controllers, and appurtenances in conformance to the requirements of this Section.

2. All shop tests may be witnessed by the Engineer. Notify the Engineer 14 days in advance of scheduled tests.

B. Performance Tests

Each pump shall be performance tested in accordance with the procedures of the Hydraulic Institute Standards.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install pumps in locations shown on the Contract Drawings, in accordance with manufacturers' installation procedures.

B. Provide a gate valve and check on the discharge of each pump.

C. Set cover over basin and fasten to top flange of basin so that cover is flush with finish floor, as applicable.

D. Field install all electrical devices furnished under this Section.

E. Verify that electrical wiring installation is in accordance with Engineer-approved submittal and in accordance with installation requirements of Division 16.

F. Clean the basin of all construction debris before putting the system into operation.

3.02 FIELD ADJUSTMENTS

A. Check alignment. Where necessary, readjust slide rail guide bars, and realign shafts of motors and pumps within tolerances recommended by pump manufacturer and in presence of the manufacturer's service representative.

B. Lubricate pumps before operation.

3.03 FIELD TESTS

Operate pumps after the installation has been completed to verify that pumps, float switches, alarms, valves, etc. are in working order. Operate pumps in accordance with manufacturer's instructions.

END OF SECTION

SECTION 15455

SUBMERSIBLE SUMP PUMPS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Sump Pump Shop Drawings

   Shop and coordination drawings shall be double line at a minimum of 3/8"=1'-0" scale.

   a. Pump layout and installation drawings, including the following at a minimum:

      (1) Plans, elevation and sections.

      (2) Hanger, support locations and details. Indicate methods of attachment to building structure.

      (3) Pipe elevations and dimensions from main piping runs to a reference point.

      (4) Location for pumping accessories, including valves and control panels.

   b. Electrical wiring diagrams for electrical power supply, interlock and pump controls. Differentiate between portions of wiring that are factory installed and portions that are field installed.

   c. Coordination drawings showing plan views and sections, drawn to scale, on which all items are shown and coordinated with all Work of other Sections.

B. Product Data / Catalog Cuts

1. Sump Pump and Accessories

   a. Catalog cuts, including product performance data for all items furnished under this Contract, including the following at a minimum:

      (1) Sump Pump: Catalog cut sheets and performance characteristic curves with design/duty points clearly indicated.

      (2) Basin and cover.

      (3) Pump motors.

      (4) Pump control panel and appurtenances.

   b. Certified shop test reports.

C. Construction and Installation Procedures

1. Field test procedure.

D. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive information for the specific approved equipment; including approved shop drawings and catalog cuts, sequence of operation, test results, troubleshooting, maintenance requirements, spare parts lists, electrical/control devices and electrical/control wiring diagram(s).

E. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15455

SUBMERSIBLE SUMP PUMPS

INSTRUCTIONS TO SPECIFIER

1.01 Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

A. Contract Drawings

(2.03 A.1)	Arrangements of pumps.
(2.03 C.1)	NEMA enclosure type and installation location of the motor control panel.
(2.03 D)	Other than cast iron basin specified and size of basin.
(3.01 A)	Pump installation locations.

B. Schedules (shown on the Contract Drawing)

(1.02 B)	Design and performance requirements of pumps (overall).
(2.03 A.1)	Sizes and capacities.
(2.03 B.1)	Electrical characteristics of motors.
(2.03 E.1)	"Explosionproof" sump pumps.

1.02 Other Items

A. Ensure that the Specifications include the following Section(s) referenced in this Section:

(2.03 B.4)	MOTORS AND MOTOR CONTROLLERS
(3.01 E)	Division 16 electrical wiring installation requirements.

B. Modify Appendix "A" - Submittals per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15456

VERTICAL SUMP PUMPS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for vertical sump pumps.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

American Society for Testing and Materials (ASTM)
American Society of Mechanical Engineers (ASME)
Hydraulic Institute (HI)
National Electrical Manufacturers Association (NEMA)
National Electrical Code (NEC)
Sump and Sewage Pump Manufacturers Association (SSPMA)
Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Design and performance requirements of vertical sump pumps shall be as specified in the Schedules shown on the Contract Drawings.

1.03 QUALITY ASSURANCE

Vertical sump pumps, of sizes and capacities required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver pumps and components in factory-fabricated protective packaging.

B. Handle pumps and components carefully to prevent breaking, denting and scoring.

C. Store pumps and components in clean, dry spaces and protect them from weather.

D. Comply with manufacturer's rigging instructions for unloading pumps and moving them to final location for installation.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with the requirements of this Section, provide vertical sump pumps of one of the following manufacturers, or approved equal:

Weil Pump Co.
Flygt Corp.
General Signal Corp./Aurora Pump
Federal Pump Corp.
Paco Pumps

2.02 MATERIALS

Materials for vertical sump pumps shall be as specified below:

Casing:	Cast iron
Impellers:	Cast iron (high strength) or bronze
Shaft:	Steel
Strainers:	Cast iron

2.03 CONSTRUCTION FEATURES

A. Pumps

1. Pumps shall be of sizes, arrangements (simplex or duplex), and capacities specified in the Schedules and as shown on the Contract Drawings.
2. Impellers shall be dynamically balanced, and shall be semi-open, non-clog type. Provide suction strainers.
3. Provide bearings (casing, guide, and thrust) in sufficient numbers and locate them to ensure proper shaft alignment and minimize noise level. All bearings shall be grease lubricated via grease fitting.
4. Casing and discharge nozzle shall be in a one-piece, symmetrical casing.
5. Each pump shall be connected directly to the driver motor with a flexible coupling and mounted on a heavy floor plate.
6. Provide stuffing box with packing, designed for minimum water leakage.
7. Provide discharge pipe above the pump floor plate.

B. Motors

1. Provide each pump with a motor having electrical characteristics specified in the Schedules shown on the Contract Drawings.

2. Provide motors in accordance with requirements specified in Division 15 Section entitled "MOTORS AND MOTOR CONTROLLERS". Select the motor characteristics, the motor mountings, and all accessories necessary to satisfy the requirements of the pump-motor drive unit in all operating modes.

C. Control System

1. Provide a motor control panel in a single enclosure with a hinged door of NEMA enclosure type as shown on the Contract Drawings. Mount the panel where shown on the Contract Drawings.

2. For single pump installations, the control equipment shall consist of an automatic, heavy-duty, float switch to start and stop the pump. The motor control panel shall contain a disconnect switch, magnetic motor starter with overload protection and "Hand-Off-Automatic" selector switch.

3. For duplex pump installations, the control equipment shall consist of four submersible mercury float switches. Each switch shall be hermetically sealed in a corrosion resistant float and mounted on a stainless steel pipe with wall bracket. The switches shall be arranged to provide pumps off, one pump operation along with alternation, two pump emergency protection and high water alarm condition. The motor control panel shall contain two fusible disconnect switches with lockout handles through cover, two magnetic across-the-line starters with 3-phase, overload and low voltage protection, two pump running lights, one automatic electric alternator, two "Hand-Off-Automatic" selector switches, two overload reset buttons, one numbered and wired terminal strip, high water alarm bell, light and silencing button.

D. Basin

Provide a cast iron basin (unless other material is shown on the Contract Drawings), complete with drain inlet fitting and steel basin cover. The cover shall be provided with openings as required for pumps, access with cover, and controls. The basin shall be provided with a cement anchor flange. Size of basin shall be as shown on the Contract Drawings.

2.04 SHOP TESTS

A. General

1. Manufacturer's standard shop tests shall be performed on pumps, motors, controllers, and appurtenances in conformance to the requirements of this Section.

2. All shop tests may be witnessed by the Engineer. Notify the Engineer 14 days in advance of scheduled tests.

B. Performance Tests

Each pump shall be performance tested in accordance with the procedures of the Hydraulic Institute Standards.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install pumps in locations shown on the Contract Drawings, in accordance with manufacturers' installation procedures.

B. Provide a gate valve and check valve on the discharge of each pump.

C. Set cover over basin and fasten to top flange of basin so that cover is flush with finish floor, as applicable.

D. Field install all electrical devices furnished under this Section.

E. Verify that electrical wiring installation is in accordance with Engineer-approved manufacturer's submittal and in accordance with installation requirements of Division 16.

F. Clean the basin of all construction debris before putting the system into operation.

3.02 FIELD ADJUSTMENTS

A. Check alignment, and where necessary, realign shafts of motors and pumps within tolerances recommended by pump manufacturer, and in presence of the manufacturer's service representative.

B. Lubricate pumps before operation.

3.03 FIELD TESTS

Operate pumps after the installation has been completed to verify that pumps, float switches, alarms, valves etc. are in working order. Operate pumps in accordance with manufacturer's instructions.

END OF SECTION

SECTION 15456

VERTICAL SUMP PUMPS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Sump Pump Shop Drawings

   Shop and coordination drawings shall be double line at a minimum of 3/8"=1'-0" scale.

   a. Pump layout and installation drawings, including the following at a minimum:

      (1) Plans, elevation and sections.

      (2) Hanger, support locations and details. Indicate methods of attachment to building structure.

      (3) Pipe elevations and dimensions from main piping runs to a reference point.

      (4) Location for pumping accessories, including valves and control panels.

   b. Electrical wiring diagrams for electrical power supply, interlock and pump controls. Differentiate between portions of wiring that are factory installed and portions that are field installed.

   c. Coordination drawings showing plan views and sections, drawn to scale, on which all items are shown and coordinated with all Work of other Sections.

B. Product Data / Catalog Cuts

1. Vertical Sump Pump and Accessories

   a. Catalog cuts, including product performance data for all items furnished under this Contract, including the following at a minimum:

      (1) Sump Pump: Catalog cut sheets and performance characteristic curves with design/duty points clearly indicated.

      (2) Pipe, pipe fitting and flanges.

      (3) Valves.

      (4) Flanges.

      (5) Basin and cover.

      (6) Pump motors .

      (7) Pump control panel and appurtenances.

   b. Certified shop test reports.

C. Construction and Installation Procedures

1. Field test procedure.

D. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive information for the specific approved equipment; including approved shop drawings and catalog cuts, sequence of operation, test results, troubleshooting, maintenance requirements, spare parts lists, electrical/control devices and electrical/control wiring diagram(s).

E. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15456

VERTICAL SUMP PUMPS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

1. Contract Drawings

(2.03 A.1)	Arrangements of pumps.
(2.03 C.1)	NEMA enclosure type and installation location of the motor control panel.
(2.03 D)	Other than cast iron basin specified and size of basin.
(3.01 A)	Pump installation locations.

2. Schedules (shown on the Contract Drawings)

(1.02 B)	Design and performance requirements of pumps (overall).
(2.03 A.1)	Sizes and capacities.
(2.03 B.1)	Electrical characteristics.

B. Other Items

1. Ensure that the Specifications include the following Section(s) referenced in this Section:

(2.03 B.2)	"MOTORS AND MOTOR CONTROLLERS"
(3.01 E)	Division 16 electrical wiring installation requirements

2. Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15457

GAS-FIRED WATER HEATERS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for gas-fired water heaters.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

American Gas Association (AGA)
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
American Society of Mechanical Engineers (ASME)
BOCA National Energy Conservation Code
National Fire Protection Association (NFPA)
New Jersey Uniform Construction Code
New York City Building Code
New York State Energy Conservation Construction Code
Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Design and performance requirements of gas-fired water heaters shall be as specified in the Gas-Fired Water Heater Schedules (hereinafter in this Section "Schedules") shown on the Contract Drawings.

C. Water storage tanks shall be designed and constructed in accordance with ASME Code and bear the ASME label.

D. Gas-fired water heater design shall be certified by AGA.

1.03 QUALITY ASSURANCE

Gas-fired water heaters, of types and capacities required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver water heaters and components in factory-fabricated protective packaging.

B. Handle water heaters and components carefully to prevent breaking, denting and scoring.

C. Store water heaters and components in clean, dry spaces and protect them from weather.

D. Comply with manufacturer's rigging instructions for unloading water heaters and moving them to final location for installation.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with the requirements of this Section, furnish and install gas-fired water heaters of one of the following manufacturers, or approved equal:

A.O. Smith Water Products Co.
Rheem Manufacturing Co.
State Industries Inc.

2.02 CONSTRUCTION FEATURES

A. Water heaters shall be equipped to burn natural gas and shall be of sizes, arrangements, heat input ratings, recovery rates and storage tank capacities as specified in the Schedules and as shown on the Contract Drawings.

B. Heaters shall have 150 psi working pressure, extruded high-density magnesium anode rods for cathodic protection, and glass-lining on internal surfaces exposed to water.

C. Controls shall regulate the gas supply to main and pilot burners.

D. Provide each water heater with an automatic gas shut-off device in event of excessive temperature in the tank, a pilot safety shut-off in case of pilot failure, and an AGA approved draft diverter.

E. The heater shall be factory insulated and enclosed with an outer jacket having a baked enamel finish.

F. Provide drain valve in the front of heater for ease of servicing.

G. Provide minimum 3/4 inch AGA approved relief valves.

2.03 SHOP TESTS

Perform manufacturer's standard shop tests and tests required by provisions of AGA and ASME.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install water heaters in accordance with manufacturer's installation procedures. Install heaters plumb and level, firmly anchored in locations shown on the Contract Drawings and maintain manufacturer's recommended clearances for service and maintenance.

B. Connect hot and cold water piping to heaters with shut-off valves and unions.

C. Provide thermometers on inlet and outlet piping of water heaters.

D. Extend relief valve discharge to closest floor drain, unless otherwise shown on the Contract Drawings.

E. Connect gas supply line with drip leg, tee, gas cock and union.

F. Field install all electrical devices furnished under this Section.

G. Verify that electrical wiring installation is in accordance with Engineer-approved submittal and in accordance with installation requirements of Division 16.

3.02 FIELD TESTS

Start up, test and adjust water heaters in accordance with manufacturer's start-up instructions.

END OF SECTION

SECTION 15457

GAS-FIRED WATER HEATERS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Shop and coordination drawings shall be single line at a minimum of 3/8"=1'-0" scale.

   a. Shop drawings indicating dimensions, required clearances, and methods of assembly of components. Piping coordination drawings showing plan views and sections, drawn to scale, on which all items are shown and coordinated with all Work of other Sections.

   b. Electrical wiring diagrams for electrical power supply, interlock and control. Differentiate between portions of wiring that are factory installed and portions that are field installed.

   c. Coordination drawings showing plan views andsections, drawn to scale, on which all items are shown and coordinated with all Work of other Sections.

B. Product Data / Catalog Cuts

1. Product data including rated capacities, recovery rates, operating weights, specialties and accessories.

C. Certificates

1. Submit certificates of shop inspection and data report required by provisions of AGA and ASME Boiler and Pressure Vessel Code.

D. Construction and Installation Procedures

1. Field test procedures.

E. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive information for the specific approved equipment; including approved shop drawings and catalog cuts, sequence of operation, test results, troubleshooting, maintenance requirements, spare parts lists, electrical/control devices and electrical/control wiring diagram(s).

F. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15457

GAS-FIRED WATER HEATERS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

1. Contract Drawings

(2.02 A)	Arrangements of water heaters.
(3.01 A)	Installation locations.
(3.01 D)	Relief valve discharge piping.

2. Schedules (shown on the Contract Drawings)

(1.02 B)	Design and performance requirements (overall).
(2.02 A)	Sizes, heat input ratings, recovery rates, storage tank capacities.

B. Other Items

Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15458

WATER HEATERS - STEAM-TO-WATER

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for steam-to-water water heaters.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

New York City Building Code

New Jersey Uniform Construction Code

New York State Energy Conservation Construction Code

The BOCA National Energy Conservation Code

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

American Society of Mechanical Engineers (ASME)

Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Design and performance requirements of steam-to-water water heaters shall be as specified in the Steam-to-Water Water Heater Schedules (hereinafter in this Section "Schedules") shown on the Contract Drawings and shall be constructed in accordance with ASME Code and bear the ASME label.

1.03 QUALITY ASSURANCE

Steam-to-water heaters, of types and capacities required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver water heaters and components in factory-fabricated protective packaging.

B. Handle water heaters and components carefully to prevent breaking, denting and scoring.

C. Store water heaters and components in clean, dry spaces and protect them from weather.

D. Comply with manufacturer's rigging instructions for unloading water heaters and moving them to final location for installation.

1.05 SUBMITTALS

Refer to Appendix A.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with the requirements of this Section, provide steam-to-water water heaters of one of the following manufacturers, or approved equal:

Patterson-Kelley Co.

Aerco-International, Inc.

2.02 CONSTRUCTION FEATURES

A. Steam-to-water water heaters shall be of sizes, arrangements, capacities, and pressure drops as specified in the Schedules and as shown on the Contract Drawings.

B. Heaters shall have 150 psig working pressure and shall control the hot water outlet temperature within plus or minus 5 degrees F of the specified temperature in the Schedules shown on the Contract Drawings, at design conditions.

C. Heater shall be Patterson-Kelley "Compact Series 400" or approved equal. It shall be completely factory assembled, requiring only connection to services, and shall consist of the following:

1. Non-ferrous shell and heat exchanger wrapper, copper tubes, non-ferous tube sheet and baffles, cast iron steam chamber, vertical steel supports with skids, and lifting lug.
2. Anticipator control assembly with adjustment valve, designed to vary the steam flow to the heat exchanger in proportion to the variation in hot water demand. Under low or no hot water demand the anticipator shall monitor the temperature of the stored water.
3. Console with steam pressure gauge and water thermometer.
4. Steam strainer.
5. Condensate strainer.
6. Main steam float and thermostatic trap.
7. Auxiliary steam trap from steam strainer to condensate line.
8. ASME pressure relief valve.
9. Temperature control valve, normally closed for dead end service, modulating type, controlled by immersion type temperature controller inserted in separable sockets in the anticipator connection on heater.

10. Bronze circulator with a motor having electrical characteristics specified in the Schedules shown on the Contract Drawings.

D. The heater shall be factory insulated and enclosed with an outer jacket having a baked enamel finish.

E. The heater's factory-furnished piping, accessories, etc., not factory insulated shall be field insulated, in accordance with Insulation Specification Section Nos. 15491 and 15945.

2.03 SHOP TESTS

Perform manufacturer's standard shop tests and tests required by provisions of ASME Boiler and Pressure Vessel Code.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install water heaters in accordance with manufacturer's installation procedures. Install heaters plumb and level, firmly anchored in locations shown on the Contract Drawings and maintain manufacturer's recommended clearances for service and maintenance.

B. Connect steam and condensate, hot and cold water piping to heaters with shut-off valves and unions.

C. Extend relief valve discharge to closest floor drain unless otherwise shown on the Contract Drawings.

D. Field install all electrical devices furnished under this Section.

E. Verify that electrical wiring installation is in accordance with Engineer-approved manufacturer's submittal and in accordance with installation requirements of Division 16.

3.02 FIELD TESTS

Start up, test, and adjust water heaters in accordance with manufacturer's start-up instructions.

END OF SECTION

SECTION 15458

WATER HEATERS - STEAM-TO-WATER

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Shop and coordination drawings shall be single line at a minimum of 3/8"=1'-0" scale.

   a. Shop drawings indicating dimensions, required clearances and methods of assembly of components.

   b. Electrical wiring diagrams for electrical power supply, interlock and control. Differentiate between portions of wiring that are factory installed and portions that are to be field installed.

   c. Coordination drawings showing plan views amd sections, drawn to scale, on which all items are shown and coordinated with all Work of other Sections.

B. Product Data / Catalog Cuts

1. Product data including rated capacities, recovery rates, operating weights, specialties and accessories.

C. Certificates

1. Submit certificates of shop inspection and data report required by provisions of ASME Boiler and Pressure Vessel Code.

D. Construction and Installation Procedures

1. Field test procedures.

E. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive information for the specific approved equipment; including approved shop drawings and catalog cuts, sequence of operation, test results, troubleshooting, maintenance requirements, spare parts lists, electrical/control devices and electrical/control wiring diagram(s).

F. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15458

WATER HEATERS - STEAM-TO-WATER

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

1. Contract Drawings

(2.02 A)	Arrangements of water heaters.
(2.02 A)	Installation locations.
(3.02 C)	Relief valve discharge piping.

2. Schedules (shown on the Contract Drawings)

(1.02 B)	Design and performance requirements (overall).
(2.02 A)	Sizes, capacities, and pressure drops (water side).
(2.02 B)	Hot water outlet set-temperature at the design conditions.
(2.02 C.10)	Electrical characteristics for circulator.

B. Other Items

1. Ensure that the Specifications include the following Sections referenced in this Section:

(2.02 E)	Section 15491 "PLUMBING INSULATION" and Section 15945 "HVAC INSULATION"

2. Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15459

ELECTRIC WATER HEATERS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for electric water heaters.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State, and Local laws, ordinances, regulations and codes and the latest industry standards including, but not limited to the entities listed below.

New York City Building Code
New Jersey Uniform Construction Code
New York State Energy Conservation Construction Code
The BOCA National Energy Conservation Code
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
American Society of Mechanical Engineers (ASME)
Underwriters Laboratories Inc. (UL)
National Electrical Code (NEC)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Design and performance requirements of electric water heaters shall be as specified in the Electric Water Heater Schedules (hereinafter in this Section "Schedules") shown on the Contract Drawings.

C. Water storage tanks shall be designed and constructed in accordance with ASME Code and bear the ASME label.

D. Electric water heaters shall be UL listed.

1.03 QUALITY ASSURANCE

Electric water heaters, of types and capacities required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver water heaters and components in factory-fabricated protective packaging.

B. Handle water heaters and components carefully to prevent breaking, denting and scoring.

C. Store water heaters and components in clean, dry spaces and protect them from weather.

D. Comply with manufacturer's rigging instructions for unloading water heaters and moving them to final location for installation.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with the requirements of this Sectionl furnish and install electric water heaters of one of the following manufacturers, or approved equal:

A.O. Smith Water Products Co.
Rheem Manufacturing Co
State Industries Inc.

2.02 CONSTRUCTION FEATURES

A. Electric water heaters shall be of sizes, arrangements, capacities, recovery rates and electrical characteristics as specified in the Schedules and as shown on the Contract Drawings.

B. Heaters shall have 150 psi working pressure, extruded high-density magnesium anode rods for cathodic protection and glass lining on internal surfaces exposed to water.

C. Number and watt density of electric heating elements shall be as specified in the Schedules shown on the Contract Drawings. Provide a thermostat and a high temperature cut-off switch for each heating element.

D. The heater shall be factory-insulated and enclosed with an outer jacket having a baked enamel finish. The heater shall be provided with full-size control compartment for service and maintenance through front panel openings.

E. Provide drain valve in the front of heater for ease of servicing.

F. Provide minimum 3/4 inch NPT relief valves.

G. Provide electrical junction boxes with heavy-duty terminal blocks.

2.03 SHOP TESTS

Perform manufacturer's standard shop tests and tests required by provisions of ASME Boiler and Pressure Vessel Code.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install water heaters in accordance with manufacturer's installation procedures. Install heaters plumb and level, firmly anchored in locations shown on the Contract Drawings and maintain manufacturer's recommended clearances for service and maintenance.

B. Connect hot and cold water piping to heaters with shut-off valves and unions.

C. Provide thermometers on inlet and outlet piping of water heaters.

D. Extend relief valve discharge to closest floor drain, unless otherwise shown on the Contract Drawings.

E. Field install all electrical devices furnished under this Section.

F. Verify that electrical wiring installation is in accordance with Engineer-approved submittals and in accordance with installation requirements of Division 16.

3.02 FIELD TESTS

Start up, test and adjust water heaters in accordance with manufacturer's start-up instructions.

END OF SECTION

SECTION 15459

ELECTRIC WATER HEATERS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Shop and coordination drawings shall be single line at a minimum of 3/8"=1'-0" scale.

   a. Shop drawings indicating dimensions, required clearances and methods of assembly of components.

   b. Electrical wiring diagrams for electrical power supply, interlock and control. Differentiate between portions of wiring that are factory installed and portions that are field installed.

   c. Coordination drawings showing plan views and sections, drawn to scale, on which all items are shown and coordinated with all Work of other Sections.

B. Product Data / Catalog Cuts

1. Product data including rated capacities, recovery rates, operating weights, specialties and accessories.

C. Certificates

1. Submit certificates of shop inspection and data report required by provisions of ASME Boiler and Pressure Vessel Code.

D. Construction and Installation Procedures

1. Field test procedures.

E. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive information for the specific approved equipment; including approved shop drawings and catalog cuts, sequence of operation, test results, troubleshooting, maintenance requirements, spare parts lists, electrical/control devices and electrical/control wiring diagram(s).

F. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15459

ELECTRIC WATER HEATERS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

1. Contract Drawings

(2.02 A)	Arrangements of water heaters.
(3.01 A)	Installation locations.
(3.01 D)	Relief valve discharge piping.

2. Schedules (shown on the Contract Drawings)

(1.02 B)	Design and performance requirements (overall).
(2.02 A)	Sizes, capacities, recovery rates, and electrical characteristics.*
(2.02 C)	Number and watt density of electric heating elements.*

*Coordinate with Electrical Staff.

B. Other Items

Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15460

CHILLED DRINKING WATER PIPING AND APPURTENANCES

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for chilled drinking water piping and appurtenances.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

New York City Building Code

New Jersey Uniform Construction Code

American National Standards Institute (ANSI)

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

American Society of Mechanical Engineers (ASME)

American Society for Testing and Materials (ASTM)

Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

1.03 QUALITY ASSURANCE

A. Chilled drinking water piping and appurtenances, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Entities performing work shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Clean all pipe sections of foreign matter and cover ends with temporary sheet metal closures or plastic end caps of sufficient tightness to prevent entry of foreign matter prior to shipping to the construction site.

B. Store pipe, fittings, valves and other components at the construction site on pallets or raised platforms with suitable coverings satisfactory to the Engineer to protect them against damage and weather.

C. Inspect all pipe, fittings, valves and other components for damage before moving them from storage to installation site.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with the requirements of this Section, furnish and install the chilled drinking water appurtenances as a package, from one of the following manufacturers, or approved equal:

A. Chiller/Filter Package

Dunham - Bush Inc.
Filtrine Manufacturing Co.
Sunroc Corporation

B. Circulation Pumps

Bell and Gossett Co.
Goulds Pumps, Inc.
Ingersoll Rand
Weil Pump Co.

2.02 PIPE, FITTINGS, AND FLANGES

A. Provide pipe, fittings, and flanges in accordance with the "Pipe, Fittings and Flanges Schedule" below, including gaskets, bolts, nuts, washers and other pressure containing parts necessary for the complete installation of the chilled drinking water piping.

B. Nipples shall be extra-heavy shoulder type. No close nipples shall be used. All nipples shall have designation mark of the manufacturer and shall conform to ASTM pipe specifications for system served.

C. Unions shall be brass, threaded, conforming to ASTM specifications for system served.

Pipe, Fittings and Flanges Schedule

System	Pipe	Fittings and Flanges
All Distribution	Copper Tubing, ASTM B.88, Type "L", Drawn, Nominal Wall	Cast Bronze, ANSI B16.18, Same Wall as Tube, Solder Joints

2.03 VALVES

A. General

1. Provide types of valves as and where shown on the Contract Drawings.
2. Unless otherwise shown on the Contract Drawings, furnish and install valves of same size as upstream pipe size.
3. Each type of valve shall be the product of one manufacturer.
4. Valves shall be of one of the following manufacturers, or approved equal:

   Crane Co.
   NIBCO Inc.
   Stockham Valves and Fittings
   Walworth Co.

B. Gate Valves

Class 150, bronze body, screw-in bonnet, rising stem, solid wedge, approved equal of Crane Fig. 431 (threaded ends), or Fig. 1334 (soldered ends).

C. Globe Valves

Class 150, bronze body, screw-in bonnet, rising stem, integral seat, renewable disc, approved equal of Crane Fig. 7TF (threaded ends), or Fig. 1310 (solder ends).

D. Drain Valves

Class 125, gate valve, bronze body, screw-in bonnet, non-rising stem, solid wedge, threaded ends on inlet side of valve, and hose end thread with cap and chain on the outlet side, similar to NIBCO Fig. T-113-HC, or approved equal.

E. Check Valves

Class 150, bronze body, horizontal swing, renewable disc, approved equal of Crane Fig. 137 (threaded ends), or Fig. 1342 (solder ends).

F. Ball Valves

For piping 1 inch and smaller: Class 150, bronze body, full port, bronze trim, approved equal of Crane Fig. F9102 (threaded ends), or Fig. F9122 (solder ends).

2.04 CHILLED DRINKING WATER PLANT

A. Furnish and install as scheduled on the Contract Drawings, a complete factory-packaged remote chilled drinking water plant to recirculate filtered, tasteless and adorless chilled drinking water to various remote drinking water outlets as indicated on the Contract Drawings. The central package water chilling unit shall include, but shall not be limited to chilled water reservoir, a refrigeration unit, a recirculating pump, make-up water treatment filter elements, in-loop sterlizer, and programmable microprocessor controls. The unit shall be completely factory pre-piped, with piping fully insulated and pre-wired for atuomatic operation. The above shall be housed within an angle iron flame, enclosed in minimum 20-gauge galvanized steel panels with removable ventilation panels around machine compartment.

B. Storage Tank

The storage tank shall be constructed of stainless steel and tested for 125 lbs. working pressure at 250 lbs. test pressure, and having a storage and cooling capacity as shown on the Contract Drawings, cooling drinking water from 80 to 45 degrees F. Evaporator shall be constructed of copper pipe. Cooler shall be insulated with 2 inch urethane foam all around, vapor sealed.

C. Circulating Pump

Provide one bronze fitted centrifugal type pump, factory installed on rubber pads over stainless steel condensation drip tray. Motor shall be equipped with magnetic starter. Piping between pump and cooler shall include dial thermometer in discharge line, by-pass flow-control valves, insulated with molded styrofoam. Pump shall have capacity as shown on the Contract Drawings.

D. Filters

Provide a dual element type filter, having a capacity as shown on the Contract Drawings. Filter shall be equipped with cell to remove taste, order, organic chemicals, PCB's, chlorine and other waste chemicals. Cell shall be charged with not less than 1.8 cu. ft. of highly activated carbon. Filter shall have separate replacement element to remove rust, silt, and other suspended matter. Each unit shall withstand 125 lbs. W.P, and be equipped with piping and valves for backwash. Four dozen extra filter elements shall be included.

E. Condensing Unit and Controls

Provide system with a hermetic compressor and condenser having total rated capacity necessary to produce the recovery noted on the Contract Drawings at 30 degrees F suction with air condensing medium of 90 degrees F. The compressor shall be factory installed in the cooler housing with magnetic starter, expansion valve, liquid solenoid valve, sight glass, dehydrator, vibration isolators, low temperature control, hi-lo pressure control, suction and liquid gauges,valves and all necessary wiring and 'ozone safe' refrigerant mounted on vibration eliminators. Condensing coils shall be fin and tube type, suitable for air as the cooling medium. Condenser fans shall be provided with permanently lubricated motors. Operation of the condensing unit shall be controlled from a thermostat sensing drinking water supply temperature at chiller's outlet. Provide a pump-down at the end of each cycle of operation.

F. Microprocessor Controller

Include on the unit a solid state microprocessor controller which shall combine process valves and diagnostic functions into a single pre-programmed display board. The board shall include a display with alpha-numeric characters, a key pad for entering the set points and alarm valves, and buttons for on/off, reset, menu, scroll and optional remote selections.

G. Complete Package System

All of the above components shall be mounted in a rust-proofed sheet housing reinforced on all four sides with welded angle iron frame. Tank section shall be insulated with 3" poured urethane and shall have snap-on panels for access to controls and removable head. Condensing unit section shall be equipped with readily removable ventilated access panels. Provide a 4" concrete house keeping pad under the entire piece of equipment.

2.05 ACCESSORIES

A. Pipe and Valve Identification

1. Adhesive Bands

a. Provide approved adhesive bands in sets of two, one identifying the piping system type and the second, the direction of flow. Sets shall be provided in quantities sufficient to accommodate the installation requirements of 3.04 A of this Section.

b. The letters and the arrow shall be not less than one inch high. Bands shall be in colors and shall conform to ANSI A13.1.

c. Adhesive bands shall be W.H. Brady Co. "Quik-Label", or approved equal.

2. Valve Tags, Charts and Schedules

a. Provide each valve with a 2-inch diameter 18 gauge brass tag with brass chain. Service designation shall be 1/4-inch high and valve number shall be 1/2-inch high, on two lines with service designation on the upper line, and valve designation on the lower line. The characters shall be indented and filled with durable black compound.

b. Provide diagrammatic valve charts and schedules, using a valve numbering system which differentiates between classes of service and indicates floor level of valve location.

c. Tags shall conform to the numbers, locations, and uses listed in the valve charts and schedules.

d. Valve charts and schedules shall be mounted under glass in wood frames or aluminum self-closing frames.

e. Valve tags and the frames for valve charts and schedules shall be manufactured by Seton Name Plate Corp., or approved equal.

B. Access Doors

Provide a complete list of all access doors required in finished walls, ceilings, partitions, etc. for access to all valves concealed behind such finished construction. These access doors will be furnished and installed under the Work of other Sections.

C. Pipe Hangers and Supports

1. Design, fabricate and provide all pipe hangers and supports adequate to support and guide the piping, allow for forces imposed by expansion joints, satisfy structural requirements and maintain proper clearances with respect to adjacent piping, equipment and structures.
2. Provide hangers and supports, with beam clamps, restraints, supplemental steel, inserts, fish plates, mounting devices, etc., to support piping alignment without sagging or interference, and to permit free expansion and contraction. Provide retaining straps when installing beam clamps or C clamps.
3. Keep the different types of hangers to a minimum and provide hangers that are neat, without complicated bolting and with the number of parts of each hanger and its anchor kept to a minimum.
4. Suspend hangers from beam clamps, brackets, fish plates, inserts or by other approved means. Furnish and install any additional miscellaneous steel supports between building framing members as may be required.
5. Support vertical piping with riser clamps.
6. Trapeze type hangers of steel construction, with hold-down U-bolts, may be used for two or more pipes which have a uniform slope throughout.
7. When loads between supports can be expected to cause a sag in the pipe in excess of 1/4 inch, reduce spacing as necessary to stay within such a limit.
8. Provide and install on all supporting rods, a forged steel turnbuckle with top and bottom lockouts having a vertical adjustment of 6 inches, minimum.
9. All pipe hangers, rods, supports, clamps, and other associated components shall be galvanized.
10. Do not hang piping from other piping and ductwork.
11. Vertical pipes shall be supported on every floor and at intervals between floors so that no more than 10 feet of pipe is unsupported.
12. Copper plate all hangers, clamps, supports, etc. that will be in direct contact with brass or copper tubing.
13. Provide protection shields for all insulated piping at all points of support. Shields shall be 12 inches long, galvanized steel plate with a radius suitable for the required applications, including insulation.
14. Tabs in metal deck construction shall not be used to support pipe.
15. Provide pipe anchors where necessary to restrain forces due to thermal expansion and contraction of pipe.

16. Anchors shall be adequately designed to rigidly oppose forces acting on them and shall be embedded in structural concrete or connected to the building structural steel framework.

17. Provide pipe guides where necessary to confine movement along the centerline of the pipe due to thermal expansion and contraction between anchors. Guides shall be adequately designed and placed, generally between 20 to 30 feet on centers and an equal distance from the expansion loop.

18. Expansion anchors, self-drilling expansion shields, power driven studs and similar devices shall not be used, unless specifically approved by the Engineer.

19. Perforated band iron, strap iron or wire are not acceptable materials to be used, and will not be approved.

20. Unless otherwise specifically approved, hanger rod size and spacing shall be within the following limits:

Pipe Size	Maximum Hanger Spacing	Minimum Rod Size
1/2" to 1-1/4"	6 ft. o.c.	3/8"
1-1/2" to 2"	8 ft. o.c.	3/8"

21. Hangers and supports shall be manufactured by Grinnell Corp., Carpenter & Patterson Inc., Michigan Hanger Co. Inc., or approved equal.

D. Sleeves, Seals and Escutcheons

1. Pipe Penetration through Walls, Partitions and Floors

a. Piping passing through masonry or concrete walls and framed partitions shall have a trim opening cut no greater than necessary for the installation of a sleeve secured therein. Sleeve shall be 1/2 inch in diameter larger than the outside diameter of the pipe or pipe insulation. Sleeve length shall be flush with the finished wall or partition surface.

b. Sleeves through concrete floors shall have the opening 1/2 inch in diameter larger than the outside diameter of the pipe or insulation passing through. Floor sleeves shall project one inch above floor slab.

c. Annular spaces between pipe or insulated piping and sleeves shall be packed with mineral wool and sealed to retain the fire integrity of the walls, partitions, and floors with non-hardening through-penetration firestops having F-ratings compatible with the fire ratings of the barriers in which they are installed, per ASTM E 814. Firestop systems shall be UL-approved, and be as manufactured by 3M, Bio Fireshield, Inc., General Electric Company, Dow-Corning Corp., or approved equal.

d. Sleeves in walls and floors shall be galvanized steel pipe, Schedule 40. Sleeves in partitions shall be 20-gauge galvanized sheet metal.

e. Piping in exposed areas, passing through walls, floors or ceilings shall be fitted with chromium-plated cast brass escutcheons with fastening set screws.

f. Piping passing through floor waterproofing membrane shall be provided with a 4-pound lead flashing or a 16-ounce copper flashing, each within an integral skirt or flange. Flashing shall be suitably formed, and the skirt or flange shall extend not less than 8 inches from the pipe and shall be set over the floor membrane in a solid coating of bituminous cement. The flashing shall extend up the pipe a minimum of 10 inches above the floor. The annular space between the flashing and the pipe shall be sealed watertight.

g. Piping passing through roof construction shall be provided with counterflashing, consisting of steel rainhood secured all around the pipe and overlapping the flashing.

PART 3. EXECUTION

3.01 INSTALLATION

A. General

1. Install piping and appurtenances in accordance with manufacturer's installation procedures, applicable codes and standards, and as specified.

2. Coordinate piping installation with other work to avoid interference. Coordinate as necessary to ensure that all hangers, supports, sleeves and other built-in devices are incorporated in forms or in masonry to avoid necessity of cutting finished structure.

3. All measurements, both horizontal and vertical, shall be based on established benchmarks. All work shall agree with these established lines and levels. Verify all measurements at site and check the correctness of same as related to the work.

4. Perform necessary cutting and patching in accordance with requirements specified in Division 2 Section entitled "CUTTING PATCHING AND REMOVAL." All openings in existing slabs required for pipe penetrations shall be core drilled.

5. Installation requirements for hangers and supports and for pipe penetration sleeves, seals and escutcheons are specified in 2.05.

B. Piping

1. Install piping as shown on the Contract Drawings, and straight and direct as possible, forming right angles or parallel lines with building walls, neatly spaced, with risers plumb and true.

2. Avoid tool marks and unnecessary pipe threads. Burrs formed when cutting pipe shall be removed by reaming. Cut all piping square and smooth; make up all joints to required limits.

3. Make changes in pipe size by the use of reducing fittings. Do not use reducing bushings except by approval of the Engineer.

4. Installed piping shall not interfere with the operation or accessibility of doors or windows; shall not encroach on aisles, passageways and equipment; add shall not interfere with the servicing or maintenance of any equipment. Adjacent pipelines shall be grouped in the same horizontal or vertical plane.

5. Make all changes in direction using pipe and fittings, only.

6. Make connections to equipment, using flanges or unions.

7. Plug each outlet, including valves, with plug or cap immediately after installation and retain until continuing piping or equipment connections are completed.

8. Use dielectric unions where dissimilar metals are joined together.

9. Install piping with 1/64 inch per foot downward slope in direction of flow.

10. Chilled water mains and branches shall be installed free of any traps or air pockets unless relieved by a fixture branch taken from the top of the main or at the high point of the system with an approved type of air vent valve.

C. Pipe Joints

1. Threaded Joints

   Make up threaded joints tight using pipe joint Teflon compound or tape, applied on the male thread only.

2. Flanged Joints

   Make up flanged joints square and tight with gaskets. Dip bolts and nuts in mixture of graphite and oil immediately prior to installation.

3. Soldered Joints

   a. Cut ends of tubing square and remove all burrs. Clean inside and outside of tubing with steel wool.

   b. Make joints with non-corrosive paste flux and 95 per cent tin and 5 per cent antimony solder. Cored or lead-containing solder is not permitted.

   c. Remove excess solder while still in plastic state.

   d. Leave a fillet at the wall of the fitting.

   e. Prior to silver soldering, remove the internal parts of all valves or other devices to be installed directly in line.

3.02 FIELD TEST

A. General

1. Perform tests on the piping system or portions thereof prior to painting, concealing or insulating.

2. Notify the Engineer and those authorities having jurisdiction, at least 48 hours in advance of making the required tests, so that arrangements can be made for their presence to witness the tests.

3. Provide and install necessary equipment, devices, materials, supplies, labor and power required in connection with tests.

4. Should the tests reveal any leaks or deficiencies, make necessary repairs immediately, or, if required by the Engineer, replace defective work with new work. Repeat tests as directed until the entire installation is proven satisfactory. No temporary method of repairing leaks will be permitted.

5. Where piping installed under this Section is connected to any existing system, such installed piping shall be isolated from the existing system during the performance of the required field tests, unless otherwise directed by the Engineer.

6. The Engineer reserves the right to direct the Contractor not to isolate the newly installed piping from the existing system during the performance of the required field tests. In such event, the Contractor shall correct any revealed leaks or other deficiencies within the first 20 feet of the existing system, measured in any direction from the point of connection with the newly installed piping, all as directed by the Engineer and at no additional cost to the Authority.

7. Dispose of water removed from pipelines in a manner that will not cause damage to any property.

8. Provide and install the required air vents at high points in the piping system that are to remain as a permanent installation.

9. All equipment, controls and instruments shall be isolated from the piping system during test, as well as during cleaning, disinfecting and flushing procedures.

10. Operation Test

After all chilled water piping and equipment has been installed, perform an operation test of the entire system, to verify that the complete factory-packaged, circulated, chilled, filtered, drinking water cooler plant and piping is installed and operating according to design and Specifications and to the satisfaction of the Engineers. Repeat test if necessary if adjustments were necessary.

B. Hydrostatic Test

1. Chilled Drinking Water

a. Cap or plug all outlets, apply a hydrostatic pressure of 125 psi and sustain such pressure for one hour.

b. For piping added, relocated or replaced on any existing systems, apply a hydrostatic pressure of 50 psi above the existing system pressure for one hour.

C. Cleaning and Disinfecting

The chilled drinking water system shall be disinfected prior to use by a method of disinfection in accordance with the applicable code.

3.03 PAINTING

Upon completion of the installation for all uninsulated, exposed pipings, remove all protecting materials, thoroughly remove all scale and grease and leave in a clean condition for painting. Piping to be painted shall be as shown on the Contract Drawings. Painting shall be in accordance with the requirements of Division 9 Section entitled "PAINTING".

3.04 PIPE AND VALVE IDENTIFICATION

A. Pipe Identification

Affix sets of pipe adhesive hands specified in 2.05 A.1 where they can be easily read, with their long dimension parallel to the axis of the pipe and no more than 40 feet apart on a piping system. At least one set of identifying bands shall be affixed in all occupied and unoccupied rooms as well as in all other spaces, such as hung ceilings or shafts, where piping may be viewed and the identity of the piping system cannot be readily ascertained. A set of such bands shall be affixed at each branch and riser takeoff; adjacent to each valve; at each pipe passage through floor and ceiling construction; at each capped line; and at each pipe passage to an underground area.

B. Valve Tags

Securely fasten valve tags specified in 2.05 A.2 with approved brass chain.

END OF SECTION

SECTION 15460

CHILLED DRINKING WATER PIPING AND APPURTENANCES

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Piping Shop Drawings

   Shop and coordination drawings shall be single line at a minimum of 3/8"=1'-0" scale.

   a. Piping layout and installation drawings, including the following at a minimum:

      (1) Plans, elevation, sections and riser diagram.

      (2) Hanger, support locations and details. Indicate methods of attachment to building structure.

      (3) Pipe elevations and dimensions from main piping runs to a reference point.

      (4) Penetrations through fire rated and other partitions.

      (5) Location for piping accessories, including valves and access doors.

   b. Piping coordination drawings showing plan views and sections, drawn to scale, on which all items are shown and coordinated with all Work of other Sections.

B. Product Data / Catalog Cuts

1. Piping and Accessories

   a. Pipe material and schedule

   b. Catalog cuts, including product performance data for all items furnished under this Contract, including the following at a minimum:

      (1) Pipe, pipe fittings and flanges.

      (2) Valves, including valve charts and schedules.

      (3) Hangers and supports, including schedule showing manufacturer's figure number, size, location and features of each required hanger and support.

      (4) Sleeves and escutcheons.

      (5) Valve tags and pipe identification bands.

      (6) Drinking water cooler package and controls.

      (7) Circulation pump.

      (8) Filters.

   c. List of access doors and schedules.

C. Construction and Installation Procedures

1. Field test procedure.

D. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive information for the specific approved equipment; including approved shop drawings and catalog cuts, sequence of operation, test results, troubleshooting, maintenance requirements, spare parts lists, electrical/control devices and electrical/control wiring diagram(s).

E. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

CHILLED DRINKING WATER PIPING AND APPURTENANCES

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.03 A.1)	Types and locations of valves
(2.03 A.2)	Valves not of the same size as upstream pipe sizes
(2.04 D)	Capacity of dual element type filter
(2.04 E)	Condensing unit recovery capacity
(2.04 A)	Parameters of complete factory-packaged remote chilled drinking water plant
(2.04 A)	Remote chilled drinking water outlets

B. Other Items

1. Ensure that the Specifications include the following Sections referenced in this Section:

   (3.01 A.4) "CUTTING, PATCHING AND REMOVAL"

   (3.03) "PAINTING"

2. Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15488

NATURAL GAS PIPING AND APPURTENANCES

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies requirements for natural gas piping and appurtenances.

B. All gas service main piping up to the gas meter will be installed by the local gas utility company. Coordinate this service main piping and the gas meter assembly installation with the utility company, and provide an entrance sleeve as required by the utility company.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local Laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

American Gas Association (AGA)

American National Standards Institute (ANSI)

American Society of Mechanical Engineers (ASME)

American Society for Testing and Materials (ASTM)

Local gas utility company

National Fire Protection Association (NFPA 54)

New York City Building Code

New Jersey Uniform Construction Code

Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

1.03 QUALITY ASSURANCE

A. Natural gas piping and appurtenances, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Entities performing work shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Clean all pipe sections of foreign matter and cover ends with temporary sheet metal closures or plastic end caps of sufficient tightness to prevent entry of foreign matter prior to shipping to the construction site.

B. Store pipe, fittings, valves and other components at the construction site on pallets or raised platforms with suitable coverings satisfactory to the Engineer to protect them against damage and weather.

C. Inspect all pipe, fittings, valves and other components for damage before moving them from storage to the point of installation at the construction site.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 PIPE, FITTINGS, AND FLANGES

A. Provide pipe, fittings and flanges in accordance with the "Pipe, Fittings and Flanges Schedule" shown within this Section including gaskets, bolts, nuts, washers and other pressure containing parts necessary for the complete installation of natural gas piping.

B. All welding elbows shall be long radius pattern unless otherwise shown on the Contract Drawings.

C. Nipples shall be extra-heavy shoulder type. No close nipples shall be used. All nipples shall have designation mark of the manufacturer and shall conform to ASTM pipe specifications for system served.

D. Buttwelding fittings shall be manufactured by Grinnell Corp., or approved equal.

E. Unions shall be malleable iron, threaded, conforming to ANSI B16.39.

F. Welding backing rings for buttwelding joints shall be Robvon Backing Ring Co. "Type CC", or approved equal.

G. Gaskets shall be 1/8-inch thick (after compression) for raised face flanges and 1/16-inch thick (after compression) for flat face flanges and shall be stainless steel, spiral-wound, non-asbestos filler, ring type.

H. Screwed fittings shall not be used in underground gas piping or piping buried in concrete; and the piping shall be coated to prevent corrosion. Coatings and their application shall be as per Utility requirements.

I. Gas piping located within crawl spaces or in areas with excessive moisture shall be wrapped and coated as per Utility requirements.

Pipe, Fittings and Flanges Schedule

Gas Pressure Range	Pipe	Fittings and Flanges
Up to 1/2 psig	Black Steel ASTM A 53, Gr.B or ASTM A 120, Schedule 40	Up to 4 inches - Threaded, Using Malleable, Iron, ANSI B16.3, 150 lb. Class 5 inches and Larger - Welded, Using Carbon Steel Fittings, ANSI B16.9, ASTM A 234 Gr. WPB, Same Rating as Pipe, Buttwelding, Forged Carbon Steel Flanges, ASTM A 105, ANSI B16.5, 150 lb. Class
Above 1/2 psig up to 3 psig	Black Steel, ASTM A 53, Gr.B. or ASTM A 120, Schedule 40	Up to 3 inches – Threaded, Using Malleable Iron, ANSI B16.3, 150 lb. Class 4 inches and Larger - Welded, Using Carbon Steel Fittings, ANSI B16.9, ASTM A 234 Gr. WPB; Same Rating as Pipe, Buttwelding, Forged Carbon Steel Flanges, ASTM A 105, ANSI B16.5, 150 lb. Class
Above 3 psig up to5 psig	Black Steel, ASTM A 53, Gr.B. or ASTM A 120, Schedule 40	All sizes - Welded, Using Carbon Steel Fittings, ANSI B16.9, ASTM A 234 GR. WPB; Same Rating as Pipe, Buttwelding, Forged Carbon Steel Flanges, ASTM A 105, ANSI B16.5, 150 lb. Class

2.02 VALVES

A. General

1. Provide types of valves as and where shown on the Contract Drawings.
2. Unless otherwise shown on the Contract Drawings, provide valves of same size as upstream pipe size.
3. Each type of valve shall be the product of one manufacturer, and shall be AGA certified.
4. Valves shall be of one of the following manufacturers, or approved equal:

   a. Plug Valves

      Walworth Co
      Homestead Valves, Div. Olson Technologies

   b. Gas Cocks

      Conbraco Industries, Inc.
      Matco Products, Inc.

B. Plug Valves

1. Valves, 2-1/2 inches and larger, shall be lubricated, iron body, 125 psi w.o.g., flanged ends, wrench operated type.

2. Valves, 2 inches and 1-1/2 inches, shall be lubricated, iron body, 125 psi w.o.g., threaded ends, wrench operated type.

C. Gas Cocks

Valves, 1-1/4 inches and smaller, shall be lever handle or tee head, bronze, straightway, 150 psi w.o.g., threaded ends type.

2.03 ACCESSORIES

A. Pipe and Valve Identification

1. Adhesive Bands

a. Provide approved adhesive bands in sets of two, one identifying the piping system type and the second, the direction of flow. Sets shall be provided in quantities sufficient to accommodate the installation requirements of 3.04 A of this Section.

b. For 3-inch or larger pipe, the adhesive band identifying the piping system shall display the name of the service in letters at least two inches high and the band indicating direction of flow shall display an arrow of similar size. For 2-1/2-inch or smaller pipe, the letters and the arrow shall be not less than one inch high. Bands shall be in colors and shall conform to ANSI A13.1.

c. Adhesive bands shall be W.H. Brady Co. "Quik-Label", or approved equal.

2. Valve Tags, Charts and Schedules

a. Provide each valve with a 2-inch diameter 18 gauge brass tag with brass chain. Service designation shall be 1/4-inch high and valve number shall be 1/2-inch high, on two lines with service designation on the upper line and valve number on the lower line. The characters shall be indented and filled with durable black compound.

b. Provide diagrammatic valve charts and schedules, using a valve numbering system that differentiates between classes of service and indicates floor level of valve location.

c. Tags shall conform to the numbers, locations, and uses listed in the valve charts and schedules.

d. Valve charts and schedules shall be mounted under glass in wood frames or aluminum self-closing frames.

e. Valve tags and the frames for valve charts and schedules shall be manufactured by Seton Name Plate Corp., or approved equal.

B. Access Doors

Provide a complete list of all access doors required in finished walls, ceilings, partitions and any other areas for access to all valves concealed behind such finished construction. Access doors will be furnished and installed under other Sections of the Specifications.

2.04 PIPE HANGERS AND SUPPORTS

A. Design, fabricate and provide all pipe hangers and supports adequate to support and guide the piping, allow for forces imposed by expansion joints, satisfy structural requirements and maintain proper clearances with respect to adjacent piping, equipment and structures.

B. Provide hangers and supports, with beam clamps, restraints, supplemental steel, inserts, fish plates, mounting devices, etc., to support piping in alignment without sagging or interference, and to permit free expansion and contraction.

C. Keep the different types of hangers to a minimum and provide hangers that are neat, without complicated bolting and with the number of parts of each hanger and its anchor kept to a minimum.

D. Suspend hangers from beam clamps, brackets, fish plates, inserts or by other approved means. Furnish and install any additional miscellaneous steel supports between building framing members as may be required.

E. Support main vertical piping with steel riser clamps.

F. Trapeze type hangers of steel construction, with hold-down U-bolts, may be used for two or more pipes which have a uniform slope throughout.

G. When loads between supports can be expected to cause a sag in the pipe in excess of 1/4 inch, reduce spacing as necessary to stay within such a limit.

H. Provide and install on all supporting rods, a forged steel turnbuckle with top and bottom lockouts having a vertical adjustment of 6 inches, minimum.

I. All pipe hangers, rods, supports, clamps, etc. shall be furnished with a finish of black protective paint.

J. Do not hang piping from other piping and ductwork.

K. Vertical risers shall be supported on every floor and at intervals between floors so that no more than 10 feet of pipe is unsupported.

L. Tabs in metal deck construction shall not be used to support pipe.

M. Provide pipe anchors where necessary to restrain forces due to thermal expansion and contraction of pipe.

N. Anchors shall be adequately designed to rigidly oppose forces acting on them and shall be embedded in structural concrete or connected to the building structural steel framework.

O. Provide pipe guides where necessary to confine movement along the centerline of the pipe due to thermal expansion and contraction between anchors. Guides shall be adequately designed and placed, generally between 20 to 30 feet on centers and an equal distance from the expansion loop.

P. Unless otherwise specifically approved, hanger rod size and spacing shall be within the following limits:

Pipe Size	Maximum Hanger Spacing	Minimum Rod Size
1/2" to 1"	8 ft. o.c.	3/8"
1-1/4" to 2"	10 ft. o.c.	3/8"
2-1/2" to 3-1/2"	12 ft. o.c.	1/2"
4" and 5"	12 ft. o.c.	5/8"
6"	12 ft. o.c.	3/4"
8"	12 ft. o.c.	7/8"

Q. Hangers and supports shall be manufactured by Grinnell Corp., Carpenter & Patterson Inc., Michigan Hanger Co Inc., or approved equal.

2.05 SLEEVES, SEALS, AND ESCUTCHEONS

A. Pipe Penetration through Walls, Partitions and Floors

1. Piping passing through masonry or concrete walls and framed partitions shall have a trim opening cut no greater than necessary for the installation of a sleeve secured therein. Sleeve shall be 1/2 inch in diameter larger than the outside diameter of the pipe. Sleeve length shall be flush with the finished wall or partition surface.

2. Sleeves through concrete floors for piping shall have the opening 1/2 inch in diameter larger than the outside diameter of the pipe passing through. Floor sleeves shall project one inch above floor slab.

3. Annular spaces between insulated piping and sleeves shall be packed with mineral wool and sealed to retain the fire integrity of the walls, partitions, and floors with non-hardening through-penetrating firestops having F-ratings compatible with the fire ratings of the barriers in which they are installed, per ASTM E 814.

   Firestop systems shall be UL-approved, and shall be as manufactured by 3M; Bio fireshield, Inc.; General Electric Company; Dow Corning Corporation; or approved equal.

4. Sleeves in walls and floors shall be galvanized steel pipe, Schedule 40 for sizes up to 10 inches and 3/8-inch wall thickness for 12 inches and larger. Sleeves in partitions shall be 20-gauge galvanized sheet metal.

5. Piping in exposed areas, passing through walls, floors or ceilings shall be fitted with chromium-plated cast brass escutcheons with fastening set screws.

6. Piping passing through floor waterproofing membrane shall be provided with a 4-pound lead flashing or a 16-ounce copper flashing, each within an integral skirt or flange. Flashing shall be suitably formed, and the skirt or flange shall extend not less than 8 inches from the pipe and shall be set over the floor membrane in a solid coating of bituminous cement. The flashing shall extend up the pipe a minimum of 10 inches above the floor. The annular space between the flashing and the pipe shall be sealed watertight.

7. Piping passing through roof construction shall be provided with counterflashing, consisting of steel rainhood secured all around the pipe and overlapping the flashing.

B. Pipe Penetration through Exterior Foundation and Pit Walls

1. General

a. All penetrations for piping through perimeter foundation walls and subgrade pit walls shall be provided with pipe sleeves and seals as shown on the Contract Drawings.

b. Sleeves shall be Schedule 40 for sizes up to 10 inches and 3/8-inch wall thickness for sizes 12 inches and larger. All pipe sleeves shall be galvanized steel, set into foundation walls with anchors and water stop plates.

2. Lead-Oakum Seals

Where "Lead-Oakum" seals are shown on the Contract Drawings, the annular space between the pipe and the sleeve shall be made watertight by caulking with oakum and poured lead, edged and trimmed.

3. Interlocking Modular Seals (Link-Seal)

a. Where "Link-Seal" is shown on the Contract Drawings, seal shall be modular mechanical type, consisting of interlocking sealing element links shaped to continuously fill the annular space between the pipe and the sleeve. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and nut. After the seal assembly is positioned in the sleeve, tightening of the bolts shall cause the sealing elements to expand and provide a watertight seal between the pipe and the sleeved opening. The seal shall provide electrical insulation between the pipe and wall.

b. The inside diameter of each wall sleeve shall be sized as recommended by the manufacturer to fit the pipe and seal to ensure a watertight joint. If pipe outside diameter is nonstandard due to coating or insulation, consult the manufacturer for recommendations before proceeding with wall sleeve sizing.

c. Install sleeves and seals in accordance with the seal manufacturer's instructions to provide a watertight installation.

d. Seals for perimeter foundation wall penetrations shall be two individual sealing units in tandem unless otherwise shown on the Contract Drawings. Single sealing unit shall be used for pit wall penetration unless otherwise shown on the Contract Drawings.

e. Seals shall be Thunderline Corp. "Link-Seal", or approved equal.

C. Gas service entry sleeve shall be in accordance with the local gas utility company's requirements.

PART 3. EXECUTION

3.01 INSTALLATION

A. General

1. Install piping and appurtenances in accordance with manufacturers' installation procedures, applicable codes and standards, and as specified.

2. Coordinate piping installation with other work to avoid interference. Coordinate as necessary to ensure that all hangers, supports, sleeves and other built-in devices are incorporated in forms or in masonry to avoid necessity of cutting finished structure.

3. All measurements, both horizontal and vertical, shall be based on established benchmarks. All work shall agree with these established lines and levels. Verify all measurements at site and check the correctness of same as related to the Work.

4. Perform necessary cutting and patching in accordance with requirements specified in Division 2 Section entitled "CUTTING, PATCHING AND REMOVAL." All openings in existing slabs required for pipe penetrations shall be core drilled.

5. Installation requirements for hangers and supports and for pipe penetration sleeves, seals, and escutcheons are specified in 2.04 and 2.05, respectively.

B. Piping

1. Install piping as shown on the Contract Drawings and straight and direct as possible, forming right angles or parallel lines with building walls, neatly spaced, with risers plumb and true.

2. Avoid tool marks and unnecessary pipe threads. Burrs formed when cutting pipe shall be removed by reaming. Cut all pipe square and smooth; make up all joints to required limits.

3. Make changes in pipe size by the use of reducing fittings. Do not use reducing bushings except by approval of the Engineer.

4. Installed piping shall not interfere with the operation or accessibility of doors or windows; shall not encroach on aisles, passageways and equipment; and shall not interfere with the servicing or maintenance of any equipment. Adjacent pipelines shall be grouped in the same horizontal or vertical plane.

5. Make all changes in direction using pipe and fittings, only.

6. Make connections to equipment, using flanges or unions.

7. Plug each gas outlet, including valves, with threaded plug or cap immediately after installation and retain until continuing piping or equipment connections are completed.

8. Use dielectric fittings where dissimilar metals are joined.

9. Install drip-legs in gas piping where shown on the Contract Drawings and where required by the applicable building code.

10. Install piping with 1/64 inch per foot downward slope in direction of flow.

C. Gas Meter Assembly

The gas meter and pressure regulating valves will be furnished by the local gas utility company but shall be installed under this Section in accordance with the local gas utility company's requirements, unless otherwise shown on the Contract Drawings.

D. Pipe Joints

1. Threaded Joints

Make up threaded joints using pipe joint Teflon compound or tape, placed on the male thread only.

2. Flanged Joints

Make up flanged joints square and tight with gaskets. Dip bolts and nuts in mixture of graphite and oil immediately prior to installation.

3. Welded Joints

a. Use shielded metal-arc welding or submerged-arc welding process. Direct current shall be used exclusively.

b. Each welder shall be certified in accordance with ASME Section IX.

c. All welded pipe joints shall be radiographed. Documentation thereof shall be submitted to the Engineer for acceptance.

3.02 FIELD TESTS

A. General

1. Perform tests on the gas piping system or portions thereof prior to painting or concealing.

2. Notify the Engineer and those authorities having jurisdiction at least 48 hours in advance of making the required tests, so that arrangements can be made for their presence to witness the tests.

3. Provide and install necessary equipment, devices, materials, supplies, labor and power required in connection with tests.

4. Should the tests reveal any leaks or deficiencies, make necessary repairs immediately, or, if required by the Engineer, replace defective work with new work without additional cost to the Authority. Repeat tests as directed until the entire installation is proven satisfactory. No temporary method of repairing leaks will be permitted.

5. All equipment, controls, instruments and valves shall be isolated from the piping system during test.

B. Air Tests

Test piping system with compressed air at a pressure 1-1/2 times the maximum working pressure, but not less than six inches of mercury (3 psig). Use a mercury gauge. Test duration shall be not less than one hour for each 500 cubic feet of pipe volume or fraction thereof. When testing a system having a volume less than 10 cubic feet, the test duration may be reduced to 10 minutes. For piping systems having a volume of more than 24,000 cubic feet, the duration of the test need not exceed 24 hours.

3.03 PAINTING

Upon completion of the installation, remove all protecting materials, thoroughly remove all scale and grease and leave in a clean condition for painting. Piping to be painted shall be as shown on the Contract Drawings. Painting shall be in accordance with the requirements of Division 9 Section entitled "PAINTING".

3.04 PIPE AND VALVE IDENTIFICATION

A. Pipe Identification

Affix sets of pipe adhesive bands specified in 2.03 A.1 where they can be easily read, with their long dimension parallel to the axis of the pipe, and no more than 40 feet apart on a piping system. At least one set of identifying bands shall be affixed in all occupied and unoccupied rooms as well as in all other spaces, such as hung ceilings or shafts, where piping may be viewed and the identity of the piping system cannot be readily ascertained.

B. Valve Tags

Securely fasten valve tags specified in 2.03 A.2 with approved brass chain.

END OF SECTION

SECTION 15488

NATURAL GAS PIPING AND APPURTENANCES

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Piping Shop Drawings

   Shop and coordination drawings shall be single line at a minimum of 3/8"=1'-0" scale.

   a. Piping layout and installation drawings, including the following at a minimum:

      (1) Plans, elevation, sections and riser diagram.

      (2) Hanger, support locations and details. Indicate methods of attachment to building structure.

      (3) Pipe elevations and dimensions from main piping runs to a reference point.

      (4) Penetrations through fire rated and other partitions.

      (5) Location for piping accessories, including valves and access doors.

   b. Piping coordination drawings showing plan views and sections, drawn to scale, on which all items are shown and coordinated with all Work of other Sections.

B. Product Data / Catalog Cuts

1. Piping and Accessories

   a. Pipe material and schedule.

   b. Catalog cuts, including product performance data for all items furnished under this Contract, including the following at a minimum:

      (1) Pipe, fittings and flanges.

      (2) Valves, including valve charts and schedules.

      (3) Hangers and supports, including schedule showing manufacturer's figure number, size, location and features of each required hanger and support.

      (4) Sleeves and escutcheons.

      (5) Valve tags and pipe identification bands.

   c. List of access doors and schedules.

C. Construction and Installation Procedures

1. Field test procedure.

D. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive information for the specific approved equipment; including approved shop drawings and catalog cuts, sequence of operation, test results, troubleshooting, maintenance requirements, spare parts lists, electrical/control devices and electrical/control wiring diagram(s).

E. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15488

NATURAL GAS PIPING AND APPURTENANCES

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.01B)	Elbows (welding) other than long radius elbows.
(2.02 A.1)	Types of valves (plug or gas cock).
(2.02 A.2)	Valve size other than upstream pipeline size.
(2.05 B.1.a)	Exterior foundation and pit wall penetration details.
(2.05 B.2)	"Lead-Oakum" seal.
(2.05 B.3.a)	"Link-Seal".
(2.05 B.3.d)	Tandem sealing and single sealing.
(3.01 B.1)	Piping layouts.
(3.01 B.9)	Drip-legs.
(3.01 C)	Gas meter and pressure regulating valves: Other than to be furnished by the Utility Company and to be installed under this Section.
(3.03)	Piping to be painted under other Sections of the Specifications.

B. Other Items

1. Ensure that the Specifications include the following Section(s) referenced in this Section:

(3.01 A.4)	"CUTTING, PATCHING AND REMOVAL"
(3.03)	"PAINTING"

2. Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15491

PLUMBING INSULATION

PART 1. GENERAL

1.01 SUMMARY

This Section specifies insulation requirements for plumbing piping and equipment.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

New York City Building Code
New York State Energy Conservation Construction Code
New Jersey Uniform Construction Code
American Society for Testing and Materials (ASTM)
National Fire Protection Association (NFPA)
Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. All insulation, including jackets or facings, adhesives, mastics, cements, tapes and glass cloth for fittings shall have composite fire and smoke hazard ratings as tested by ASTM E 84, NFPA 255, and UL 723 procedures, not exceeding a "Flame Spread" of 25 and "Smoke Developed" of 50.

C. Any treatment of jackets or facings to impart flame and smoke safety shall be permanent. The use of water-soluble treatments is prohibited.

1.03 QUALITY ASSURANCE

A. Insulation materials and accessories, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Entities performing the Work of this Section shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver insulation, coverings, cements, adhesives, and coatings to the construction site in manufacturer's sealed containers with manufacturer's stamp or label affixed, showing fire hazard indexes of products.

B. All insulation components shall be stored at the construction site on pallets or raised platforms with suitable shed enclosures to protect against foreign matter and rain.

C. Before moving insulation materials from storage platforms to construction site, all insulation sections and component materials shall be inspected for damage. Remove damaged materials from construction site.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with the requirements of this Section, furnish and isntall insulation materials of one of the following manufacturers, or approved equal:

Schuller International, Inc.
Certain-Teed Corp./Insulation Group
Owens-Corning Fiberglas Corp.
Knauf Fiber Glass

2.02 MATERIALS

A. Piping Insulation

1. Insulation Thickness

Piping System	Pipe Size	Insulation Minimum Thickness*
Domestic Cold Water	up to 6 in.	0.5
	8 in. & larger	0.5
Chilled Drinking Water	All	1"
Horizontal Storm Water	All	0.5
Domestic Hot Water and Hot Water Circulation	1 1/2 in. & smaller	1"
	2 in. & larger	1.5
Floor Drain receiving condensate/ waste from HVAC cooling equipment, plus 15 feet of associated downstream drain piping.	All	0.5
Lavatory Waste Piping, exposed under fixtures for the disabled	All	0.5

Electric Drinking Water Cooler Waste, up to connection with sanitary system	All	0.5

*Weatherproof or frostproof insulation, where shown on the Contract Drawings, shall have 3-inch thickness.

2. Indoor Piping and Frostproof Insulation

   a. Insulation shall be molded fiberglass with factory-applied, pressure-sensitive, lap-sealing system jacket as a vapor barrier.

   b. Molded fiberglass insulation shall conform with ASTM C 547, Class 1.

   c. The insulation shall be Schuller "MICRO-LOK" with AP-T Plus jacket, having a bare insulation K-factor of 0.25 at 75 dgrees mean temperature, or approved equal.

   d. Fitting, valve, and flange insulation requirements are specified in 3.02 B.2.

3. Outdoor Piping (or Weatherproof) Insulation

   a. Insulation shall be molded fiberglass with aluminum jacket (ASTM B209, 3003 Alloy, H-14 temper).

   b. Molded fiberglass insulation shall conform with ASTM C 547, Class 1 and shall be Schuller "MICRO-LOK", having a bare insulation K-factor of 0.25 at 75 degrees F mean temperature, or approved equal.

   c. Insulation jacket shall be 0.06-inch thick aluminum for pipe 2-1/2 inches and larger and 0.010-inch thick aluminum for pipe 2 inches and smaller, with a built-in isolation felt. All seams and joints shall be weatherproof.

   d. Fitting, valve and flange insulation requirements are specified in 3.02 C.3.

B. Equipment Insulation

1. Insulation Thickness

Equipment	Insulation Thickness
Meter Assembly	1"
Condensate Coolers/ Preheaters	2"
Hot Water Heaters (Field applied insulation)	2"
Storage Tanks	2"

2. Hot Surfaces

   a. Insulation shall be rigid fiberglass board.

   b. Rigid fiberglass board insulation shall conform with ASTM C 612, Type 1 except that the density shall not be less than 3 lbs. per cubic foot. The insulation shall be Schuller "814 SPIN-GLAS", having a bare insulation K-factor of 0.23 at 75 degrees F mean temperature, or approved equal.

   c. Finishing requirements are specified in 3.02 D.1.

3. Cold Surfaces

   a. Insulation shall be flexible blanket fiberglass.

b. Flexible blanket fiberglass insulation shall conform with ASTM C 553, Type I, and shall be Schuller "MICROLITE", having a compressed thickness K-factor of 0.27 at 75oF mean temperature, or approved equal.

c. Finishing requirements are specified in 3.02 D.2.

PART 3. EXECUTION

3.01 PREPARATION

A. Insulation shall be applied only after the piping systems have been hydrostatically tested and approved by the Engineer.

B. Install insulation subsequent to installation of heat tracing and any coating or painting.

C. Surfaces shall be clean of rust, scale, dirt, dust, grease and other foreign matter, and shall be dry before application of insulation.

3.02 INSTALLATION

A. General

1. Install insulation products in accordance with this Section and manufacturer's installation procedures.

2. Insulation shall be continuous through hangers, slabs, walls, ceiling openings and sleeves. Where pipes pass through non-fire rated walls, floors or partitions, the space around the insulated pipe shall be sealed with mineral wool.

3. Omit insulation through fire rated walls and slabs. Terminate insulation at penetration and seal insulation ends with vapor barrier coating. The annular space between the sleeve and bare pipe shall be filled with approved material and sealed to prevent flame spread.

4. Insulate specialties to match those of the systems to which they are connected.

5. Insulate horizontal leader piping to and including the first fitting of the vertical leader.

6. Fill surface imperfections of insulation such as chipped edges, small joints, cracks, voids or holes, with insulation material and smooth all such areas with a skim coat of insulating cement. Makeshift patching or filling with hose driven or blown insulation, because of lack of space, will not be permitted.

7. Do not insulate equipment nameplates, identification tags, stampings and final connections to plumbing fixtures beyond walls.

8. Omit insulation on hot and cold water toilet room group fixture roughing within concealed pipe chases.

9. Omit insulation on chrome-plated exposed piping (except for handicapped fixtures), air chambers, strainers, buried piping and pre-insulated equipment.

10. Insulation on all piping at hangers and supports shall be provided with galvanized protection shields or saddles to prevent crushing of insulation and damage to vapor barrier.

11. Install insulation with smooth and even surfaces. Insulation shall be continuous, and be carefully fitted, with side and end joints butted tightly and staggered. Install each continuous insulation course with full-length units of insulation, with single cut piece to complete run. Do not use multiple cut pieces or scraps abutting each other.

12. For cold surface insulation, all openings, joints, laps, and end strips shall be sealed against moisture penetration with fire-retardant vapor barrier.

13. Maintain integrity of vapor-barrier jackets on insulation, and protect to prevent puncture or other damage. Staples and similar fastening material are prohibited for securing vapor barrier in insulation.

14. Do not apply seal or cement until all previous application of cement and adhesives have thoroughly dried.

15. Hangers and supports which are directly connected to cold surfaces must be adequately insulated and vapor-sealed to prevent condensation.

B. Indoor Piping and Frostproof Insulation

1. Longitudinal lap joints and end butt joints shall be sealed with approved adhesive. Butt joints shall be wrapped with a minimum three-inch wide strip of same material as pipe jacket.

2. Fittings, valves, flanges and accessories shall be insulated with compressed fiberglass of two lbs. per cubic foot density and of the same thickness as pipe insulation, wired in place with 18-gauge galvanized steel wire. Apply a uniform coat of fire retardant vapor barrier coating to the entire surface then cover with a factory-fabricated pre-formed insulated fitting cover, with sealed joints. The fire retardant vapor barrier shall be compatible with said insulation cover material.

C. Outdoor Piping Insulation

1. Longitudinal lap joints and end butt joints shall be sealed with approved adhesive.

2. Apply outer metal jackets over insulation. All seams and joints shall be weatherproof.

3. Fittings, valves and flanges shall be covered with either a fabricated metal jacket or matching aluminum fitted cover with sealed weatherproof joints.

D. Equipment Insulation

1. Hot Surfaces

Cut and miter fiberglass board and secure in place with bands or wire on 12-inch centers. Point up all joints with insulating cement. Cover insulation with one-inch hexagonal wire mesh. Apply two coats of mineral wool cement and trowel to a smooth finish. Finish with two coats of Foster (H.B. Fuller Co./Foster Products Div.) 30-36 adhesive, or approved equal.

2. Cold Surfaces

Fit and contour to shape blanket fiberglass and secure in place with bands or wire. Apply two coats of mineral wool cement and trowel to a smooth finish. Finish with two coats of Foster 30-35 vapor barrier finish, or approved equal.

END OF SECTION

SECTION 15491

PLUMBING INSULATION

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Catalog Cuts / Product Data

1. Plumbing Insulation

   a. Catalog cuts of insulation.

   b. Product performance data for each type of insulation.

   c. Schedule showing product number, k-factor, thickness and furnished accessories for each plumbing system requiring insulation.

   d. Installation procedures.

B. Samples

1. Submit sample of each insulation type required. Affix label on sample, completely describing product.

END OF APPENDIX "A"

SECTION 15491

PLUMBING INSULATION

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.02 A.1) Weatherproof or frostproof piping insulation.

B. Other Items

Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15501

HVAC - PIPING AND APPURTENANCES

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for heating, ventilation and air-conditioning (HVAC) piping and appurtenances.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards, including, but not limited to the entities listed below.

American National Standards Institute (ANSI)
American Society of Mechanical Engineers (ASME)
American Society for Testing and Materials (ASTM)
Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)
Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Design and performance requirements of piping systems are as follows:

1. Steam and Condensate Piping

	System		
	Low Press.	High Press.	Medium Press.
Operating Pressure	58-150 psig	16-57 psig	0-15 psig
Operating Temperature	251-360°F	212-305 °F	250 °F
Hydrostatic Test Pressure	225 psi	125 psi	125 psi
Duration of Hydrostatic Test	2 hours	2 hours	2 hours
Design Code (ANSI)	B31.1	B31.1	B31.9

2. Heating Hot Water Piping

Operating Pressure	125 psig
Operating Temperature	150-250 °F
Hydrostatic Test Pressure	200 psi
Duration of Hydrostatic Test	2 hours
Design Code (ANSI)	B31.9

3. Chilled Water Piping

Operating Pressure	125 psig
Operating Temperature	40-60 °F
Hydrostatic Test Pressure	200 psi
Duration of Hydrostatic Test	2 hours
Design Code (ANSI)	B31.9

4. HighTemperature Hot Water Piping

Operating Pressure	300 psig, maximum
Operating Temperature	360-380 °F
Hydrostatic Test Pressure	450 psi
Duration of Hydrostatic Test	2 hours
Design Code (ANSI)	B31.1

5. Condenser Water Piping

Operating Pressure	125 psig
Operating Temperature	80-110 °F
Hydrostatic Test Pressure	200 psi
Duration of Hydrostatic Test	2 hours
Design Code (ANSI)	B31.9

1.03 QUALITY ASSURANCE

A. HVAC piping and appurtenances, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Entities performing Work shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Clean all pipe sections of foreign matter and cover ends with temporary sheet metal closures or plastic end caps of sufficient tightness to prevent entry of foreign matter prior to shipping to the construction site.

B. Store pipe, fittings, valves and other components at the construction site on pallets or raised platforms with suitable coverings satisfactory to the Engineer to protect them against damage and weather.

C. Inspect all pipe, fittings, valves and other components for damage before moving them from storage to the point of installation at the construction site.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 PIPE, FITTINGS, AND FLANGES

A. Provide pipe (and tube), fittings, and flanges in accordance with the "Pipe, Fittings, And Flanges Schedule" found at the end of the Section, including gaskets, bolts, nuts, washers and other pressure containing parts necessary for the complete installation of piping systems.

B. All welding elbows shall be long radius pattern unless otherwise shown on the Contract Drawings.

C. Where changes of size occur in horizontal piping, provide eccentric type reducing fittings to attain proper drainage and venting of pipeline.

D. All pipe nipples over six inches in length shall be of corresponding material, quality and thickness as the pipe on which they are used. All nipples up to and including six inches in length shall be extra-heavy shoulder type. No close nipples shall be used. All nipples shall have designation mark of the manufacturer and shall conform to ASTM pipe specifications for system served.

E. Buttwelding fittings shall be manufactured by Ladish Company or approved equal.

F. Socket welding fittings shall be manufactured by Crane, Grinnell, or approved equal.

G. Unions for use with cast iron fitting system shall be 250 lb. Class, malleable iron with bronze seats. The unions shall be Grinnell "Figure 554", or approved equal.

H. Welding backing rings for buttwelding joints shall be Robvon Backing Ring Co. "Type CC", or approved equal.

I. Gaskets shall be of materials, thicknesses and types that are compatible with fluids to be handled; and shall be suitable for the design temperatures and pressures.

J. Connections between pipes or between pipes and equipment of dissimilar metals shall be made with isolating union or flange connections, as made by EPCO Sales Inc., or approved equal.

2.02 GATE, GLOBE, AND CHECK VALVES

A. Provide valves as and where shown on the Contract Drawings, in accordance with the "Gate, Globe, And Check Valves Schedule" found at the end of the Section.

B. Provide drain and vent valves that are not shown on the Contract Drawings but are necessary for the proper operation of piping systems, as follows:

1. Drain valves at all water piping low points, conforming to the gate valve specifications for the particular system

2. Manual vent valves at high points of piping conforming to the globe valve specifications for the particular system

C. All gate and globe valves shall be the products of one manufacturer.

D. Swing check valves shall be suitable for installation in the horizontal position.

E. Provide chain wheel operators on all valves six inches and larger, located more than six feet above the floor in the mechanical equipment rooms, unless otherwise shown on the Contract Drawings.

F. Provide motor operators for valves where shown on the Contract Drawings.

G. Valves shall be capable of being repacked while wide open and operating at their rated pressure.

H. Where angle valves are indicated or required, use equivalent of specified globe type.

I. Valves shall be of one of the following manufacturers, or approved equal:

1. Cast Steel Valves

   Crane Co.
   Walworth Co.
   Powell (William) Co.

2. Forged Steel Valves

   Smith Valve Corp.
   Vogt (Henry) Machine Co. Inc.

3. Bronze Valves

   Crane Co.
   Stockham Valves and Fittings, Inc.

4. Silent Check Valves

   Mueller Steam Specialty Co. (MUESSCO)

2.03 BUTTERFLY VALVES

A. Provide butterfly valves where shown on the Contract Drawings.

B. Butterfly Valves, 2-1/2 through 12 inches, shall be flangeless lug type body, rated at 175 psi for water service temperature up to 250 degrees F. Body shall be cast iron (ASTM A 126, Class B) with bronze (ASTM B 62) disc, and stainless steel (ASTM A 416) shaft with bronze bearings, shaft seal. Resilient seat shall be Ethylene Propylene Terpolymer (EPDM).

C. Provide butterfly valves of up to 6 inches with lever type ten-position handles; provide valves 8 inches and larger with totally enclosed worm and gear operators with handwheels. Where shown on the Contract Drawings, off-the-floor valves shall be equipped with chainwheels and chains.

D. Where required, provide butterfly valves with "memory stops" which permit the valves to be closed to a dead tight position and then reopened to the same balanced position.

E. Butterfly valves shall be DeZurik Fig. 632, or approved equal.

2.04 PLUG VALVES

Plug valves for balancing Heating Hot Water and Chilled Water piping systems shall be of the non-lubricated type for balancing and shutoff with memory stop. Valves shall be suitable to 250 degrees F water temperature and shall be DeZurik Series 400, or approved equal.

2 inches and smaller - Screwed, 175 psi Class
2 1/2 through 12 inches - Flanged, 175 psi Class

Valves 6 inches and larger shall be gear operated.

2.05 SAFETY RELIEF VALVES - STEAM

A. Provide safety relief valves in locations and of sizes shown on the Contract Drawings, or as required, for the proper protection of steam piping and equipment.

B. Safety relief valves shall be sized and set to relieve the system so that the resulting pressure does not exceed the maximum allowable working pressure of the vessel or piping system to which it is connected.

C. All such pressure relieving devices shall be equipped with a manual lifting device so that the disc can be lifted from the seat when the pressure in the pipe or vessel is 75 percent of the pressure at which the valve is set to operate.

D. Where two or more required safety relief valves are placed on one connection, the inlet cross-sectional area of this connection shall not be less than the combined inlet areas of all the safety relief valves connected to it.

E. Discharge lines from the outlets of safety relief valves shall be arranged to ensure drainage and to prevent liquid from lodging in the discharge side of the valve. The size of discharge lines, whether individual or combined, shall be such that any back pressure that may develop during valve operation shall not reduce the relieving capacity of the valves below that required to properly protect the vessel or piping.

F. All safety relief valves shall be rated, tested and approved in accordance with the ASME Boiler and Pressure Vessels Code Section VIII, Unfired Pressure Vessels, and shall be National Board Certified. Valves shall be manufactured by Spirax/Sarco, Inc., Kunkle Valve Div., Crosby Valve & Gage Co., or approved equal.

G. For safety relief valves for hot water and chilled water systems refer to Division 15 Section entitled "HYDRONIC SPECIALTIES".

2.06 STRAINERS

A. Provide strainers where shown on the Contract Drawings, in accordance with the "Strainers Schedule".

B. All strainers shall be "Y" type, and strainer screens shall be stainless steel with perforation sizes as indicated on the Contract Drawings.

C. Provide all strainers with tapped blowdown connections.

Strainers Schedule					
				Rating	
Service Features	Size	Fig. No.	Ends	Class	Construction
H.P. Steam & Cond. H.T. Hot Water	2" and smaller	MUESSCO 862	SW	600 ASTM A	Body – Cast Steel, 216 Gr WCB, Bolted Cover
	2-1/2" and larger	MUESSCO 762	FL	300	
M.P. Steam & Cond.	All sizes	MUESSCO 752	FL	250 ASTM A	Body – Cast Iron, 126 Class B or C
L.P. Steam & Cond.	2" and smaller	MUESSCO 11M	SCR	250 ASTM A	Body – Cast Iron, 126 Class B or C
Htg. Hot Water Chilled Water Condenser Water	2-1/2" and larger	MUESSCO 761	FL	150 ASTM A	Body – Cast Steel, 216 GR WCB

2.07 ACCESSORIES

A. Pipe and Valve Identification

1. Adhesive Bands

a. Provide approved adhesive bands in sets of two, one identifying the piping system type and the second, the direction of flow. Sets shall be provided in quantities sufficient to accommodate the requirements of 3.05 A.

b. For 3-inch or larger pipe, the adhesive band identifying the piping system shall display the name of the service in letters at least two inches high and the band indicating direction of flow shall display an arrow of similar size. For 2-1/2-inch or smaller pipe, the letters and the arrow shall be not less than one inch high. Bands shall be in colors as indicated below and shall conform to ANSI A 13.1.

System Identity	Background	Letters & Arrows
High Temp. Water	Yellow	Black
Steam	Yellow	Black
Condensate	Yellow	Black
Hot Water	Yellow	Black
Chilled Water	Green	Black
Condenser Water	Green	Black

c. Adhesive bands shall be manufactured by W.H. Brady Co. "Quick-Label", or approved equal.

2. Valve Tags, Charts and Schedules

a. Provide each valve with a 2-inch diameter 18 GAUGE brass tag with brass chain. Service designation shall be 1/4-inch high on the upper line, and valve number shall be 1/2-inch high on the lower line. The characters shall be indented and filled with durable black compound.

b. Provide diagrammatic valve charts and schedules, using a valve numbering system which differentiates between classes of service and indicates floor level of valve location.

c. Tags shall conform to the numbers, locations, and uses listed in the valve charts and schedules.

d. Valve charts and schedules shall be mounted under glass in wood frames or aluminum self-closing frames.

e. Tags and the frames for valve charts and schedules shall be manufactured by Seton Name Plate Corp., or approved equal.

B. Access Doors

Provide a complete list of all access doors required in finished walls, ceilings, partitions and any other areas for access to all valves concealed behind such finished construction. Access doors shall be furnished and installed under other Sections.

2.08 PIPE HANGERS AND SUPPORTS

A. Design, fabricate and provide all pipe hangers and supports adequate to support and guide the piping, allow for forces imposed by expansion joints, satisfy structural requirements and maintain proper clearances with respect to adjacent piping, equipment and structures.

B. Hangers and supports shall include guides, anchors, stops, restraints, welded attachments, insulation saddles, saddle strands, stays, braces, bolts, nuts, washers, expansion bolts, pipe clamps, beam clamps, and supplementary structural steel for pipe hangers and supports.

C. All hangers and supports shall conform to requirements of ANSI B31.1 or B31.9 as applicable, MSS SP-58 and SP-69.

D. Structural members required for suspended loads shall be shop fabricated for bolting to building structural members.

E. Do not hang piping from other piping. In no case shall hangers be supported by means of vertical expansion bolts.

F. Keep the different types of hangers to a minimum and provide hangers that are neat, without complicated bolting and with the number of parts of each hanger and its anchor kept to a minimum.

G. Make accurate weight balance calculations to determine the required supporting force at each hanger or support location and the pipe weight load at each equipment connection.

H. Pipe hangers shall be capable of supporting the pipe in all conditions of operation. They shall allow free expansion and contraction of the piping, and prevent excessive stress resulting from transferred weight being induced into the pipe or connected equipment.

I. For critical high temperature piping, at hanger locations where the vertical movement of the piping is 3/4 inch or more, or where it is necessary to avoid the transfer of load to adjacent hangers or connected equipment, provide approved constant support hangers. Hangers shall be Grinnell Fig. 80-V and Fig. 81-H, or approved equal. However, where the piping movement occurs at a hanger supporting a portion of piping riser on which a rigid support is also located, variable spring hangers may be used for any amount of expansion up to the full recommended working range of the spring, provided the change in supporting effect of the variable spring is added to the design load of the rigid support assembly.

J. Where transfer of load to adjacent hangers or equipment is not critical, and where the vertical movement of the piping is less than 3/4 inch, variable spring hangers may be used, provided the variation in supporting effect does not exceed 25 percent of the calculated piping load through its total vertical travel.

K. The total travel for constant support hangers shall be equal to actual travel plus 20 percent. In no case shall the difference between actual and total travel be less than one inch.

L. Furnish constant support hangers with travel stops which shall prevent upward and downward movement of the hanger. The travel stops shall be factory installed so that the hanger level is at the "cold" position. The travel stops shall be of such design as to permit future reengagement, even in the event the lever is at a position other than "cold", without having to make hanger adjustments.

M. Where horizontal piping movements are greater than 1/2 inch, or where the hanger rod angularity from the vertical is greater than four degrees from the cold to hot position of the pipe, the hanger pipe and structural attachments shall be offset in such manner that the rod is vertical in the hot position.

N. Design hangers such that they cannot become disengaged by movements of the supported pipe.

O. Support riser piping independently from the connected horizontal piping.

P. Pipe support attachments to the riser piping shall be riser clamp lugs at each floor level. Welded attachments shall be of material comparable to that of the pipe.

Q. Design supports, guides, and anchors such that excessive heat will not be transmitted to the building steel. The temperature of supporting parts shall be based on a temperature gradient of 100 degrees F per inch of distance from outside surface of the pipe.

R. If removal of existing fireproofing is required for installation purposes, such removal shall be performed by the Contractor and shall be kept to a minimum. The Contractor shall replace all removed fireproofing with new fireproofing to the satisfaction of the Engineer and at no additional cost to the Authority.

S. Anchors shall be adequately designed to rigidly oppose forces acting on them and shall be embedded in structural concrete or connected to the building structural steel framework.

T. For low temperature systems where vertical movements are anticipated, use approved precompressed variable spring hangers. Hangers shall be Grinnell Fig. B268 Series, or approved equal.

U. Use roller for pipe supports where horizontal movement due to expansion and contraction will occur.

V. Provide all rigid hangers with a means of vertical adjustment after installation.

W. Where the piping system is subject to shock loads, such as thrusts imposed by the actuation of safety valves, design hangers with a provision of approved shock-absorbing devices.

X. All hangers and supports shall be painted black or coated, assembled and tagged to identify them for their specific use and locations as shown on the approved shop drawings prior to delivery to the construction site.

Y. Trapeze type hangers of steel construction may be used for two or more pipes which have a uniform slope throughout.

Z. Provide protection saddles for piping carrying fluids with a temperature above 250 degrees F. Provide protection shields at all points of support for piping carrying fluids with a temperature of 250 degrees F or below. Saddles shall be 12-inch long steel plate with notched edges turned up for welding to the pipe. Shields shall be 12-inch long galvanized steel plate with a radius suitable for the required applications.

AA. Support hangers from building steel framing with approved type beam clamps. Provide any additional miscellaneous steel supports between existing framing members as may be required. No hangers shall be supported from metal deck floor. Welding to building structure members will not be permitted unless approved by the Engineer.

BB. Pipe hangers, rods, inserts and clamps shall be those UL approved for their respective uses. Auxiliary hangers shall be installed on the cross mains to overcome the strain put on this piping by the sloped branch lines.

CC. Use only adjustable ring type, copper-plated, carbon steel hangers for uninsulated copper tubing.

DD. Provide pipe anchors where shown on the Contract Drawings and where necessary to restrain forces due to thermal expansion and contraction of pipe.

EE. Provide pipe guides where shown on the Contract Drawings and where necessary to confine movement along the centerline of the pipe due to thermal expansion and contraction between anchors. Guides shall be adequately designed and placed, generally between 20 to 30 feet on centers and an equal distance from the expansion loop.

FF. Unless indicated otherwise on the Contract Drawings, hanger maximum spacings shall comply with MSS Std. SP-69 "Pipe Hangers and Supports - Selection and Application". Hanger rod sizes shall be compatible with hanger spacings, the loads carried by the hangers and the types of hangers utilized.

GG. All hangers and supports shall comply with the requirements specified under Division 15 Section entitled "VIBRATION ISOLATION AND CONTROL".

HH. Hangers and supports shall be manufactured by Grinnell Corp., Carpenter & Patterson Inc., Michigan Hanger Co. Inc., or approved equal.

2.09 SLEEVES, SEALS, AND ESCUTCHEONS

A. Pipe Penetration through Walls, Partitions and Floors

1. Piping passing through masonry or concrete walls and framed partitions shall have a trim opening cut no greater than necessary for the installation of a sleeve secured therein. Sleeve shall be 1/2 inch in diameter larger than the diameter of the insulated pipe. Sleeve shall be flush with the finished wall or partition surface.

2. Sleeves through concrete floors for piping shall have the opening 1/2 inch in diameter larger than the diameter of the insulated pipe passing through. Floor sleeves shall project one inch above floor slab.

3. Pipe insulation shall be omitted at penetrations through fire-rated barriers. In all cases pack the annular space between the pipe (whether insulated or not) and sleeve with mineral wool. Additionally, at penetrations through fire-rated barriers, seal the annular space to retain the fire rating integrity of the barrier with non-hardening through-penetration firestops having F-ratings compatible with the fire ratings of the barriers in which they are installed, as determined by ASTM E 814. Firestop systems shall be UL-approved and shall be as manufactured by 3M, Bio Fireshield, Inc., General Electric Company, Dow Corning Corporation, or approved equal.

4. Sleeves in walls and floors shall be galvanized steel pipe, Schedule 40 for sizes up to 10 inches and 3/8-inch wall thickness for 12 inches and larger. Sleeves in partitions shall be 20-gauge galvanized sheet metal.

5. Piping in exposed areas, passing through walls, floors or ceilings shall be fitted with chromium-plated cast brass escutcheons with fastening set screws.

6. Piping passing through floor waterproofing membrane shall be provided with a 4-pound lead flashing or a 16-ounce copper flashing, each within an integral skirt or flange. Flashing shall be suitably formed, and the skirt or flange shall extend not less than 8 inches from the pipe and shall be set over the floor membrane in a solid coating of bituminous cement. The flashing shall extend up the pipe a minimum of 10 inches above the floor. The annular space between the flashing and the pipe shall be sealed watertight.

7. Piping passing through roof construction shall be provided with counterflashing, consisting of steel rainhood secured all around the pipe and overlapping the flashing.

B. Pipe Penetration through Exterior Foundation and Pit Walls

1. General

a. All penetrations for piping through perimeter foundation walls and subgrade pit walls shall be provided with the pipe sleeves and seals as shown on the Contract Drawings.

b. Sleeves shall be Schedule 40 for sizes up to 10 inches and 3/8-inch wall thickness for sizes 12 inches and larger. All pipe sleeves shall be galvanized steel, set into foundation walls with anchors and water stop plates.

2. Interlocking Modular Seals (Link-Seal)

a. Where "Link-Seal" is shown on the Contract Drawings, seal shall be modular mechanical type, consisting of interlocking sealing element links shaped to continuously fill the annular space between the pipe and the sleeve. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and nut. After the seal assembly is positioned in the sleeve, tightening of the bolts shall cause the sealing elements to expand and provide watertight seal between the pipe and the sleeved opening. The seal shall provide electrical insulation between the pipe and wall.

b. The inside diameter of each wall sleeve shall be sized as recommended by the manufacturer of the modular seals to fit the pipe, seal, and any coating or insulation to ensure a watertight joint.

c. Install sleeves and seals in accordance with the seal manufacturer's instructions to provide a watertight installation.

d. Seals for perimeter foundation wall penetrations shall be two individual sealing units in tandem unless otherwise shown on the Contract Drawings. Single sealing unit shall be used for pit wall penetration unless otherwise shown on the Contract Drawings.

e. Seals shall be Thunderline Corp. "Link-Seal", or approved equal.

PART 3. EXECUTION

3.01 INSTALLATION

A. General

1. Install piping systems and accessories in accordance with manufacturers' installation procedures/recommendations, and the requirements of ANSI B31.1 or B31.9, as applicable and as specified.

2. Coordinate piping with other Work to avoid interference. Coordinate as necessary to ensure that all hangers, supports, sleeves and other built-in devices are incorporated in forms or in masonry to avoid necessity of cutting finished structure.

3. Pipe sizes shall be as shown on the Contract Drawings. Any pipe sizes not shown shall be in proportion to the load carried at the same frictional resistance as adjacent piping.

4. The piping shown on the Contract Drawings shall be considered as diagrammatic. Install piping in every respect suitable for the purpose intended and clearances required.

5. Run all exposed piping perpendicular and parallel to floors and walls.

6. Install all valves and specialties to permit easy operation and access. Provide access for maintenance of equipment to all valves, controls and accessories installed in concealed areas including, but not limited to, furred spaces, hung ceilings and shafts. Install valves with the stems horizontal or vertically upward, unless specifically shown otherwise on the Contract Drawings.

7. Pitch all piping systems for proper drainage. Steam and condensate piping shall have a minimum pitch of one inch in forty feet.

8. All equipment connections shall be provided with screwed unions or flanges for disconnection of equipment.

9. Bend copper tubing with approved tubing benders to prevent deformation of the tubing in the bends. Use approved sweat-to-pipe threaded adapters for connection with valves and other equipment having threaded connections.

10. Low points in piping systems shall be provided with 6-inch long dirt leg and valved drain connection with hose thread. All vents at high points of piping shall be piped to the nearest floor drain or service sink.

11. All piping shall be concealed above furred ceilings, walls, and partitions, except where otherwise shown on the Contract Drawings.

12. Installation requirements for pipe hangers and supports and pipe penetration sleeves, seals and escutcheons are specified in 2.08 and 2.09, respectively.

B. Pipe Joints

1. Threaded Joints

Make up threaded joints tight using pipe joint Teflon compound or tape, applied on the male thread only.

2. Flanged Joints

Make flanged joints square and tight with gaskets. Dip bolts and nuts in mixture of graphite and oil immediately prior to installation.

3. Welded Joints

a. Prior to the start of any welding, remove all corrosive products and other foreign matter from the surface to be welded by either scraping, chipping or wire brushing.

b. Weld pipe joint in accordance with ANSI B31.1 or ANSI B31.9, as applicable.

c. Use shielded metal-arc welding or submerged-arc welding process. Direct current shall be used exclusively. Oxy-acetylene welding may be used for socket welded joints.

d. Each welder shall be certified in accordance with ASME Section IX. Such certification shall have been obtained a maximum of one year prior to the performance of Work under this Contract. Only recognized testing agencies, as approved by the Engineer, will be acceptable for certification. Each welder's certificate shall be on file at the construction site and shall be made available to the Engineer upon his request.

e. Each welder shall be assigned an identification mark that shall be stamped on the pipe surface adjacent to each weld performed by him.

f. In making new connections to existing piping systems, drain the minimum length of existing piping necessary and provide any adjustments, adapters and offsets as may be necessary to make connections.

g. In welding to existing piping, attach the ground connections to the existing pipe section. All welds performed in connecting to existing piping will be radiographically inspected by the Engineer.

h. Tees and reducing tees shall be used for all branch connections with the following two exceptions. Where the branch line is smaller than the main, weldolets or threadolets may be used in lieu of tees and where branch line size is less than or equal to the size of the existing piping, weldolets may be used for connections to existing piping.

4. Soldered Joints

a. Cut ends of tubing square and remove all burrs. Clean inside and outside of tubing with steel wool.

b. Make joints with non-corrosive paste flux and 95 percent tin and 5 percent antimony solder. Cored solder is not permitted.

c. Remove excess solder while still in plastic state.

d. Leave a fillet at the wall of the fitting.

e. Prior to silver soldering, remove the internal parts of all valves or other devices to be installed directly in the line.

3.02 PROTECTION, CLEANING, AND FLUSHING

A. Protection

1. Protect entire piping installation from damage during construction.

2. Cover and protect all openings in floors during construction.

B. Cleaning and Flushing

1. Notify the Engineer 72 hours prior to the scheduled cleaning and flushing of the piping systems. Provide temporary piping and equipment required for the cleaning and flushing. Route the discharge to the nearest storm water system.

2. Circulate a chemical detergent solution mixed with water throughout the system for a minimum of four hours. Retain the services of a recognized water treatment laboratory such as Hammond Montell, Inc., or approved equal, to furnish the required type and quantity of cleaning chemicals, supervise the process and analyze the results.

3. After cleaning, flush the system to the satisfaction of the Engineer, with water a minimum velocity of 7 feet per second. All strainers shall be cleaned after flushing.

4. Upon approved completion of the cleaning and flushing, fill the water piping systems with treated fresh water. Provision shall be made to prevent freeze-up in any piping system exposed to freezing temperature conditions.

3.03 FIELD TESTS

A. General

1. Notify the Engineer a minimum of 48 hours in advance of each time a piping system or portion is ready for inspection and tests.

2. Perform all tests prior to backfilling, installing pipe insulation and painting. In areas where piping will be concealed, tests shall be performed prior to concealment.

3. Should the tests reveal any leaks or deficiencies in piping installed under this Section, make necessary corrections immediately and flush, clean and retest the system for the Engineer's approval at no cost to the Authority.

4. Repair or replace any portion of the system installed under this Section that is damaged as a result of test operations at no cost to the Authority.

5. Where piping installed under this Section is connected to any existing system, such installed piping shall be isolated from the existing system during the performance of the required field tests, unless otherwise directed by the Engineer.

6. The Engineer reserves the right to direct the Contractor not to isolate the newly installed piping from the existing system during the performance of the required field tests. In such event, the Contractor shall correct any revealed leaks or other deficiencies within the first 20 feet of the existing system, measured in any direction from the point of connection with the newly installed piping, all as directed by the Engineer and at no additional cost to the Authority.

7. Dispose of water removed from pipelines in a manner that shall not cause damage to any property.

8. Isolate all equipment, controls and instruments from the piping system during the required tests.

9. Provide and install necessary equipment, instruments, hardware, temporary piping, vents, drains, and include the necessary personnel required to perform all tests.

B. Hydrostatic Tests

Perform hydrostatic tests for each piping system in accordance with ANSI B31.1 or B31.9, as applicable. The test pressures and duration of tests shall be as specified in 1.02 B.

C. Radiographic Tests

1. Radiography of all welding will be performed by the Authority at the discretion of the Engineer. Fifteen percent of welds of piping systems specified in 1.02 B will be randomly selected for radiographic tests.

2. Provide access to and clearance of areas to allow Engineer's radiographic inspection during normal working hours.

3. Any weld deemed defective, in the opinion of the Engineer, shall be ground out for the full depth and rewelded to the Engineer's satisfaction and at no cost to the Authority. Removal of defective weld material by burning will not be permitted.

3.04 PAINTING

Upon completion of the installation, remove all protecting materials, thoroughly remove all scale and grease and leave in a clean condition for painting. Piping to be painted shall be as shown on the Contract Drawings. Painting shall be in accordance with the requirements of Section 09910 - "PAINTING".

3.05 PIPE AND VALVE IDENTIFICATION

A. Pipe Identification

Affix sets of pipe adhesive bands specified in 2.07 A.1 where they can be easily read, with their long dimension parallel to the axis of the pipe and no more than 40 feet apart on a piping system.

At least one set of identifying bands shall be affixed in all occupied and unoccupied rooms as well as in all other spaces, such as hung ceilings or shafts, where piping may be viewed and the identity of the piping system cannot be readily ascertained. A set of such bands shall be affixed at each branch and riser takeoff; adjacent to each valve; at each pipe passage through floor and ceiling construction; at each capped line; and at each pipe passage to an underground area.

B. Valve Tags

Securely fasten valve tags specified in 2.07 A.2 with approved brass chain.

PIPE, FITTINGS, AND FLANGES SCHEDULE

Service (see 1.03 Design Req.)	Pipe			Joints	Fittings		Flanges
	Material	Wall Thickness	Size		Dimension & Material	Rating	Dimension & Material
High Press. Steam and Condensate	ASTM A 106, Gr. B Seamless	Sch. 80	Up to 2"	Socket weld	ANSI B16.11, ASTM A 105	3,000 lb.	ANSI B16.5, 300 lb. Class, ASTM A 105
High Temp. Hot Water		Sch. 40 0.375" Sch. 30	2-1/2" to 10" 12" to 16" 18" to 24"	Butt weld	ANSI B16.9, ASTM A 234 Gr. WPB	Same as pipe	ANSI B16.5, 300 lb. Class, ASTM A 105
Medium Press. Steam and Condensate	ASTM A 53, Gr. B Seamless	Sch. 80	Up to 2"	Socket weld	ANSI B16.11, ASTM A 105	3,000 lb.	ANSI B16.5, 150 lb. Class, ASTM A 105
		Sch. 40 0.375"	2-1/2" to 10" 12" to 24"	Butt weld	ANSI B16.9, ASTM A 234 Gr. WPB	Same as pipe	ANSI B16.5, 150 lb. Class, ASTM A 105
Low Press. Steam and Condensate Pumped Condensate Heating Hot Water, Chilled Water, Condenser Water	ASTM A 53, Gr. B Cont. Weld or ASTM 53, Gr. B Seamless	Sch. 80	Up to 2"	Screwed	Malleable Iron, ASTM A 197	150 lb.	Malleable Iron, 150 lb. Class, ANSI B16.3
					Cast Iron, ANSI B16.4, ASTM A 126, Class B or C	250 lb.	Cast Iron, 250 lb. Class, ANSI B16.4
		Sch. 40 0.375"	2-1/2" to 10" 12" to 20"	Butt weld	ANSI B16.9, ASTM A 234 Gr. WPB	Same as pipe	ANSI B16.5, 150 lb. Class, ASTM A 105
Domestic Cold Water Makeup	ASTM B 88, Type "L" Annealed	Nominal Wall	Up to 2"	Solder 95-5	Wrought Copper, ANSI B16.22	Same as pipe or better	

GATE, GLOBE AND CHECK VALVES SCHEDULE (2 INCHES AND SMALLER)

SERVICE	TYPE	FIG. #	ENDS	RATING CLASS	CONSTRUCTION FEATURES
H.P. Steam & Cond. H.T. Hot Water	Gate	SMITH 830	FL	300	Compliance with MSS SP-84 for socket weld end valves and ANSI B16.34 for flanged end valves. GATES & GLOBES: Rising stem, OS&Y, back seated, bolted bonnet and gland (gasketed), renewable seats and wedges CHECKS: Renewable seats and discs, bolted bonnet MATERIALS: Body & Bonnet – Forged Steel, ASTM A 105 Stem & Disc – 11-14 Chrome, ASTM A 182 F6 heat treated Seat – Base metal stellite
		888W	SW 600 or 800		
	Globe	G83	FL	300	
		G80W	SW 600 or 800		
	Lift Check		FL	300	
		C80W	SW 600 or 800		
M.P. Steam & Cond.	Gate	SMITH 815	FL	150	
	Globe		FL	150	
	Lift Check		FL	150	
L.P. Steam & Cond.	Gate	CRANE 634E	SCR	300	Compliance with MSS SP-80 GATES & GLOBES: Rising stem, back seated, union bonnet, inside screw, solid wedge or plug type disc, integral seat CHECKS: Renewable disc, union bonnet MATERIALS: Body & Bonnet – Bronze, ASTM B 62 for Class 150, B 61 for Class 300 Stem – Bronze, ASTM B 584, Alloy C87600 Seat Ring & Seat – Bronze, ASTM B 62 for Class 150, B 61 for Class 300 Wedge or Disc – Bronze (Gates), ASTM B 62 for Class 150, B61 for Class 300; hardened SS (Globes), AISI 420
	Globe	382P	SCR	300	
	Swing Check	76E	SCR	300	
	Lift Check	366E	SCR	300	
Htg. Hot Water Chilled Water Condenser Water	Gate	CRANE 431UB	SCR	150	
	Globe	14 1/2P	SCR	150	
	Swing Check	137	SCR	150	
	Lift Check	27TF	SCR	150	
Other than H.T. Hot Water (Pump Discharge)	Silent Check	MUESSCO 101M-BP	FL (wafer)	150	Compliance with ANSI B16.34 CHECKS: Guided disc (both top and bottom), spring-loaded, wafer type MATERIAL: Body, Disc & Seat – Bronze, ASTM B 62 Guide Pin & Bushing – ASTM B 584, Alloy C87600

GATE, GLOBE AND CHECK VALVES SCHEDULE (2-1/2 INCHES AND LARGER)

SERVICE	TYPE	FIG. #	ENDS	RATING CLASS	CONSTRUCTION FEATURES
H.P. Steam & Cond. H.T. Hot Water		CRANE			Compliance with ANSI B16.34 for flanged end valves. GATES & GLOBES: Rising stem, OS&Y, back seated, bolted bonnet and gland (gasketed), renewable seats and discs (flexible wedge up to 12", solid wedge for 14" and up), ball bearing yoke (8" and up) CHECKS: Renewable seats and discs, bolted bonnet MATERIALS: Body & Bonnet – Cast Steel, ASTM A 216 Gr. WCB Stem – 11-14 Chrome, ASTM A 182 F6 heat treated Seat & Backseat Facing – Ferritic or austenitic base metal stellite face Disc Facing – 11-14 Chrome, ASTM A 182 F6 heat treated
	Gate	33	FL	300	
		33-1/2	BW	300	
	Globe	151	FL	300	
		151-1/2	BW	300	
	Swing Check	159	FL	300	
		159-1/2	BW	300	
M.P. Steam & Cond. L.P. Steam & Cond. Pumped Cond. Htg. Hot Water Chilled Water Condenser Water		CRANE			
	Gate	47	FL	150	
		47-1/2	BW	150	
	Globe	143	FL	150	
		143-1/2	BW	150	
	Swing Check	147	FL	150	
		147-1/2	BW	150	
H.T. Hot Water (Pump Discharge)	Silent Check	MUESSCO 109M-DT	FL	300	Compliance with ANSI B16.34 CHECKS: Guided disc (both top and bottom), spring-loaded, globe type MATERIAL: Body – Cast Steel, ASTM A 216 Gr. WCB Seat & Disc – ASTM A 351 Gr. CF8M Spring & Guide Bushing – ASTM A 276
Other than H.T. Hot Water (Pump Discharge)	Silent Check	MUESSCO 105M-BP	FL	150	Compliance with ANSI B16.34 CHECKS: Guided disc (both top and bottom), spring-loaded, globe type MATERIALS: Body, Disc & Seat – Bronze, ASTM B 62 Guide Pin & Bushing – ASTM B 584, Alloy C87600
M.P. Steam & Cond.		CRANE			Compliance with MSS SP-70, 72 & 85 Flanged ends per ANSI B16.1 GATES & GLOBES: Rising stem, OS&Y, back seated, bolted bonnet and gland (gasketed), screwed-in seat ring CHECKS: Bolted bonnet, screwed in seat ring MATERIALS: Body & Bonnet – Cast Iron, ASTM A 126 Class B or C Stem – Bronze, brass or nickel plated steel Seat Ring & Seat – Bronze or bronze faced Wedge or Disc – Bronze or bronze faced
	Gate	7 1/2E	FL	250	
	Globe	21E	FL	250	
	Swing Check	39E	FL	150	
L.P. Steam & Cond. Pumped Cond. Htg. Hot Water Chilled Water Condenser Water		CRANE			
	Gate	465 1/2	FL	125	
	Globe	351	FL	125	
	Swing Check	373	FL	125	

END OF SECTION

SECTION 15501

HVAC - PIPING AND APPURTENANCES

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Piping Shop Drawings

   Shop and coordination drawings shall be double-line and shall be at a minimum of 3/8"=1'-0" scale.

   a. Piping layout and installation drawings including, at a minimum, the following:

      (1) Plans, elevations and sections.

      (2) Hangers, support locations and details. Indicate methods of attachment to building structure.

      (3) Pipe elevations and dimensions from main piping runs to a reference point.

      (4) Penetrations through fire-rated and other partitions.

      (5) Locations for piping accessories, including valves, strainers and access doors.

   b. Piping coordination drawings showing plan views, sections, and piping elevations, drawn to scale, on which all items are shown and coordinated with all Work of other Sections.

B. Product Data / Catalog Cuts

1. Piping and Accessories

   a. Pipe material and schedule for each piping system.

   b. Catalog cuts, including product performance data for all items furnished under this Contract, including the following at a minimum:

      (1) Fittings and flanges.

      (2) Hangers and supports.

      (3) Sleeves, seals, and escutcheons.

      (4) Pipe identification bands.

   c. List of access doors, including sizes and locations.

   d. Hangers and support schedule showing manufacturer's figure number, size, location and features of each required hanger and support.

2. Valves

a. Catalog cuts, including product performance data for all items under this Contract, including the following at a minimum:

(1) Valves, valve operators and strainers.

(2) Valve tags.

b. Valve charts and schedules.

C. Design Calculations

1. Piping stress analysis.

D. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive detailed information for the specific approved equipment; including approved shop drawings and catalog cuts, troubleshooting, maintenance requirements, spare part lists, test results, electrical/control devices and electrical/control wiring diagram(s).

E. Construction and Installation Procedures

1. Field test procedures.

F. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15501

HVAC - PIPING AND APPURTENANCES

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.01 B)	Elbows (welding) other than long radius elbows
(2.02 A)	Type of valves (gate, globe, swing check, lift check, silent check), end of valves, and rating class of valves (as per "Gate, Globe and Check Valves Schedule")
(2.02 E)	Valves, six inches and larger, located 6 feet above the floor, and not requiring chain wheel operator
(2.02 F)	Motor Operators - Locations
(2.03 A)	Butterfly Valves - Locations
(2.03 C)	Butterfly Valves - Chainwheel and chain locations
(2.05 A)	Safety Relief Valves - specific locations and sizes
(2.06 A)	Strainers - locations
(2.06 B)	Strainer screen perforation sizes
(2.08 DD)	Pipe Anchors - specific locations
(2.08 EE)	Pipe Guides - specific locations
(2.08 FF)	Hanger Spacing if other than recommended by MSS
(2.09 B.1.A)	Exterior foundation and pit walls penetration details
(2.09 B.2.A)	"Link Seal" - locations
(2.09 B.2.D)	Tandem sealing and single sealing
3.01 A.3)	Pipe sizes
(3.01 A.6)	Valves with stems not in the horizontal or vertical positions
(3.01 A.11)	Exposed piping
(3.04)	Piping to be painted under other Sections of the Specifications

B. Other Items

1. Ensure that the Specifications include the following Section(s) referenced in this Section:

(2.05 G)	Section 15515 "HYDRONIC SPECIALTIES"
(2.08 GG)	"VIBRATION ISOLATION AND CONTROL"
(3.04)	"PAINTING"

2. Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15502

REFRIGERANT PIPING AND APPURTENANCES

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for refrigerant piping and appurtenances.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

American National Standards Institute (ANSI)
Air-Conditioning and Refrigeration Institute (ARI)
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
American Society of Mechanical Engineers (ASME)
American Society for Testing and Materials (ASTM)
Environmental Protection Agency (EPA)
National Electrical Manufacturers Association (NEMA)
American Welding Society (AWS)
Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Refrigerant piping systems shall be designed in accordance with ANSI B 31.5.

1.03 QUALITY ASSURANCE

A. Refrigerant piping and appurtenances, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than 3 years.

B. Entities performing work shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Clean and dehydrate copper tube, and seal tube ends with temporary plastic end caps of sufficient tightness to prevent entry of foreign matter prior to shipping to the construction site.

B. Store tube, fittings, valves, specialties and other components at the construction site on pallets or raised platforms with suitable coverings satisfactory to the Engineer to protect them against damage and weather.

C. Inspect all tube, fittings, valves, specialties and other components for damage before moving them from storage to the point of installation at the construction site.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 COPPER TUBE AND FITTINGS

A. Copper tube shall be ASTM B 88, Type K, hard drawn temper, nominal (standard) sizes.

B. Fittings shall be wrought copper, solder-joint, pressure fittings in accordance with ANSI B 16.22 and shall be same rating as pipe.

C. Tubing joints shall be solder joints, using appropriate ASTM B 32 solder metal.

2.02 REFRIGERANT VALVES AND SPECIALTIES

A. General

1. Provide required types, sizes and capacities of refrigerant valves and specialties where shown on the Contract Drawings.

2. Unless otherwise shown on the Contract Drawings, all valves and specialties shall be UL listed and have a rating of 240 degrees F, minimum, and 350 psi working pressure and shall have solder ends.

B. Refrigerant Valves

1. Globe Valves

a. Forged brass body, packed type with back seating and cap seals

b. Forged brass body, packless, diaphragm type with back seating and hermetic seals

2. Check Valves

Forged brass body, accessible internal parts, Teflon synthetic seat, with fully guided piston and stainless steel spring.

Valves shall be operable whether installed horizontally or vertically.

3. Solenoid Valves

Two-way, forged brass or corrosion-resistant steel body, conforming to ARI 760, normally closed, Teflon valve seat, NEMA 1 solenoid enclosure, 24-volt/60 Hz (unless otherwise shown on the Contract Drawings), with 1/2-inch conduit adapter. Valve with 1/4-inch and smaller ports shall be direct-operated, without manual stem. Valves having a port greater than 1/4-inch shall be pilot-operated and provided with a manual stem. Solenoid valves shall be Parker-Hannifin RB Series, or approved equal.

C. Refrigerant Specialties

1. Strainers

a. Strainers for systems with a capacity of 4 tons or less shall be of the sealed type, having brass or corrosion-resistant steel shall, and stainless steel or monel element capabile of removing particles 15 microns and larger. Strainer shall be Henry Valve Company 891S Series, or approved equal.

b. Strainers for systems with a capacity greater than 4 tons shall be of the replaceable - core type, having a brass or corrosion-resistant steel shell, a steel flange ring and spring, cover plate with cap screws, and corrosion-resistant element, capable of removing particles 15 microns and larger. Strainers shall be Henry Valve Company 866 Series, or approved equal.

2. Moisture-liquid indicators shall have forged brass body, single port, removable cap, polished optical glass. Moisture-liquid indicators shall be Henry Valve Company MI-30 Series, or approved equal.

3. Filter-dryers shall be sealed or replaceable core type as indicated on the Contract Drawings.

a. Sealed filter-dryers shall have corrosion-resistant steel shell, with wrought copper fittings and ceramic-fired, desiccant core. Sealed Filter-dryers shall be Henry Valve Company H Series, or approved equal.

b. Replaceable core filter-dryers shall have corrosion-resistant steel shell with wrought copper fittings, steel flange ring and spring, cover plate with cap screws, replaceable filter-dryer core. Replaceable core filter-dryers shall be Henry Valve Company V8 Series, or approved equal.

4. Thermal expansion valve shall be thermostatic adjustable, modulating type; size as required for specific evaporator requirements and factory set for proper evaporator superheat requirements. Valve shall be complete with sensing bulb, a distributor having a side connection for hot gas bypass line if required, and an external equalizer line.

5. Hot gas bypass valve shall be adjustable type, sized to provide capacity reduction beyond the last step of compressor unloading.

D. Refrigerant valves and specialties shall be manufactured by Sporlan Valve Co., Parker-Hannifin Corp., Henry Valve Co. Inc., or approved equal.

2.03 PIPE AND VALVE IDENTIFICATION

A. Adhesive Bands

1. Provide approved adhesive bands in sets of two, one identifying the system and the second, the direction of flow.

2. For pipe 3 inches and larger, the adhesive band identifying the piping system shall display the name of the service in letters at least two inches high and the band indicating direction of flow shall display an arrow of similar size. For pipe 2 1/2 inches and smaller, the letters and the arrow shall be not less than one inch high.

3. Adhesive bands shall be W.H. Brady Co. "Quik-Label", or approved equal.

B. Valve Tags, Charts and Schedules

1. Provide each valve with a 2-inch diameter 18 gauge brass tag with brass chain. Service designation shall be 1/4-inch high and on the upper line. The valve number shall be 1/2-inch high and on the lower line. The characters shall be indented and filled with durable black compound.

2. Provide diagrammatic valve charts and schedules, using a valve numbering system which differentiates between classes of service and indicates floor level of valve location.

3. Tags shall conform to the numbers, locations, and uses listed in the valve charts and schedules.

4. Valve charts and schedules shall be mounted under glass in wood frames or aluminum self-closing frames.

5. Valve tags and the frames for valve charts and schedules shall be manufactured by Seton Name Plate Corp., or approved equal.

2.04 PIPE HANGERS AND SUPPORTS

A. Design, fabricate and provide all pipe hangers and supports adequate to support and guide the piping, allow for forces imposed by expansion joints, satisfy structural and seismic requirements and maintain proper clearances with respect to adjacent piping, equipment and structures.

B. Hangers and supports shall include, but not limited to guides, anchors, stops, restraints, welded attachments, insulation saddles, saddle strands, stays, braces, bolts, nuts, washers, expansion bolts, pipe clamps, beam clamps, and supplementary structural steel for pipe hanger and supports.

C. All hangers and supports shall conform to requirements of ANSI B 31.5.

D. Do not hang piping from other piping. In no case shall hangers be supported by means of vertical expansion bolts.

E. Keep the types of hangers used to a minimum and provide hangers that are neat, without complicated bolting and with the number of parts of each hanger and its anchor kept to a minimum.

F. Support riser piping independently from the connected horizontal piping.

G. Pipe support attachments to the riser piping shall be riser clamp lugs at each floor level.

H. Use only adjustable ring type, copper-plated, carbon steel hangers for uninsulated copper tubing.

I. Provide pipe anchors where shown on the Contract Drawings and where necessary to restrain forces due to thermal expansion and contraction of pipe.

J. Anchors shall be adequately designed to rigidly oppose forces acting on them and shall be embedded in structural concrete or connected to the building structural steel framework.

K. Unless otherwise specifically approved, hanger size and spacing for copper tubing shall be as follows:

Pipe Size	Maximum Hanger Spacing	Minimum Rod Size
1/2" to 1"	5 ft. o.c.	3/8"
1-1/4" to 2"	7 ft. o.c.	3/8"
2-1/2" to 3"	9 ft. o.c.	1/2"
3-1/2" to 4"	11 ft. o.c.	5/8"

L. All hangers and supports shall comply with the requirements specified under the Section entitled "VIBRATION ISOLATION AND CONTROL."

M. Hangers and supports shall be manufactured by Grinnell Corp., Carpenter & Patterson Inc., Michigan Hanger Co. Inc., or approved equal.

2.05 SLEEVES, SEALS, AND ESCUTCHEONS

A. Piping passing through masonry or concrete walls and framed partitions shall have a trim opening cut no greater than necessary for the installation of a sleeve secured therein. Sleeve shall be 1/2 inch in diameter larger than the diameter of the insulated pipe. Sleeve shall be flush with the finished wall or partition surface.

B. Sleeves through concrete floors for piping shall have the opening 1/2-inch in diameter larger than the diameter of the insulated pipe passing through. Floor sleeves shall project one inch above floor slab.

C. Annular spaces between insulated piping and sleeves shall be packed with mineral wool and sealed to retain the fire integrity of the walls, partitions and floors with non-hardening through-penetration firestops having F-ratings compatible with the fire ratings of the barriers in which they are installed, as determined by ASTM E 814. Firestop systems shall be UL-approved, and shall be as manufactured by 3M, Bio fireshied, Inc., General Electric Company, Dow Corning Corporation, or approved equal.

D. Sleeves in walls and floors shall be galvanized steel pipe, Schedule 40. Sleeves in partitions shall be 20-gauge galvanized sheet metal.

E. Piping in exposed areas, passing through walls, floors or ceilings shall be fitted with chromium-plated, cast brass escutcheons with fastening set screws.

F. Piping passing through roof construction shall be provided with counterflashing, consisting of copper rainhood secured all around the pipe and overlapping the flashing, unless otherwise shown on the Contract Drawings.

G. Piping passing through floor waterproofing membrane shall be provided with a 4-pound lead flashing or a 16-ounce copper flashing, each within an integral skirt or flange. Flashing shall be suitably formed, and the skirt or flange shall extend not less than 8 inches from the pipe and shall be set over the floor membrane in a solid coating of waterproof cement compatible with the water proofing membrane. The flashing shall extend up the pipe a minimum of 10 inches above the floor. The annular space between the flashing and the pipe shall be packed to ensure a watertight seal.

PART 3. EXECUTION

3.01 PREPARATION

A. Verify cleanliness of all tube, fittings, valves and specialties immediately prior to installation in the refrigeration system.

B. Verify status of all precharged gas-or refrigerant-containing equipment for pressure retention and dehydration status. Replenish gas or refrigerant charges only after verification of internal conditions under the direction of the equipment manufacturer's representative at the construction site.

C. Where necessary, clean refrigerant piping by swabbing with dry, lintless (linen) cloth, followed by refrigerant oil soaked swab. Remove excess oil by swabbing with cloth soaked in high flash point petroleum solvent, squeezed dry.

3.02 INSTALLATION

A. Install piping system in accordance with manufacturer's installation procedures, requirements of ANSI B 31.5 and as specified.

B. Coordinate piping installation with other work to avoid interference.

C. The piping layout shown on the Contract Drawings shall be considered as diagrammatic. Install piping suitable in every respect for the work-intended clearances required.

D. Run all piping perpendicular and parallel to walls and floors.

E. Bend copper tubing with approved tubing benders to prevent deformation of the tubing in the bends. Use approved sweat-to-pipe threaded adapters for connection with valves and other equipment having threaded connections.

F. All piping shall be concealed above furred ceilings, in furred walls and partitions, unless otherwise shown on the Contract Drawings.

G. Bleed nitrogen through refrigerant piping during soldering operations and during idle periods of construction work to ensure maintenance of dehydrated status. Maintain 10 psi nitrogen charge with pipe end closures.

H. Install solenoid valves with stem pointing upwards. Wiring of solenoid valves is specified in applicable Sections of Division 16.

I. All equipment connections shall be provided with isolation valved disconnections and pump-down recharge connections.

J. Installation requirements for hangers and supports and for pipe penetration sleeves, seals and escutcheons are specified in 2.04 and 2.05, respectively.

K. Soldered Joints

1. Cut ends of tubing square and remove all burrs. Clean inside and outside of tubing with steel wool.

2. Remove excess solder while still in plastic state.

3. Leave a fillet at the wall of the fitting.

4. Prior to soldering, remove the internal parts of all valves or other devices to be installed directly in the line.

L. Piping shall be so arranged and valved that any part or portion of the system may be cut out of service without pumping down the system, or otherwise interfering with the operation of other portions or equipment in the system.

M. Provision shall be made for attaching pressure gauges, or for the installation of test thermometers. Suitable fittings with wells shall be installed where required for the insertion of temperature control sensing bulbs.

N. In multi-circuit evaporators (split direct-expansion cooling coils), each circuit shall be provided with its individual thermostatic expansion valve, and its own refrigerant solenoid valve. Each solenoid valve shall be provided with a valved bypass and inlet and outlet isolation valves.

3.03 FIELD TESTS

A. Refrigerant Piping Leak Tests

1. Test refrigerant piping in accordance with ANSI B 31.5 and refrigeration equipment manufacturer's recommendations, using inert gas such as nitrogen or carbon dioxide, with leak tracer introduced to the piping system through a pressure regulator and gauge manifold.

2. Maintain 150 psi inert gas test pressure in the piping system. Perform bubble test on all joints and then check complete system with halide torch or electronic leak detector.

3. Maintain 150 psi pressure for 24 hours after tests.

B. Dehydration and Charging System

1. Procedure for dehydration and charging shall meet all requirements of EPA Section 608 of the Clean Air Act of 1990.

2. Install core in the filter-dryer after leak test but before evacuation.

3. Evacuate refrigerant system with vacuum pump until refrigerant pressure reaches the level established by EPA for the type of refrigerant and its ultimate recovery. During evacuation, apply heat to pockets, elbows, and low spots in piping.

4. Maintain vacuum on system for a minimum of 5 hours after closing valve between vacuum pump and system.

5. Break vacuum with refrigerant gas, allow pressure to build up to EPA acceptable level.

6. Complete charging of system, using new filter-dryer core in charging line. Provide full operating charge of refrigerant.

7. Maintain the charged system until startup.

3.04 PAINTING

Upon completion of the installation, remove all protecting materials, thoroughly remove all scale and grease and leave in a clean condition for painting. Piping to be painted shall be as shown on the Contract Drawings. Painting shall be in accordance with the requirements of Section 09910 "PAINTING".

3.05 PIPE AND VALVE IDENTIFICATION

A. Pipe Identification

Affix pipe adhesive bands specified in 2.03 A where they can be easily read and with their long dimension parallel to the axis of the pipe.

At least one set of identifying bands shall be affixed in all occupied and unoccupied rooms as well as in all other spaces, such as hung ceilings or shafts, where piping may be viewed, and the identity of the piping system cannot be readily ascertained. As a minimum, a set of such bands shall be affixed at each branch and riser takeoff; adjacent to each valve; at each pipe passage through floor and ceiling construction; at each capped line; and at each pipe passage to an underground area.

B. Valve Tags

Securely fasten valve tags specified 2.03 B with approved brass chain.

END OF SECTION

SECTION 15502

REFRIGERANT PIPING AND APPURTENANCES

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Piping Shop Drawings

   a. Piping layout drawings (minimum 1/4"=1'-0" scale) including, at a minimum, hangers, support locations and details.

   b. Piping coordination drawings (minimum 1/4"=1'-0" scale), showing plan views, sections and piping elevations, on which all items are shown and coordinated with all Work of other Sections.

B. Product Data / Catalog Cuts

1. Piping and Accessories

   a. Pipe material and schedule for each piping system.

   b. Catalog cuts, including product performance data for all items furnished under this Contract, including the following at a minimum:

      (1) Fittings.

      (2) Hangers and supports.

      (3) Sleeves, seals and escutcheons.

      (4) Pipe identification bands.

2. Valves

   a. Catalog cuts, including product performance data, for all items furnished under this Contract, including the following at a minimum:

      (1) Valves, valve operators and strainers.

      (2) Valve tags.

   b. Valve charts and schedules.

C. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive detailed information for the specific approved equipment; including approved shop drawings and catalog cuts, troubleshooting, maintenance requirements, spare part lists, test results, electrical/control devices and electrical/control wiring diagram(s).

D. Construction and Installation Procedures

1. Field test procedures.

E. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15502

REFRIGERANT PIPING AND APPURTENANCES

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.02 A.1)	Required refrigerant valves and specialties (types, sizes and capacities)
(2.02 A.2)	Requirements of UL listing, rating and end type (other than specified)
(2.02 B.3)	Solenoid valve rating other than specified
(2.04 I)	Anchor locations
(2.05 F)	Pipe roof penetration counterflashing method other than specified
(3.02 F)	Concealed piping requirements other than specified
(3.04)	Piping to be painted under Section entitled "PAINTING" included in this Specification

B. Other Items

1. Ensure that the following Specification Sections are included in the Contract Booklet as required:

(2.04 L)	"VIBRATION ISOLATION AND CONTROL"
(3.04)	"PAINTING"

2. Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15503

FUEL OIL PIPING AND APPURTENANCES

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for fuel oil piping and appurtenances.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

American National Standards Institute (ANSI)

American Society of Mechanical Engineers (ASME)

American Society for Testing and Materials (ASTM)

Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)

National Electrical Code (NEC)

National Fire Protection Association (NFPA)

Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

A. Fuel oil piping systems shall be designed in accordance with NFPA 31, and leak detection system shall comply with National Electrical Code.

1.03 QUALITY ASSURANCE

A. Fuel oil piping and appurtenances, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Entities performing the Work of this Section shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Clean all pipe sections of foreign matter and cover ends with temporary sheet metal closures or plastic end caps of sufficient tightness to prevent entry of foreign matter prior to shipping to the construction site.

B. Store pipe, fittings, valves and other components at the construction site on pallets or raised platforms with suitable coverings satisfactory to the Engineer to protect them against damage and weather.

C. Inspect all pipe, fittings, valves and other components for damage before moving them from storage to the point of installation at the construction site.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 PIPE, FITTINGS, AND FLANGES

A. Provide pipe (and tube), fittings, and flanges in accordance with the "PIPE, FITTINGS, AND FLANGES SCHEDULE" shown within this Section, including gaskets, bolts, nuts, washers and other pressure containing parts necessary for the complete installation of fuel oil piping.

B. All welding elbows shall be long radius pattern unless otherwise shown on the Contract Drawings.

C. Buttwelding fittings shall be manufactured by Ladish Company, Crane Co., Grinnell Corp., or approved equal.

D. Socket welding fittings shall be manufactured by Crane, Grinnell, or approved equal.

E. Underground fuel oil piping shall consist of a primary (carrier) pipe, completely enclosed within a secondary (containment) pipe. The primary and secondary pipes and fittings shall be manufactured of glass fiber reinforced epoxy resins. Both pipes shall incorporate integral corrosion-resistant resin-rich reinforced liners. The primary pipe shall be centered within the secondary pipe by use of centering spacers furnished by the pipe manufacturer. Adhesive for joining the piping shall be UL listed epoxy, manufactured by pipe manufacturer. Pipe shall be Ameron Co. "Dualoy 3000/L"; Smith Fiberglass Products, Inc. "Red Thread IIa"; or approved equal. The secondary containment pipe shall be sized and configured so that the interstitial space between the primary and secondary pipes will accommodate adequately a leak detection system cable running throughout the length of the pipe. It shall be Contractor's responsibility to coordinate the piping (size and configuration) with the leak detection system specified herinafter in this Section. Means for installing the leak detection cable, and for venting and draining the piping, and for inspecting the leak detection system shall be provided adequately along the length of piping and where required.

F. Required disconnects for above ground piping shall be made up using welding neck flanges.

G. Welding backing rings for buttwelding joints shall be Robvon Backing Ring Co. "Type CC", or approved equal.

H. Gaskets for steel pipe shall be 1/8-inch thick (after compression) for raised face flanges and 1/16-inch thick (after compression) for flat face flanges, and shall be stainless steel, spiral-wound, non-asbestos filler, ring type.

I. Gaskets for glass fiber pipe shall be Class 150 full-face, 1/8-inch thick (after compression) sheet rubber, ANSI B16.21, with a Shore durometer hardness between 55 and 65, ASTM D1330.

J. Gaskets for glass fiber pipe-to-steel pipe flanged joints shall be as described hereinbefore 2.01 I for glass fiber pipe.

K. Piping shall be designed to contain and remain inert to diesel fuel and heating fuel oil.

Pipe, Fittings and Flanges Schedule				
Fuel Oil Above Ground				
Size	Pipe	Joints	Fittings	Flanges
Up to 2"	ASTM A 53, Gr.B, Seamless, Sch. 80	Socket Weld	ASTM A 105, ANSI B16.11, 3000 lb. Rating, Gr. WPB	ASTM A 105, ANSI B16.5, 150 lb. Class
2-1/2" to 10"	ASTM A 53, Gr.B, Seamless, Sch. 40	Butt Weld	ASTM A 234, Gr. WPB, ANSI B 16.9, Same as Pipe Rating	ASTM A 105, ANSI B 16.5, 150 lb. Class
Up to 2"	ASTM B 88 Type K, Drawn, Nominal Wall (where shown on the Contract Drawings)	Solder 95-5	Wrought Copper ANSI B16.22, Same as Pipe Rating	

Fuel Oil Underground		
Pipe	Joints	Fittings
Primary carrier pipe, centered within a secondary containment pipe Both pipes shall be Glass Fiber Reinforced Epoxy Resin Pipe, UL-Listed, ASTM D2310, ASTM D 2996; Grade 1, Type 1, Class C	Bell and Spigot	Same as pipe; flat face only

2.02 GATE, GLOBE, AND CHECK VALVES

A. Provide valves where shown on the Contract Drawings, in accordance with the "Gate, Globe and Check Valves Schedule" shown in this Section.

B. All gate and globe valves shall be the products of one manufacturer.

C. Swing check valves shall be suitable for installation in the horizontal position.

D. All valve Figure Numbers specified in the "Gate, Globe and Check Valves Schedule" shown in this Section, are those of Crane Co. for cast steel valves (2 1/2 inches and larger) and Smith Valve Corp. for forged steel valves (2 inches and smaller).

E. Subject to compliance with requirements of this Section, valves shall be one of the following manufacturers, or approved equal:

1. Cast Steel Valves

   Crane Co.

   Walworth Co.

   Powell (William) Co.

2. Forged Steel Valves

   Smith Valve Corp.

   Vogt (Henry) Machine Co. Inc.

GATE, GLOBE AND CHECK VALVES (2-1/2 INCHES AND LARGER) SCHEDULE				
Type	Fig. No.	Ends	Rating Class	Construction Features
Gate	47	FL	150	Compliance with ANSI B16.34
	47-1/2	BW	150	Gates & Globes: Rising stem, OS&Y, back seated, bolted bonnet and gland (gasketed), renewable seats and discs, flexible wedge (for gate) and plug type (for globe) disc Checks: Renewable seats and discs, bolted bonnet.
Globe	143	FL	150	
	143-1/2	BW	150	
Swing Check	147	FL	150	Materials: Body & bonnet – Cast Steel, ASTM A216 Gr. WCB
	147-1/2	BW	150	Stem – 11-14 Chrome, ASTM A182 F6 heat treated
				Seat & Backseat Facing – Ferritic or austentic base metal stellite face
				Disc Facing - 11-14 Chrome, ASTM A 182 F6 heat treated

GATE, GLOBE AND CHECK VALVES (2 INCHES AND SMALLER) SCHEDULE				
Type	Fig. No.	Ends	Rating Class	Construction Features
Gate	888W	SW	600	Compliance with MSS SP-84
Globe	G80W	SW	600	Gates & Globes: Rising stem, OS&Y, back seated, bolted bonnet and gland (gasketed), renewable seats and wedges
Lift Check	C80W	SW	600	
				Checks: Renewable seats and discs, bolted bonnet
				Materials: Body & Bonnet - Forged steel, ASTM A 105 Stem and Disc - 11-14 Chrome, ASTM A 182 F6 heat treated Seat - Base metal stellite

2.03 FUEL OIL SPECIALTIES

Provide the following fuel oil specialties where shown on the Contract Drawings:

A. Fuel Oil Foot Valves

Bronze body, integral intake strainer, single poppet, screwed ends, Preferred Utilities Fig. No. 932 and 918; or approved equal.

B. Pressure Relief Valves

Bronze body, steel spring, 300 psi w.o.g. rating, adjustable pressure settings, screwed ends, Preferred Utilities Type R; or approved equal.

C. Pressure Regulating Valves

Bronze body, steel spindle end spring, 300 psi w.o.g. rating, screwed ends, Preferred Utilities Model BQ; or approved equal.

D. Duplex Strainers

Cast iron body, brass strainer baskets with 3/64 inch perforations, quick-opening covers with airtight seals, switching handles, Preferred Utilities Fig. No. 50; or approved equal.

2.04 ACCESSORIES

A. Pipe and Valve Identification

1. Adhesive Bands

a. Provide approved adhesive bands in sets of two, one identifying the piping system type and the second, the direction of the flow. Sets shall be provided in quantities sufficient to accommodate the installation requirements of 3.04 A of this Section.

b. For 3-inch or larger pipe, the adhesive band identifying the piping system shall display the name of the service in letters at least two inches high and the band indicating direction of flow shall display an arrow of similar size. For 2 1/2-inch or smaller pipe, the letters and the arrow shall be not less than one inch high. Bands shall be in colors and shall conform to ANSI A 13.1.

c. Adhesive bands shall be W.H. Brady Co. "Quick-Label", or approved equal.

2. Valve Tags, Charts and Schedules

a. Provide each valve with a 2-inch diameter 18 gauge brass tag with brass chain. Service designation shall be 1/4-inch high on the upper line, and valve number shall be 1/2-inch high on the lower line. The characters shall be indented and filled with durable black compound.

b. Provide diagrammatic valve charts and schedules, using a valve numbering system that differentiates between classes of service and indicates floor level of valve location.

c. Tags shall conform to the numbers, locations, and uses listed in the valve charts and schedules. Valve charts and schedules shall be mounted under glass in wood frames or aluminum self-closing frames.

d. Valve tags and the frames for the valve charts and schedules shall be manufactured by Seton Name Plate Corp., or approved equal.

B. Access Doors

Provide a complete list of all access doors required in finished walls, ceilings, partitions and any other areas for access to all valves concealed behind such finished construction. Access doors shall be furnished and installed under other Sections.

2.05 PIPE HANGERS AND SUPPORTS

A. Design, fabricate and provide all pipe hangers and supports adequate to support and guide the piping, allow for forces imposed by expansion joints, satisfy structural requirements and maintain proper clearances with respect to adjacent piping, equipment and structures.

B. Hangers and supports shall include guides, anchors, stops, restraints, welded attachments, insulation saddles, saddle strands, stays, braces, bolts, nuts, washers, expansion bolts, pipe clamps, beam clamps, and supplementary structural steel for pipe hanger and supports.

C. All hangars and supports shall conform to requirements of MSS SP-58 and SP-69.

D. Structural members required for suspended loads shall be shop fabricated for bolting to building structural members.

E. Do not hang piping from other piping. In no case shall hangers be supported by means of vertical expansion bolts.

F. Keep the different types of hangers to a minimum and provide hangers that are neat, without complicated bolting and with the number of parts of each hanger and its anchor kept to a minimum.

G. Support riser piping independently from the connected horizontal piping.

H. Pipe support attachments to the riser piping shall be riser clamp lugs at each floor level.

I. Provide pipe anchors where shown on the Contract Drawings and where necessary to restrain forces due to thermal expansion and contraction of pipe.

J. Anchors shall be adequately designed to rigidly oppose forces acting on them and shall be embedded in structural concrete or connected to the building structural steel framework.

K. Unless otherwise specifically approved, hanger size and spacing shall be as follows:

1. Steel Piping

Pipe Size	Maximum Hanger Spacing	Minimum Rod Size
1/2" to 1"	5 ft. o.c.	3/8"
1-1/2" to 3-1/2"	9 ft. o.c.	1/2"
4" to 6"	14 ft. o.c.	3/4"
8" to 12"	19 ft. o.c.	7/8"

2. Copper Tubing

Pipe Size	Maximum Hanger Spacing	Minimum Rod Size
1/2" to 1"	5 ft. o.c.	3/8"
1-1/4" to 2"	7 ft. o.c.	3/8"
2-1/2" to 3"	9 ft. o.c.	1/2"
3-1/2" to 4"	11 ft. o.c.	5/8"

L. All hangers and supports shall comply with the requirements specified under the Section entitled "VIBRATION ISOLATION AND CONTROL".

M. Hangers and supports shall be manufactured by Grinnell Corp., Carpenter & Patterson Inc., Michigan Hangar Co. Inc., or approved equal.

2.06 SLEEVES, SEALS, AND ESCUTCHEONS

A. Pipe Penetration through Walls, Partitions and Floors

1. Piping passing through masonry or concrete walls and framed partitions shall have a trim opening cut no greater than necessary for the installation of a sleeve secured therein. Sleeve shall be 1/2 inch in diameter larger than the diameter of the insulated pipe. Sleeve shall be flush with the finished wall or partition surface.

2. Sleeves through concrete floors for piping shall have the opening 1/2-inch in diameter larger than the diameter of the pipe passing through. Floor sleeves shall project one inch above floor slab.

3. Pack the annular space between the pipe and sleeve with mineral wool. Additionally at penetrations through fire-rated barriers, seal the annular space to retain the fire rating integrity of the barrier with non-hardening through-penetration firestops having F-ratings compatible with fire ratings of the barriers in which they are installed, per ASTM, E814. Firestop systems shall be UL-approved, and shall be as manufactured by 3M, Bio-fireshield, Inc., General Electric Co., Dow Corning Corp., or approved equal.

4. Sleeves in walls and floors shall be galvanized steel pipe, Schedule 40. Sleeves in partitions shall be 20-gauge galvanized sheet metal.

B. Pipe Penetration through Exterior Foundation and Pit Walls

1. General

a. All penetrations for piping through perimeter foundation walls and subgrade pit walls shall be provided with the pipe sleeves and seals as shown on the Contract Drawings;

b. Sleeves shall be Schedule 40 for sizes up to 10 inches and 3/8-inch wall thickness for sizes 12 inches and larger. All pipe sleeves shall be galvanized steel, set into foundation walls with anchors and water stop plates.

2. Lead-Oakum Seals

Where "Lead-Oakum" seals are shown on the Contract Drawings, the annular space between the pipe and the sleeve shall be made watertight by caulking with oakum and poured lead, edged and trimmed.

3. Interlocking Modular Seals (Link-Seal)

a. Where "Link-Seal" is shown on the Contract Drawings, seal shall be modular mechanical type, consisting of interlocking sealing element links shaped to continuously fill the annular space between the pipe and the sleeve. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and nut. After the seal assembly is positioned in the sleeve, tightening of the bolts shall cause the sealing elements to expand and provide a watertight seal between the pipe and the sleeved opening. The seal shall provide electrical insulation between the pipe and wall.

b. The inside diameter of each wall sleeve shall be sized as recommended by the manufacturer to fit the pipe and seal to ensure a watertight joint. If pipe outside diameter is nonstandard due to coating or insulation, consult the manufacturer for recommendations before proceeding with wall sleeve sizing.

c. Install sleeves and seals in accordance with the seal manufacturer's instructions to provide a watertight installation.

d. Seals for perimeter foundation wall penetrations shall be two individual sealing units in tandem unless otherwise shown on the Contract Drawings. Single sealing unit shall be used for pit wall penetration unless otherwise shown on the Contract Drawings.

e. Seals shall be Thunderline Corp. "Link-Seal", or approved equal.

2.07 UNDERGROUND FUEL OIL PIPE LEAK DETECTION SYSTEM

A. Provide a complete leak detection system to automatically detect and locate the presence of leaked fuel oil and/or underground water at any point along the secondary (containment) pipe of the fuel oil piping system. The leak detection system shall include electronic control module, fuel/water sensing cable, graphic display panel, and all auxiliary equipment, accessories and appurtenances necessary to make the system complete and operable.

B. The system shall sound audible and visual alarms and locate the event with a digital display to within approximately one foot.

C. The system shall have uniform sensitivity throughout the length of the sensing cable. No more than one (1) foot of leaked fluid in contact with the cable, at a depth of 1/8-inch shall be required to actuate the audible and visual alarms.

D. The system shall operate in such a manner that the presence of a leak cannot be suppressed or otherwise ignored once it is detected. However, it shall be possible to silence the audible alarm after acknowledgement; but the visual alarm shall be maintained until the leak has been corrected.

E. The system shall be UL listed and FM approved.

F. The system shall be tested to Third Party Procedures developed according to the US EPA's "Standard Test Procedures for Evaluating Leak Detection Methods: Liquid Phase Out of Tank Product Detectors."

G. The electronic control module shall be capable of monitoring the entire length of the sensing cable(s). It shall continuously monitor the sensing cable for fuel and/or water contact. Contact with any fuel/water shall result in visual/audible alarms, a "leak" LED signal, actuation of an output relay, and a digital display of the location of the point of contact.

H. The electronic control module shall monitor the sensing cable and interconnecting cable for continuity. Any break in the cables shall result in an audible alarm and a "continuity" LED signal, and shall actuate the output relay.

I. The electronic control module shall provide the following additional features:

1. An "events history log" which shall allow events (leaks) to be tracked, if not responded to immediately. A password shall be required to access the log for modifications or erasure.
2. Ability to customize user settings, such as choice of units, use and update of passwords, modifying the re-alarm intervals, etc.
3. Nonvolatile memory to hold the events history log and user settings.
4. Provisions for connection to building management and control system.

J. Control module power requirements shall be 120 Vac, 240 Vac or 24 Vac/Vdc, single phase, 60Hz, as indicated on the Contract Drawings.

K. The electronic control module shall require no operator programming, and shall be capable of automatically calibrating the entire system whenever power is applied.

L. The fuel sensing cable shall detect the presence of fuel oil and other hydrocarbons, as well as water; and shall be capable of accommodating any number of branches using the system's branching connectors.

M. Provide jumper cable as required to interconnect sensing cables, or for remote mounting of the electronic panel, without reducing the maximum amount of sensor cable that the electronic panel is capable of monitoring.

N. Provide a portable test box to permit field inspection and testing of the complete system or portions thereof.

O. The fuel oil leak detection system shall be the product of Raychem Corporation, Trace Tek Products Group; or PermAlert, Subsidiary of Perma-Pipe, Inc.; or approved equal.

PART 3. EXECUTION

3.01 PRE-INSTALLATION INSPECTION

A. Fully inspect FRP pipe for damage. Locate, cut out or replace damaged pipe.

B. Contractor shall complete items A thru E of checklist FPTPI-P8/89 and obtain the Engineer's initials where required.

3.02 INSTALLATION

A. Install piping system in accordance with manufacturers' installation procedures, requirements of NFPA 31 and applicable codes, and as specified.

B. Coordinate piping installation with other Work to avoid interference. Coordinate as necessary to ensure that all hangers, supports, sleeves and other built-in devices are incorporated in forms or in masonry work to avoid necessity of cutting finished structure.

C. The piping layouts shown on the Contract Drawings shall be considered as diagrammatic. Install piping suitable in every respect for the Work intended and clearances required.

D. Run exposed piping perpendicular and parallel to walls and floors.

E. Install all valves and specialties to permit easy operation and ready access for maintenance and repair.

F. Install an isolation gate valve at each branch connection to supply mains and elsewhere as indicated on Contract Drawings.

G. Install drain valves at low points and vents at high points in mains, risers, branch lines, and elsewhere as required for system drainage and venting.

H. Installation requirements for hangers and supports and for pipe penetration sleeves, seals and escutcheons are specified in 2.05 and 2.06, respectively.

I. Glass Fiber Reinforced Epoxy Pipe

1. Install all glass fiber reinforced epoxy piping in compliance with requirements/recommendation of the manufacturer.
2. Unless otherwise indicated on the Contract Drawings, install the underground piping in a compacted, fine sand bedding. Bedding shall be free of clay or sharp gravel.
3. Flanged valves in glass fiber piping shall be flat face or raised face, with spacer or backer rings provided for the mating glass fiber flange.
4. Transitioning from glass fiber pipe to steel pipe shall be accomplished after termination of the secondary (containment) pipe aboveground, immediately after exiting the ground. It shall be achieved by means of flanged joints for pipe sizes 2 1/2-inch and larger, and via glass fiber adaptors (bell x female NPT) for pipe sizes 2-inch and smaller.
5. Valves, strainers and all other fuel oil system components shall be supported independently of the glass fiber pipes.
6. Glass fiber piping shall be supported/restrained, as required, at all changes in direction and at all branches.
7. Secondary containment piping shall be sealed only after primary piping passes inspection and hydrostatic testing.

J. Steel Pipe

1. All steel pipe shall be welded unless otherwise shown on the Contract Drawings.
2. Each welder shall be certified in accordance with ASME Section IX.

K. Copper Tubing

Joints shall be silver soldering.

L. Glass Fiber Pipe Fuel Oil Leak Detection System

1. It shall be Contractor's responsibility to coordinate the installation of the glass fiber fuel oil piping system specified herein in this Section with the installation of the fuel oil leak detection system serving that system.

2. The piping installer shall provide a clean and dry secondary (containment) piping system with free-running pull ropes and adequate clearances to install the sensing cable system.

3. The fuel oil leak detection system shall be installed in accordance with system manufacturer's installation instructions/procedures. Installation shall include, but shall not be limited to functional testing of the system and mapping thereof.

3.03 FIELD TESTS

A. Glass fiber reinforced epoxy pipe shall be hydrostatically tested in accordance with the manufacturer's recommendations.

B. Steel piping from the pump discharge to the oil burner connection shall be hydrostatically tested at 200 psi, for a period of two hours. All equipment controls and instruments shall be isolated from the piping system during the test.

C. Fuel Oil Leak Detection System:

1. Upon completion of the fuel oil leak detection system installation, a factory-furnished fuel sensing cable, of a length established by the system manufacturer, shall be temporarily installed at the far end of the leak detection circuit. One foot of the fuel sensor shall be immersed in a trough containing fuel oil, to a depth of 1/8-inch, to confirm that an alarm is generated and the location thereof is identified on the control module. The procedure shall be repeated utilizing water. The test shall be performed and certified in the presence of Engineer.

2. Upon completion of the test and removal of the temporary test section, the containment piping system shall be sealed.

3. A graphic display map, prepared from "as-built" drawings, shall be furnished upon completion of the test. The map shall indicate the location of the permanent sensor cable and landmarks such as equipment, piping access parts, changes in cable direction, and cable distance readings.

4. Provide qualified technical representatives of the system's manufacturer to instruct and train Authority personnel in the operation and maintenance of the leak detection system for a minimum of 8 hours.

D. Prior to backfilling pipe trench, primary piping system shall be hydrostatically tested to either 150% of working pressure or 50 psig for 30 minutes. All piping found leaking shall be repaired or replaced. After test has been completed, maintain 25 psig pressure on primary piping and monitor pressure loss while installing secondary containment piping. Secondary containment piping shall be pneumatically tested with soap at 5 psig for 30 minutes upon completion. Make repairs as required if pressure loss occurs for either piping system.

3.04 PAINTING

Upon completion of the installation, remove all protecting materials, thoroughly remove all scale and grease and leave in a clean condition for painting. Piping to be painted shall be as shown on the Contract Drawings. Painting shall be in accordance with the requirements of Section entitled "PAINTING".

3.05 PIPE AND VALVE IDENTIFICATION

A. Pipe Identification

Affix sets of pipe adhesive bands specified in 2.04 A.1 where they can be easily read, with their long dimension parallel to the axis of the pipe and no more than 40 feet apart on a piping system. At least one set of identifying bands shall be affixed in all occupied and unoccupied rooms as well as in all other spaces, such as hung ceilings or shafts, where piping may be viewed and the identity of the piping system cannot be readily ascertained.

B. Valve Tags

Securely fasten valve tags specified in 2.04 A.2 with approved brass chain.

END OF SECTION

SECTION 15503

FUEL OIL PIPING AND APPURTENANCES

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Piping Shop Drawings

   a. Piping layout drawings (minimum 1/4"=1'-0" scale) including, at a minimum, hangers, support locations and details.

   b. Piping coordination drawings (minimum 1/4"=1'-0" scale), showing plan views, sections and piping elevations, on which all items are shown and coordinated with all Work of other Sections.

B. Product Data / Catalog Cuts

1. Piping and Accessories

   a. Pipe material and schedule for each piping system.

   b. Catalog cuts, including product performance data, for all items furnished under this Contract, including the following at a minimum:

      (1) Fittings and flanges.

      (2) Hangers and supports.

      (3) Sleeves, seals, and escutcheons.

      (4) Pipe identification bands.

      (5) Fuel oil leak detection system and components.

      (6) Fuel oil leak detection system control schematic, including power/control wiring diagram(s) and graphic display map.

2. Valves

   a. Catalog cuts, including product performance data, for all items furnished under this Contract, including the following at a minimum:

      (1) Valves, valve operators and strainers.

      (2) Valve tags.

   b. Valve charts and schedules.

C. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive detailed information for the specific approved equipment; including approved shop drawings and catalog cuts, troubleshooting, maintenance requirements, spare part lists, sequence of operations, test results, electrical/control devices and electrical/control wiring diagram(s).

D. Construction and Installation Procedures

1. Fiberglass Installation

a. "Fiberglass Piping Systems Installation Checklist for Underground Petroleum Pipe," published by the Fiberglass Petroleum Tank & Piping Institute.

2. Field test procedures.

E. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15503

FUEL OIL PIPING AND APPURTENANCES

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.01 A)	"PIPE, FITTINGS AND FLANGES SCHEDULE": Copper tubing (ASTM B 88)
(2.01 B)	Other than long radius welding elbows
(2.02 A)	Valves (types & ends)
(2.03)	Fuel oil specialties (foot valves, pressure relief valves, pressure regulating valves and duplex strainers)
(2.05 I)	Pipe anchors
(2.06 B.1.a)	Exterior foundation and pit wall penetration details
(2.06 B.2)	"Lead-Oakum" seal
(2.06 B.3.a)	"Link-Seal"
(2.06 B.3.d)	Sealing other than two sealing units in tandem
(2.07 J)	Control module power requirements
(3.02 F)	Isolation gate valves
(3.02 I.2)	Installation of underground glass fiber piping in other than compacted fine sand bedding
(3.02 J.1)	Other than welded steel piping
(3.04)	Piping to be painted under other Sections of the Specifications

B. Other Items

1. Ensure that the following Specification Sections are included in the Contract Booklet as required::

(2.05 L)	"VIBRATION ISOLATION AND CONTROL"
(3.03)	"PAINTING"

2. Modify Appendix "A" - Submittals per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15515

HYDRONIC SPECIALTIES

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies requirements for hydronic specialties.

B. Hydronic specialties specified in this Section are:

Compression Tanks
Diaphragm-type Expansion Tanks
Air Separators
Balancing and Shut-off Valves
Flow Indicators
Radiator Supply Valves
Thermostatic Radiator Valves (Self-Contained)
Pump Suction Diffusers
Safety Relief Valves
Pressure Reducing Valves

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State, and Local laws, ordinances, regulations and codes, and the latest industry standards including but not limited to the entities listed below.

American National Standards Institute (ANSI)
American Society of Mechanical Engineers (ASME)
American Society for Testing and Materials (ASTM)
American Welding Society (AWS)

In addition, specific provisions cited herein shall govern for the associated specific application.

BOCA Basic Building Code
New York City Building Code

B. Design and performance requirements of the hydronic specialties shall be as shown on the Contract Drawings.

1.03 QUALITY ASSURANCE

A. Hydronic specialties of types and sizes required shall have performed satisfactorily for purposes similar to those included herein, for not less than three years.

B. Entities performing the Work of this Section shall have experience on at least two projects involving complexities similar to those required under this Contract

1.04 DELIVERY, STORAGE, AND HANDLING

A. All specialties shall be factory-cleaned, wrapped and packaged in boxes prior to shipping to construction site.

B. Store specialties in clean, dry spaces and protect them from weather.

C. Prior to installation, inspect specialties for damage.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide hydronic specialties of one of the following manufacturers, or approved equal:

A. Compression Tanks

ITT Bell & Gossett
Wessels Company

B. Diaphragm-Type Expansion Tanks
Amtrol Inc.
Armstrong Pumps Inc.
ITT Bell & Gossett

C. Air Separators

ITT Bell & Gossett
Amtrol Inc.

D. Balancing and Shut-Off Valves

ITT Bell & Gossett
Spirax Sarco Inc.

E. Flow Indicators

Eugene Ernst Products Co.
John C. Ernst Co., Inc.

F. Radiator Supply Valves and Vent Valves

ITT Hoffman Specialty
Hammond Valve Corp.
Spirax Sarco Inc.

G. Thermostatic Radiator Valves

Danfoss Inc.
Honeywell Inc.

H. Pump Suction Diffusers

ITT Bell & Gossett
Amtrol Inc.
Armstrong Pumps Inc.

I. Safety Relief Valves

ITT Bell & Gossett
Amtrol, Inc.
Spirax Sarco, Inc.

J. Pressure Reducing Valves

ITT Bell & Gossett
Amtrol, Inc.
Armstrong Pumps, Inc.

2.02 CONSTRUCTION FEATURES

A. Compression Tanks

Shell:	Welded carbon steel construction per ASME Boiler and Pressure Vessel Code Section VIII, Division 1, stamped with "U" symbol, tappings for gauge glass and tank fitting
Rating:	125 psi at 240 degrees F, Minimum
Capacity:	As shown on the Contract Drawings
Mounting:	As shown on the Contract Drawings
Fitting:	Cast iron, with an air separating trap, water control baffle and a manual air vent or a separate vent tube for air volume adjustment.
Gauge Glass:	Full height and have dual manual shutoff valves, 3/4-inch diameter gauge glass, and slotted metal glass guard.

Compression tanks and fittings shall be ITT Bell & Gossett compression tank and "Airtrol" tank fitting; or approved equal.

B. Diaphragm-Type Expansion Tanks

Shell:	Welded carbon steel construction per ASME Boiler and Pressure Vessel Code Section VIII, Division 1, stamped with "U" symbol, standard air valve, factory-pressurized at the pressure shown on the Contract Drawings. Stainless steel system connection.
Diaphragm:	Heavy-duty Butyl, bonded with polypropylene liner to tank shell.
Rating:	125 psi at 240 degrees F, minimum
Capacity:	As shown on the Contract Drawings
Mounting:	As shown on the Contract Drawings

Expansion tanks shall be Amtrol "Extrol"; or approved equal.

C. Air Separators

Shell:	Welded carbon steel construction per ASME Boiler and Pressure Vessel Code Section VIII, Division 1, stamped with "U" symbol, tangential piping connections, bottom blow down and top connection to compression tank.
Rating:	125 psi at 240 degrees F, minimum
Size:	As shown on the Contract Drawings
Mounting:	As shown on the Contract Drawings
Accessories:	Perforated stainless steel air collector tube. Galvanized steel strainer with 3/16-inch perforations.

Air separators shall be ITT Bell & Gossett "Rolairtrol"; or approved equal.

D. Balancing and Shut-Off Valves

Type:	Calibrated for use as a presettable balance valve, variable orifice flow meter and positive shut-off service.
Body:	2 inch and smaller, bronze body; 2-1/2 inch and larger, cast iron body
	Sizes 1/2 to 3 inches: Brass ball; glass and carbon filled seat rings; capped brass differential pressure readout valves with internal check valves; stem 0 ring suitable for the temperature rating of the valve; 1/4 inch tapped and plugged drain ports
	Sizes 4 inch and over: bronze disc with insert suitable for the temperature rating of the valve, stainless steel stem; teflon-graphite packing; asbestos-free gasket; seal ring; zinc-plated steel bushing; capped differential pressure readout valves with internal check valves
Rating:	125 psi at 240 degrees F, minimum
End Connections:	As shown on the Contract Drawings
Adjustment Device:	Calibrated nameplate and memory stop indicator
Readout Kit:	One portable readout meter for all balancing valves furnished.
	0-35 feet of water scale range with 1% accuracy of full scale range, 10-foot hose, readout probe, carry case, and balancing valve calculator.

Balancing and shut-off valves shall be ITT Bell & Gossett "Circuit Setter" Model CB Calibrated Balance Valves with "RO-4 Readout Kit"; or approved equal.

E. Flow Indicators

Type:	Flapper with flanged glass retaining covers, double window
Body:	Carbon steel
Pressure Rating:	150 psi
End Connections:	Threaded
Position:	Horizontal or upward vertical flow

Flow indicators shall be Eugene Ernst Products Co. "EEP 100-S Sight Flow Indicators"; or approved equal.

F. Radiator Supply Valves

Type:	Spring packed, modulating, non-rising handle, angle or straightway pattern as shown on the Contract Drawings
Material:	Cast brass body, brass union and nut.
Pressure Rating:	150 psi

Radiator supply valves shall be ITT Hoffman Specialty "No. 185 Modulating Type"; or approved equal.

G. Thermostatic Radiator Valves (Self-contained)

Type:	Self-contained, non-electric, modulating, angle or straight pattern as shown on the Contract Drawings, packless, fail-safe open design.
Components:	Bronze body with stainless steel disc, seat and return spring
Temperature Rating:	250 degrees F
Positive Shut-Off	
Pressure:	As shown on the Contract Drawings
Pressure Drop:	As shown on the Contract Drawings
Temp. Setting:	45 to 86 degrees F, adjustable
Accuracy:	1 degree F of setting
Sensor:	Integral valve mounted or remote mounted, with 6-foot capillary tubing, as shown on Contract Drawings
Dial:	Valve mounted

Thermostatic radiator valves shall be Danfoss "RA 2000"; or approved equal.

H. Pump Suction Diffusers

Components:	Cast iron body, stainless steel inlet vanes and orifice cylinder, 16-mesh bronze start-up strainer. Angular pattern, with adjustable support, gauge port and blow down.
Capacity:	As shown on the Contract Drawings
Pressure Drop:	2 psi, maximum
End Connections:	As shown on the Contract Drawings
Rating:	175 psi at 300 degrees F

Pump suction diffusers shall be as manufactured by ITT Bell & Gossett; or approved equal.

I. Safety Relief Valves

Components:	Cast iron or brass body as required for pressure settings; all wetted internal working parts of brass and rubber; designed, manufactured, tested, and labeled in accordance with the requirements of Section IV of the ASME Boiler and Pressure Vessel Code
Capacity:	As shown on Contract Drawings
Relief Setting:	As shown on Contract Drawings
Valve Rating:	125 psig working pressure at 250 degree F.

Safety relief valves shall be as manufactured by ITT Bell & Gossett, or approved equal.

J. Pressure Reducing Valves

Components:	Diaphragm operated, cast-iron or brass body, with low inlet pressure check valve, inlet strainer removable without system shut-down; non-corrosive valve seat and stem
Capacity:	As shown on Contract Drawings
Operating Pressure:	As shown on Contract Drawings
Setting:	Factory-set at operating pressure with capability for field adjustment

Pressure reducing valves shall be as manufactured by ITT Bell and Gossett, or approved equal.

2.03 SHOP PAINTING

Apply one coat of standard gray epoxy paint on exterior surfaces of compression and expansion tanks and air separators.

2.04 SHOP TESTS

A. Hydrostatically test specialties in the shop at 1 1/2 times the working pressure.

B. Perform all shop tests required by ASME Code for compression and expansion tanks and air separators.

C. Calibrate and test balancing valves for accuracy.

PART 3. EXECUTION

3.01 INSTALLATION

Install hydronic specialties in accordance with the manufacturers' installation procedures and requirements of ANSI B31.1 or B31.9, as applicable.

END OF SECTION

SECTION 15515

HYDRONIC SPECIALITIES

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Product Data / Catalog Cuts

1. Hydronic Specialties

a. Product outlines and dimensions of selected models, including required clearances.

b. Components, materials, weights (shipping, installed and operating) and assembly details.

c. Rated capacity and performance data.

d. Catalog cuts.

e. Installation procedures.

f. Certfiication of compliance with ASTM, ASME and ANSI manufacturing requirements for specialties, including at a minimum, the following manufacturers' certificates:

(1) ASME Boiler and Pressure Vessel Code, Form U-1, for expansion and compression tanks and safety relief valves.

(2) Shop calibration for balancing valves.

g. Shop test results.

B. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive detailed information for the specific approved equipment; including approved shop drawings and catalog cuts, troubleshooting, maintenance requirements, spare part lists and test results.

END OF APPENDIX "A"

SECTION 15515

HYDRONIC SPECIALTIES

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(1.02 B)	Hydronic specialties:	Design and performance requirements
(2.02 A)	Compression Tanks:	Capacity Mounting
(2.02 B)	Diaphragm Type Expansion Tanks:	Factory-Pressurization Value Capacity Mounting
(2.02 C)	Air Separators:	Size Mounting
(2.02 D)	Balancing Valves:	End connections (type)
(2.02 F)	Radiator Supply Valves:	Pattern (angle or straightway)
(2.02 G)	Thermostatic Radiator Valves:	Pattern (angle or straightway) Shut-off pressure Pressure drop Sensor mounting (integral or remote)
(2.02 H)	Pump Suction Diffusers:	Capacity End connections (type)
(2.02 I)	Safety Relief Valves:	Capacity Relief setting
(2.02 J)	Pressure Reducing Valves:	Capacity Operating Pressure

B. Other Items

Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15525

STEAM AND CONDENSATE SPECIALTIES

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies requirements for steam and condensate specialties.

B. Steam and condensate specialties specified in this Section are:

Steam Traps
Pressure Reducing Valves
Silencers
Radiator Supply ValvesThermostatic Radiator Valves (self-contained)
Flash Tanks
Vent Exhaust Heads
Drip Pan Elbows (for safety relief valves)

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State, and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

New York City Building Code
BOCA Basic Building Code
American National Standards Institute (ANSI)
American Society of Mechanical Engineers (ASME)
American Society for Testing and Materials (ASTM)
American Welding Society (AWS)
Steam Heating Equipment Manufacturer Association (SHEMA)
Fluid Controls Institute, Inc. (FCI)

In addition, specific provisions cited shall govern for the associated specific application.

B. Design and performance requirements of the steam and condensate specialties shall be as shown on the Contract Drawings.

1.03 QUALITY ASSURANCE

A. Steam and condensate specialties of types and sizes required shall have performed satisfactorily for purposes similar to those included herein, for not less than three years.

B. Entities performing the Work of this Section shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.04 DELIVERY, STORAGE, AND HANDLING

A. All specialties shall be factory-cleaned, wrapped and packaged in boxes prior to shipping to construction site.

B. Store specialties in original packaging in clean, dry spaces and protect them from weather.

C. Prior to installation, inspect specialties for damage.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide steam and condensate specialties of one of the following manufacturers, or approved equal:

A. Steam Traps

Spirax Sarco, Inc.
ITT Hoffman Specialty
Armstrong Machine Works
Nicholson Steam Trap, Inc. (Drain Orifice)

B. Pressure Reducing Valves

Leslie Co.
Dresser/Masoneilan
Fisher Controls International, Inc.
ITT Hoffman Specialty

C. Silencers

Flaregas Corp.

D. Radiator Supply Valves

ITT Hoffman Specialty
Hammond Valve Corp.
Spirax Sarco Inc.

E. Thermostatic Radiator Valves (Self-contained)

Danfoss Inc.
Honeywell Inc.

F. Flash Tanks

Dunham - Bush, Inc., Dunham Div.
Spirax Sarco Inc.
Wessels Co.

G. Vent Exhaust Heads

Crane/Cochrone Environmental Systems
Bryan Steam Corporation
Spirax Sarco Inc.

H. Drip Pan Elbows

ITT Grinnell
Spirax Sarco Inc.
Kunkle Valve Div.

2.02 CONSTRUCTION FEATURES

A. Steam Traps

Type	Working Pressure	Body	Components	Specification Based On
Thermo-static	125 psi, max.	Brass	Brass cap and union; stainless steel (s.s) element/head assembly, seat, and spring; brass seat gasket; renewable seat bellows	Spirax Sarco, Inc. Thermostatic Traps T-125
Float and Thermo-static	125 psi, max.	Cast iron of 30,000 psi tensile strength	Cast iron cover; stainless steel internals	Spirax Sarco, Inc. Series FT/FTI Float & Thermostatic Traps
Inverted Bucket	250 psi, max.	Cast iron of 30,000 psi tensile strength	S.S. mechanism; S.S. bucket; bi-metal air vent; integral strainer	Spirax Sarco, Inc. Series B Inverted Bucket Traps
Thermo-dynamic	10 psi, min. 600 psi max.	303 Stainless steel	S.S. cap, disc and seat; graphite seal	Spirax Sarco, Inc. Series TD-52 Thermo-Dynamic
Drain Orifice	600 psi, max.	Cast steel ASTM A 105	Spiral wound S.S. gaskets; 1/4-inch thick 304 S.S. orifice plate, residing within a forged steel (3000lb.) DUA orifice union; cast steel Y strainer; and strainer forged steel blow-down gate valve; 0.020-inch perforated screen	Nicholson Steam Trap, Inc. "DUM-T" Drain Orifice Traps

Types, patterns, and capacities (or sizes) of steam traps are shown on the Contract Drawings.

B. Pressure Reducing Valves

1. Self-contained Pressure Reducing Valves

Type:	Pilot actuated, dual diaphragm type, with minimum, 95% accuracy of regulation
Body:	Cast iron
Diaph. Cover & Spring Case:	Cast iron
Pilot Diaphragm:	300 series S.S.
Main Diaphragm:	300 series S.S., pre-formed
Pilot Valve & Seal:	17-4 PH S.S.
Main Valve Plug:	Hardened 17-4 PH S.S.
Seat Ring:	Hardened S.S., stellited
End Connections:	As shown on the Contract Drawings
Adjustment Range:	As shown on the Contract Drawings
Inlet Steam Pressure:	Up to 250 psi
Reduced Steam Press. Range	10-150 psi with replaceable adjusting springs
Temperature:	Up to 450 degrees F
Capacity:	As shown on the Contract Drawings

Self-contained, pressure-reducing valves shall be Leslie "GPKP Series"; or approved equal.

2. Air-loaded Pressure-reducing Valves

Type:	Air-operated, remote setpoint and adjustment, with minimum 95% accuracy of regulation
Body:	Cast iron
Diaphragm Cover:	Carbon steel
Diaphragm:	300 series S.S.
Valve Plug:	Hardened S.S
Seat Ring:	Hardened S.S., stellited
Spring:	Stainless steel
End Connections:	As shown on the Contract Drawings
Air-loading Pressure:	250 psi, maximum
Inlet Steam Pressure:	As shown on the Contract Drawings
Reduced Steam Press. Range:	0.5-245 psi with air loader compatible with available supply air pressure
Supply Air Pressure:	As shown on the Contract Drawings
Temperature:	450 degrees F, maximum
Capacity:	As shown on the Contract Drawings

Valves shall be Leslie "G-Series Air-loaded Pressure-reducing Valves, Class GPK", or approved equal.

a. Air Loader

Body & Spring Case::	Die cast aluminum
Adjustable Spring:	Stainless steel

Diaphragm:	Synthetic rubber
Air Inlet Pressure:	200 psi, maximum
Reduced Air Press. Range:	2-150 psi, with replaceable adjusting springs
Temperature:	150 degrees F. maximum
End Connections:	1/4-inch NPT
Filter Bowl:	Die cast aluminum
Filter:	Phenolic resin-impregnated cellulose
Filtration:	10 microns, maximum
Filter Areas:	4.3 sq. in.
Filter to Flow Area Ratio:	88:1, minimum
Filter Bowl Capacity:	4.5 cu. in.
Gauge Press. Range:	Matching loader adjustable pressure range

Air loaders shall be Leslie "Air Mate" air pressure regulators, Class AFG-2; or approved equal.

3. Pneumatic Pressure-reducing Control Valves

Type:	Cage throttling, reverse-acting, fail to close, balanced control valves with diaphragm actuator, control pilot and air loader
Body:	Cast iron
Cage::	Hardened 410 S.S.
Valve Plug:	Stainless steel, stellited, cage throttled
Seat Ring:	Hardened 410 S.S., stellited, cage retained
Packing:	Teflon
Packing Studs/Nuts:	316 S.S.
Packing Spring:	Spring steel
Bonnet:	Cast steel, bolted to valve body
Bonnet Gasket:	Spiral wound S.S.
End Connections:	As shown on the Contract Drawings
Inlet Steam Pressure:	Up to 250 psi
Reduced Steam Press. Range:	Full range, with compatible control pilot
Temperature:	450 degrees F
Seat Tightness:	0.01% of rated Cv
Capacity:	As shown on the Contract Drawings

a. Diaphragm Actuator

Diaphragm:	Neoprene
Diaphragm Case:	Stamped steel plate
Yoke:	Cast iron, bolted to bonnet
Yoke Spring:	Externally adjustable steel spring, cadmium-plated
Oper. Air Pressure:	20 psi (but suitable for 60 psi, maximum)
Size:	Matching the valve (i.e. depending on the steam pressure drop, as well as shutoff conditions

b. Constant Pressure Control Pilot

Type:	Constant pressure, reverse-acting, force-balanced, with zero air consumption in the steady state
Diaphragm Chamber:	Aluminum
Diaphragm:	Neoprene
Inlet Air Pressure:	22/30 psig
Outlet Air Pressure:	0-22 psig, variable
Resolution Sensitivity:	0.01 psi
Pressure Gauge Range:	0-30 psi

Pneumatic pressure-reducing valves shall be Leslie "Class DDBOY Control Valve", with matching diaphragm actuator and type "PRA Constant Pressure Control Pilot", or approved equal.

c. Air Loader

Body & Spring Case:	Die cast aluminum
Adjustable Spring:	Stainless steel
Diaphragm:	Synthetic rubber
Air Inlet Pressure:	200 psi, maximum
Reduced Air Pressure Range:	2-60 psi, with replaceable adjusting springs
Temperature:	150 degrees F, maximum
End Connections:	1/4-inch NPT
Filter Bowl:	Die cast aluminum
Filter:	Phenolic resin-impregnated cellulose
Filtration:	10 microns, maximum
Filter Areas:	4.3 sp. in.
Filter to Flow Area Ratio:	88:1, minimum
Filter Bowl Capacity:	4.5 cu. in.
Gauge Pressure Range:	Matching loader adjustable pressure range

Air loaders shall be Leslie "Air Mate" air pressure regulators, Class AFG-2; or approved equal.

C. Silencers

Shell:	Carbon steel, ASTM A 106, Gr B construction per ASME Boiler and Pressure Vessel Code Section VIII, Division 1, stamped with "U" symbol.
Components:	Inlet diffuser, primary expansion chamber, perforated flow tubes, acoustical packing
Size:	As shown on the Contract Drawings
End Connections:	As shown on the Contract Drawings
Noise Level:	85 dBA, or less

Silencers shall be Flaregas, Inc. "QUIETFLO In-Line Silencers, Type LAS"; or approved equal.

D. Radiator Supply Valves

Type:	Spring-packed, modulating, non-rising handle, angle or straightway pattern as shown on the Contract Drawings
Material:	Cast brass body, brass union and nut
Pressure Rating:	150 psi

Radiator supply valves shall be ITT Hoffman Specialty "No. 185 Modulating Type"; or approved equal.

E. Thermostatic Radiator Valves (Self-contained)

Type:	Self-contained, non-electric, modulating, angle or straightway pattern as shown on the Contract Drawings, packless, fail-safe, open design
Components:	Nickel-plated, brass body with EPDM disc seat and S.S. return spring
Temperature Rating:	250 degrees F
Operating Pressure:	15 psi
Positive Shutoff Pressure:	As shown on the Contract Drawings
Pressure Drop:	As shown on the Contract Drawings
Temperature Setting:	45-86 degrees F, adjustable
Accuracy:	1 degree F of setting
Sensor:	Integral valve mounted or remote-mounted, with 6-foot capillary tubing, as shown on the Contract Drawings
Dial:	Valve-mounted

Thermostatic radiator valves shall be Danfoss, type "RA2000" or approved equal.

F. Flash Tanks

1. Flash tanks shall be of the sizes, capacities and configurations as shown on Contract Drawings.
2. Tanks shall be designed, constructed and stamped for 250 psig, per ASME Section VIII, Div. 1 for unfired pressure vessels.
3. Construct tanks of all welded carbon steel.
4. Provide tappings of sizes as shown on Contract Drawings for all incoming condensate lines, flash steam vent, condensate drain and all other indicated services and connections.
5. Tanks shall be securely supported or as shown on Contract Drawings.
6. Provide each tank with a handhole and with all accessories as shown on Contract Drawings.
7. Flash tanks shall be Wessels Company "FTA ASME Flash Receiver Tanks", or approved equal.

G. Vent Exhaust Heads

1. Provide exhaust heads for each steam vent and where shown on the Contract Drawings.

2. Exhaust heads shall be designed to separate and remove entrainment from vented steam at point of relief to atmosphere. Design shall provide liberal passages to prevent buildup of back pressure. Design shall also minimize noise and eliminate hiss and whistle.

3. Exhaust heads shall be of all-steel construction.

4. Provide each exhaust head with threaded opening for draining all collected water. Carry drained water to a drain location at roof by means of galvanized drain piping.

5. End of exhaust heads shall be flanged.

6. Vent exhaust heads shall be Crane/Cochrane Environmental System "Low Noise Exhaust Heads," or approved equal.

H. Drip Pan Elbows

1. Where indicated on Contract Drawings, provide drip pan elbows at the discharge of safety relief valves.

2. The drip pan elbow shall be cast iron, and of the same size as the safety relief valve outlet. It shall include an elbow with a drain tapping at the heal, a nipple and an integral drain pan. Inlet connection shall be threaded or flanged to match safety relief valve outlet. Provide a separate drain tapping for the drain pan or drain via the elbow.

3. Pipe the drip pan elbow drain(s) to waste as shown on the Contract Drawings.

4. Drip pan elbow shall be ITT Grinnell, Fig. 1538 (threaded) or Fig. 1538F (flanged), or approved equal.

2.03 SHOP PAINTING

Apply one coat of high temperature aluminum paint on exterior surfaces of pressure reducing valves.

2.04 SHOP TESTS

A. Hydrostatically test specialties in the shop at 1 1/2 times the working pressure.

B. Pressure reducing valves shall be factory adjusted, tested for flow rate and set for the inlet and outlet pressures as shown on the Contract Drawings.

C. Test silencers to verify the attenuation of noise level specified in 2.02 C.

PART 3. EXECUTION

3.01 INSTALLATION

Install steam and condensate specialties in accordance with the manufacturers' installation procedures and requirements of ANSI B31.1 or B31.9, as applicable.

END OF SECTION

SECTION 15525

STEAM AND CONDENSATE SPECIALTIES

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Product Data / Catalog Cuts

1. Steam and Condensate Specialties

a. Product data, including manufacturer's figure numbers, weights (shipping, installed and operating), outlines, dimensions of selected models and required clearances.

b. Components, materials, assembly details and location and size of each field connection.

c. Rated capacity and performance data.

d. Catalog cuts.

e. Installation procedures.

f. Certfication of compliance with ASTM, ASME and ANSI manufacturing requirements for specialties.

g. Shop Test Results

(1) Hydrostatic tests for specialties.

(2) Flow rate tests for pressure reducing valves.

(3) Noise level test for silencers.

B. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive detailed information for the specific approved equipment; including approved shop drawings and catalog cuts, troubleshooting, maintenance requirements, spare part lists and test results.

END OF APPENDIX "A"

STEAM AND CONDENSATE SPECIALTIES

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(1.02 B)	Steam and condensate specialties:	Design and performance requirements
(2.02 A)	Steam traps:	Types Patterns Capacities (or sizes)
(2.02 B.1)	Self-contained PRV:	End connections (type) Adjustment range Capacity
(2.02 B.2)	Air-loaded PRV:	End connections (type) Supply air pressure Capacity
(2.02 B.3)	Pneumatic PRV:	End connections (type) Capacity
(2.02 C)	Silencers:	Size (pipe) End connections (type)
(2.02 D)	Radiator Supply Valves:	Pattern (angle or straightway)
(2.02 E)	Thermostatic Radiator Valves:	Pattern (angle or straightway) Shut-off pressure Pressure drop Sensor mounting (integral or remote)
(2.02 F.1)	Show flash tank sizes, capacities and configurations.	
(2.02 F.4)	Show tappings and sizes of all incoming and outgoing connections to flash tanks.	
(2.02 F.5)	Show method of flash tanks support.	
(2.02 F.6)	Show flash tank accessories.	
(2.02 G.1)	Show all required vent exhaust heads.	
(2.02 G.4)	Indicate drain lines from vent exhaust heads.	
(2.02 H.1)	Indicate required drip pan elbows.	
(2.02 H.3)	Indicate drains from drip pan elbows.	
(2.04 B)	Inlet and outlet pressure settings for PRVs	

B. Other Items

Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15526

PIPING EXPANSION JOINTS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for ball and slip type piping expansion joints.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to, the entities listed below.

American National Standards Institute (ANSI)
American Society of Mechanical Engineers (ASME)
American Society for Testing and Materials (ASTM)
Expansion Joint Manufacturer's Association (EJMA)
American Welding Society (AWS)

In addition, specific provisions cited herein shall govern for the associated specific application.

1.03 QUALITY ASSURANCE

A. Piping expansion joints of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

1.04 DELIVERY, STORAGE, AND HANDLING

A. All expansion joints shall be factory-cleaned, wrapped and packaged in boxes prior to shipping to construction site.

B. Store expansion joints in original packaging in clean, dry spaces and protect them from weather.

C. Prior to installation, inspect expansion joints for damage.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section provide piping expansion joints of one of the following manufacturers, or approved equal:

A. Ball Joints

Advanced Thermal Systems, Inc.
Barco Div., Marison Industries

B. Slip Joints

Advanced Thermal Systems, Inc.
Adsco Manufacturing Corp.

2.02 CONSTRUCTION FEATURES

A. Ball Joints

Components:	Carbon steel for all pressure containing parts, conforming to ANSI B31.1.
	Teflon-graphite metallic containment seals and ductile-iron compression seals.
	Carbon steel ball, with spherical surface plated with one-mil hard chrome over one-mil crack-free hard chrome. Certified coating thickness by magnetic inspection per ASTM B 499.
	Ball socket, one piece with integral socket/retainer to eliminate the need for threaded caps or bolted retainer flanges.
Packing Cylinders:	Ball socket to incorporate packing cylinders of size and design that shall provide check valve effect, permitting the addition of packing while preventing blow back. Cylinders shall be furnished with matching plungers. Cylinders shall be of optimum number to guarantee full and uniform packing under full line pressure. Refer to Contract Drawings for system operating pressure.
Packing:	Self-lubricating flake graphite, injectable under full line pressure
Temperature Range:	0-750 degrees F
Rotation:	360 degrees
Angular Flexing:	As shown on the Contract Drawings
End Connections:	As shown on the Contract Drawings
Operating Pressure:	As shown on the Contract Drawings

Ball joint, in its entirety, shall be completely compatible with, and functional under system operating pressure.

Ball joints shall be Advanced Thermal Systems Series "P2", or approved equal.

B. Slip Joints

Sliding Slip:	Machined heavy wall, ASTM A 53, GR. B seamless steel pipe, sliding surface plated with one-mil hard chrome over one-mil crack-free hard chrome. Certified coating thicknesses by magnetic inspection per ASTM B 499.
Stuffing Box"	Machined heavy wall, ASTM A 53, Gr. B seamless steel pipe, with internal and external guides of non-metallic low-friction materials to prevent scoring or binding of sliding slip.
Packing Cylinder:	Machined seamless steel tubing, welded to stuffing box, acme threaded to match the aluminum-bronze (ASTM B-150) packing plunger. Packing cylinder design shall provide a check valve effect to prevent blow back at the system operating pressure indicated on the Contract Drawings. Packing cylinder design and number shall guarantee full and uniform packing under full line pressure.
Support Base:	Fabricated from ASTM A 36 steel
Drain:	3000 lb. forged steel half coupling with forged steel pipe plug, size as shown on the Contract Drawings
Limit Stops:	Stainless steel
Packing:	Self-lubricating, high performance, flake graphite, injectable under full line pressure
Temperature Range:	0-500 degrees F
Traverse Distance:	As shown on the Contract Drawings
End Connections:	As shown on the Contract Drawings
Operating Pressure:	As shown on the Contract Drawings

Slip joint, in its entirety, shall be completely compatible with, and functional under system operating pressure.

Slip Joints shall be Advanced Thermal Systems Type "TP2" with "HPI" graphite packing; or approved equal.

2.03 SHOP PAINTING

Apply one coat of high temperature aluminum paint to exterior surfaces of ball joints and slip joints.

2.04 SHOP TESTS

A. Hydraulically test ball joints and slip joints in the shop at 1 1/2 times the working pressure.

B. Perform a factory "Hydraulic Cycle" test for the ball joints and slip joints for high temperature hot water services after packing has been injected into the stuffing box to ensure free movement of the total rated swing or traverse. Cycle test reports shall be prepared and certified by an independent laboratory.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install piping expansion joints in accordance with the manufacturer's installation procedures and requirements of ANSI B31.1 or B31.9, as applicable.

B. Clean all factory-furnished surfaces. Repair scratched and marred surfaces with manufacturer's touchup paint.

END OF SECTION

SECTION 15526

PIPING EXPANSION JOINTS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Product Data / Catalog Cuts

1. Piping Expansion Joints

   a. Product outlines and dimensions of selected models including, at a minimum, required clearances.

   b. Components, materials, weights (shipping, installed and operating) and assembly details.

   c. Rated capacity and performance data.

   d. Catalog cuts.

   e. Installation procedures.

   f. Shop test results.

   g. Manufacturer's certificate for cycle test reports.

   h. Performance requirements and design criteria for each anchor and alignment guide, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

B. Design Calculations

1. Calculations of requirements for thermal expansion of piping systems and selection and design of expansion joints.

C. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive detailed information for the specific approved equipment; including approved shop drawings and catalog cuts, troubleshooting, maintenance requirements, spare part lists and test results.

END OF APPENDIX "A"

SECTION 15526

PIPING EXPANSION JOINTS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.02 A)	Ball Joints:	System operating pressure Angular flexing End connections (type) Operating pressure (ball joint)
(2.02 B)	Slip Joints:	System operating pressure Drain size Traverse distance End connections (type) Operating pressure (slip joint)

B. Other Items

Modify Appendix "A" - Submittals as per specific project requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15527

FLOW METERS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for flow meters.

1.01 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

American National Standards Institute (ANSI)

American Society of Mechanical Engineers (ASME) American Society for Testing and Materials (ASTM)

Instrument Society of America (ISA)

National Electrical Manufacturers Association (NEMA)

In addition, specific provisions cited herein shall govern for the associated specific application.

A. All flow meters shall have an accuracy as specified in 2.01.

1.02 QUALITY ASSURANCE

A. Flow meters of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Entities performing work shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.03 DELIVERY, STORAGE, AND HANDLING

A. All flow meters shall be factory-cleaned, wrapped and packaged in boxes prior to shipping to construction site.

B. Store flow meters in original packaging in clean, dry spaces and protect them from weather.

C. Prior to installation, inspect flow meters for damage.

1.04 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 CONSTRUCTION FEATURES

A. In-Line Turbine Flow Meters

1. General

Type:	In-line, turbine flow meter with magnetic pick-up, and with converter/transmitter
Accuracy:	0.25% over 10:1 flow range
Repeatability:	+ 0.1% of flow rate or better
Max. Press. Drop:	6 psi at rated flow
Temperature Range:	0 to 300 degrees F
Pressure Range:	0 to 300 psi
Housing Body:	316 stainless steel
Rotor Assembly:	17-4 PH stainless steel
Bearings:	Ceramic (Aluminum Oxide)
Connections:	316 stainless steel flanges, ANSI B16.5, Class as shown on the Contract Drawings
Flow Range:	As shown on the Contract Drawings

2. Electronic Unit

Cabinet:	NEMA, Class 1
Power:	115-volt AC, 50-60 Hz
Readouts:	Rate of flow in gpm. Programmable totalizer in gallons

In-line turbine flow meters shall be Fischer & Porter Turbine Flow meters, Series 10C 1516 with integral magnetic pickoff coil and preamplifier; or approved equal.

B. Pressure Differential Flow Meters

1. General

Type:	Universal venturi tube, with flow transmitter and indicating recorder
Accuracy:	0.5% at design flow
Beta Ratio:	0.6
Discharge	Coefficient:0.98
Maximum Head Loss:	8% of differential
Temperature Range:	0 to 400 degrees F
Pressure Range:	0 to 300 psi

2. Venturi Tube

Body:	ASTM A 126, Gr. B, with bronze throat
Size:	Full line size as shown on the Contract Drawings
End Connections:	As shown on the Contract Drawings
Inlet Section:	2-vena contraction, minimum
Throat Length:	0.5 throat diameter, minimum
Outlet Section:	10 degrees diverging cone

3. Flow Transmitter

U8	Electronic 2-wire type, operating on differential capacitance, with local LCD indicator which shall indicate flow in engineering units (gpm)
Housing:	Cast copper aluminum alloy, NEMA 4, anodized and finished with aliphatic urethane
Signal Output:	4-20 ma DC into 540 ohms
Accuracy:	0.25% of full span
Temperature Limits: Minus (-)32 to 180 degrees F ambient; 250 degrees F for barrier diaphragm	
Accessory:	316 stainless steel, 3-valved manifold

4. Indicating Recorder

Recorder Case:	NEMA 1 enclosure
Components:	Front mounted circular chart and pen, indicator scale and totalizer
Signal Input:	DC current, pulse duration or voltage signal
Power Supply:	110-volt, single-phase, 60 Hz, with switch and fuse
Chart Size:	12-inch diameter, 7 days
Indicator Scale:	10-inch long
Totalizer:	Electronic, 7 digit resettable via a password
Pen:	Felt tip with 4-20 ma DC input
Accuracy:	0.5% of full span

Pressure differential flow meters shall be General Signal Corp./BIF Model 181 Universal Venturi Tube with Leeds & Northrup Model 210 Electronic Indicating Recorder and Leeds & Northrup Model IPT-4000 Electronic pressure differential Flow Transmitter; or approved equal.

2.02 SHOP PAINTING

A. In-Line Turbine Flow Meters

Apply epoxy paint to the meter housing, pickup coil and amplifier case.

B. Pressure Differential Flow Meters

1. Apply coal tar paint to the venturi tube.
2. Apply epoxy paint to the cases of the flow transmitter and indicating recorder.

2.03 SHOP TESTS

All flow meters shall be factory calibrated and tested for the accuracy specified in 2.01.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install flow meters in accordance with the manufacturer's installation requirements and procedures and requirements of ANSI B31.1 or B31.9, as applicable.

B. Calibrate meters according to manufacturer's written instruction after installation.

C. Clean all factory-finished surfaces. Repair scratched and marred surfaces with manufacturer's touchup paint.

END OF SECTION

SECTION 15527

FLOW METERS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Product Data / Catalog Cuts

1. Flow Meters

   a. Product data including, at a minimum, measurement range, calibrated performance curve, outlines and dimensions of selected models and required clearances.

   b. Components, materials and assembly details.

   c. Rated capacity and performance data.

   d. Catalog cuts.

   e. Manufacturer's calibration certificates for flow meters.

   f. Electrical wiring diagram for power supply and controls.

   g. Installation procedures.

B. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive detailed information for the specific approved equipment; including approved shop drawings and catalog cuts, troubleshooting, maintenance requirements, spare parts lists, sequence of operations, test results, electrical/control devices and electrical/control wiring diagram(s).

END OF APPENDIX "A"

SECTION 15527

FLOW METERS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.01 A.1) In-Line Turbine Flow Meter Flange connection Class (ANSI B 16.5), and flow range

(2.01 B.2) Venturi tube full line size and end connections (type).

B. Other Items

Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15528

THERMOMETERS AND GAUGES

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for thermometers and gauges.

1.02 REFERENCES

Not Used.

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with the applicable provisions of the codes, standards, recommendations of the entities listed below.

American National Standards Institute (ANSI)
American Society of Mechanical Engineers (ASME)
American Society for Testing and Materials (ASTM)
Instrument Society of America (ISA)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. All instruments shall have an accuracy as specified in 2.02.

1.04 DELIVERY, STORAGE, AND HANDLING

A. All thermometers and gauges shall be factory-cleaned, wrapped and packaged in boxes prior to shipping to construction site.

B. Store thermometers and gauges in original packaging in clean, dry spaces and protect them from weather.

C. Prior to installation, inspect thermometers and gauges for damage.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide thermometers and gauges of one of the following manufacturers:

Taylor Instrument Co.
Weiss Instruments Inc.
Weksler Instruments Corp.

2.02 CONSTRUCTION FEATURES

A. Thermometers

1. General

The temperature ranges for various systems are as follows:

System	Temperature Range (degrees F)
Condenser Water	50-200
Chilled Water	40-70
Hot Water	60-260
High Temp. Hot Water	100-410

Thermometer range shall be such that the above applicable system range shall be completely included with sufficient safety margins at either end. Provide thermometers of types and at locations shown on the Contract Drawings.

2. Bi-Metal Dial Thermometers

Case:	Stainless steel (entire case assembly), glass lens, friction fitted, moisture proof unit
Temperature Elements:	Bi-metal, Helix wound, silicone fluid dampened, externally recalibratable
Dial Size:	5 inches
Accuracy:	1% of full scale range
Stem:	Stainless steel, all welded, 1/2-inch NPT for separable socket
Separable Socket:	Stainless steel, socket stem length within one inch of pipe diameter

Bi-metal dial thermometers shall be Weiss "Bi-metal Dial Thermometers", or approved equal.

3. Vapor Tension Dial Thermometers

Case:	Chrome-plated steel, friction fitted, glass lens, machined brass gear and phospher tube
Thermal Bulb:	Copper, length to suit the particular service
Dial Size:	4-1/2 inches
Accuracy:	1% of full scale range

Stem:	Length to suit the particular service
Separable Socket:	Bronze, socket stem length within one inch of pipe diameter

Vapor tension dial thermometers shall be Weiss "Vari-angle Vapor Tension Dial Thermometers", or approved equal.

4. Industrial Glass Type Thermometers

Case:	V-shaped cast aluminum, finished in baked epoxy enamel, glass front, spring secured
Adjustable Joint:	Cast aluminum, finished to match case
Locking Device:	Adjusting screws to provide full 360-degree adjustment of case and stem
Readability:	Mercury-filled, magnifying lens, "red reading" tube
Scale:	Satin-faced, non-reflective aluminum with bold black numbers and graduation, 9 inches long
Accuracy:	1% of full scale range
Stem:	Matching taper in separable socket, length to suit the particular service
Separable Socket:	Stainless steel, extension neck length to suit the insulation thickness

Industrial glass type thermometers shall be Weiss "Vari-angle Industrial Thermometers", or approved equal.

B. Pressure Gauges

1. General

The gauges shall be capable of registering pressure ranges and shall be of bourdon tube material as follows:

Gauge	Pressure Range (psi)	Tube Material
Condenser & Chilled Water	0 – 160	bronze
Hot Water	0 – 160	bronze
Pump Suction	0 – 60	bronze
Fuel Oil	0 – 125	bronze
Steam Pressure - Low	0 – 30	bronze
Steam Pressure - Medium	0 – 125	stainless steel
Steam Pressure - High	0 – 300	stainless steel
High Temp. Hot Water	0 – 600	stainless steel

Pressure gauges shall be Weiss Series UG 2; or approved equal. Provide pressure gauges where shown on the Contract Drawings.

2. Pipe or Equipment Mounted Type

Tube Material:	Specified in 2.02 B.1 above
Case Dial:	Aluminum with white background and black lines and numbers
Dial Size:	4-1/2 inches

Accuracy:	0.5% of full scale range
Accessories:	Snubber and gauge cock

C. Thermometer Wells

1. General

Provide thermometer wells where shown on the Contract Drawings except where separable sockets for thermometers are specified in 2.02 A.

2. Thermometer Wells

Material::	Stainless steel
Pressure Ratings:	Matching piping system design pressure
Extension:	Allowance for insulation thickness
Accessories:	Cap nut with chain, fastened permanently to the thermometer well

PART 3. EXECUTION

3.01 INSTALLATION

Install thermometers and gauges in accordance with the manufacturer's installation procedures and requirements of ANSI B31.1 or B31.9, as applicable.

END OF SECTION

SECTION 15528

THERMOMETERS AND GAUGES

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Product Data / Catalog Cuts

1. Thermometers and Gauges

   a. Product outlines and dimensions of selected models including, at a minimum, required clearances.

   b. Components, materials and assembly details.

   c. Capacity and performance data.

   d. Catalog cuts.

   e. Installation procedures.

   f. Manufacturer's calibration certificates for thermometers and gauges.

END OF APPENDIX "A"

SECTION 15528

THERMOMETERS AND GAUGES

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.02 A.1) Types and locations of thermometers.

(2.02 B.1) Locations of pressure gauges.

(2.02 C.1) Locations of thermometer wells.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15541

CHILLED AND HOT WATER PUMPS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for chilled and hot water pumps.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

American Society for Testing and Materials (ASTM)
American Society of Mechanical Engineers (ASME)
Hydraulic Institute (HI)
National Electrical Code (NEC)
National Electrical Manufacturers Association (NEMA)
Underwriters Laboratories, Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Design and performance requirements of chilled and hot water pumps shall be as specified in the Pump Schedules shown on the Contract Drawings.

1.03 QUALITY ASSURANCE

Chilled and hot water pumps proposed for use hereunder shall have performed satisfactorily for purposes similar to those intended herein, for not less than three years.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver pumps and components in factory-fabricated protective packaging.

B. Handle pumps and components carefully to prevent breaking, denting and scoring.

C. Store pumps and components in clean, dry spaces and protect them from weather.

D. Comply with the manufacturer's rigging instructions for unloading pumps and moving them to final location for installation.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with the requirements of this Section, provide chilled and hot water pumps of one of the following manufacturers, or approved equal:

General Signal/Aurora Pump
Bell and Gossett Co.
Weinman Pump
Goulds Pump, Inc.

2.02 MATERIALS

Materials for chilled and hot water pumps shall be as specified below:

Casing:	Cast iron
Baseplate:	Cast iron/steel
Impellers:	Bronze
Wearing Rings:	Bronze
Shaft:	Steel
Shaft Sleeves:	Bronze

2.03 CONSTRUCTION FEATURES

A. Pumps

Chilled and heating hot water pumps:

1. Pumps shall be of the centrifugal, single stage, horizontally split case type, unless otherwise indicated on the Contract Drawings. Impellers shall be dynamically balanced.
2. Provide mechanical seals suitable for use with water at 240 degrees F without external cooling.
3. Provide each pump with coupling guards, motors, baseplates, flushing connections and grease lubricated bearings.

B. Provide motors with non-overloading characteristics on all portions of the pump curve.

C. Motors

Provide motors in accordance with the requirements specified in the Section of these Specifications entitled "MOTORS AND MOTOR CONTROLLERS". Motors shall be mounted on adjustable bases. Select the motor characteristics, the motor mounting and all accessories necessary to satisfy the requirements of the pump motor drive unit in all operating modes.

D. Vibration Isolation

Provide vibration isolation in accordance with the requirements specified in the Section of these Specifications entitled "VIBRATION ISOLATION AND CONTROL". Consult with the supplier of vibration isolation devices concerning the selection of the types required.

2.04 SHOP TESTS

A. General

1. Manufacturer's standard shop tests shall be performed on pumps, motors, controllers, and appurtenances in conformance with the requirements of this Section.

2. All shop tests may be witnessed by the Engineer. Notify the Engineer 14 days in advance of scheduled tests.

B. Performance Tests

Each pump shall be performance tested in accordance with the procedures of the Hydraulic Institute.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install pumps in locations shown on the Contract Drawings, in accordance with manufacturer's installation procedures.

B. Field install all electrical devices furnished under this Section.

C. Verify that electrical wiring installation is in accordance with Engineer-approved manufacturer's submittal and in accordance with installation requirements of Division 16 Specifications.

3.02 FIELD TESTS

Operate pumps after installation has been completed to verify that pumps are in working order. Operate pumps in accordance with manufacturer's instructions.

END OF SECTION

SECTION 15541

CHILLED AND HOT WATER PUMPS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings / Product Data / Catalog Cuts

1. Chilled and Hot Water Pumps

   a. Shop drawings indicating dimensions of selected models, materials, weights (shipping, installed and operating), load distribution, required clearances and methods of assembly of components.

   b. Certified pump performance characteristic curves with design points clearly indicated.

   c. Catalog cuts.

   d. Electrical wiring diagrams for power supply, interlock and controls.

   e. Installation procedures.

   f. Shop test results.

B. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive detailed information for the specific approved equipment; including approved shop drawings and catalog cuts, troubleshooting, maintenance requirements, spare part lists, sequence of operations, test results, electrical/control devices and electrical/control wiring diagram(s), bearings maintenance procedures, lubrication procedures and lubricant type.

C. Construction and Installation Procedures

1. Field test procedures.

D. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

CHILLED AND HOT WATER PUMPS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(1.02 B)	Design and performance requirements (in Pump Schedules).
(2.03 A)	Pumps other than centrifugal, single stage, horizontally split cast type.
(3.01 A)	Pump locations.

B. Other Items

1. Ensure that the following Specification Sections are included in the Contract Booklet as required:

(2.03 C)	"MOTORS AND MOTOR CONTROLLERS"
(2.03 D)	"VIBRATION AND ISOLATION CONTROL"

2. Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15555

CAST IRON HOT WATER BOILERS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for cast iron hot water boilers.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

New York City Building Code
New York City Department of Environmental Protection "Air Resources"
New York State Energy Conservation Construction Code
New Jersey Uniform Construction Code
American Society of Mechanical Engineers (ASME)
American Boiler Manufacturers Association (ABMA)
American National Standards Institute (ANSI)
Hydronics Instititue (HI)
National Electrical Code (NEC)
National Fire Protection Association (NFPA)
Underwriters Laboratory (UL)
American Gas Association (AGA)
BOCA National (Mechanical and Energy) Code (BOCA)
Industrial Risk Insurers (IRI)
Factory Mutual (FM)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Design, performance requirements, and pressure rating of boilers shall be as specified in the Boiler Schedules (hereinafter in this Section "SCHEDULES"), shown on the Contract Drawings.

1.03 QUALITY ASSURANCE

A. Boilers, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein, for not less than three years.

B. Entities performing the Work of this Section shall have experience on at least two projects involving complexities similar to those required under this Contract.

C. Provide products that are listed and labeled in accordance with Article 100 of National Electrical Code.

D. Fabricate and stamp boilers according to ASME Boiler and Pressure Vessel Code, Section IV, "Heating Boilers".

E. Test and rate boilers according to Hydronics Institute's "Testing and Rating Standard for Heating Boilers", with I-B-R emblem on a nameplate affixed to the boiler.

F. Boilers shall be subject to factory inspection prior to shipping.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver boilers with factory-installed wooden skids and lifting lugs; pack components in factory-fabricated protective containers.

B. Handle boilers carefully to avoid damage to components, enclosures, and finish.

C. Store boilers in clean, dry spaces and protect them from weather.

D. Comply with the manufacturer's rigging instructions for unloading boilers and moving them to final location for installation.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with the requirements of this Section, provide factory-fabricated boilers of one of the following manufacturers, or approved equal:

Smith Cast Iron Boilers
Weil McLain
Burnham Corporation
Peerless Heater Company

2.02 MATERIALS

Materials for boilers shall be as specified below:

Sections:	Cast iron
Jacket:	Steel, 20 gauge, minimum
Smokehood with Integral Damper:	Cast iron or aluminized steel
Cleanout Covers:	Cast iron
Floor Rails:	Steel angles
Burner Mounting Plate:	Cast iron
Burner	Cast iron

2.03 CONSTRUCTION FEATURES

A. General

1. Boilers shall be of sizes, arrangements and capacities specified in the Schedules shown on the Contract Drawings.
2. Boilers shall consist of cast iron sections, jacket, smokehood with integral damper, cleanout covers, floor rails, burner mounting plate, burner, burner controls and trim.

B. Sections

1. Provide one-piece design sections incorporating the furnace space and flue gas collector space with perimeter joints between sections arranged for permanent pressure sealing with high temperature, non-metallic fiber rope.
2. Upper and lower ports for connecting the water space of adjacent sections shall be sealed by means of composition "hi-temp" hydronic seals.
3. Sections shall be assembled with short rods that are torqued to the boiler manufacturer's recommended installation specifications.

C. Jacket

1. Provide boilers with jacket panels arranged with slots and knockouts to accommodate boiler piping and allow jacket installation after piping is in place.
2. Provide side panels with chrome plated knobs for easy panel removal and access to cleanout covers.
3. All side panels shall be secured in place without use of metal screws and shall afford easy access for cleaning and joint seal inspection.
4. Panels shall be insulated with 1-1/2 lb/cu.ft density fiber insulation glued to the inside of the panels.

D. Smokehood with Integral Damper

1. Provide smokehood with integral damper. Smokehood slide damper shall be arranged for easy adjustments with the boiler vent outlet connected to the flue gas vent.
2. Failsafe slide damper shall provide fixed minimum free opening and shall enter from the bottom of the smokehood.
3. Smokehood outlet collars shall be sized to fit inside a standard round sheet metal pipe.

E. Cleanout Covers

1. Cleanout covers shall be sized and located to allow full access to the entire heating surface areas for cleaning with a wire brush.
2. Cleanout covers shall have grooves that shall contain high temperature mineral fiber rope seals.

F. Floor Rails

Provide 3 inch x 3 inch base angles, minimum, to be set under field assembled boilers to provide level support for the sections when shimmed and grouted to concrete floor. Base angles shall be tapped to receive the supporting frame for the insulated metal jacket.

G. Burner Mounting Plates

1. Provide burner-mounting plates arranged for gas-tight fit on the front section.
2. Burner mounting plate shall have a proper opening for the burner air tube and a raised surface for sealing at the burner-mounting flange.
3. Insulate mounting plate with high temperature ceramic faced insulating block. Attach insulation to plate with high temperature alloy bolts, washer and nuts.

H. Burners

1. Provide boilers with gas/oil burners. Burners shall include forced draft retention type combination nozzle mix, multi-port gas burner and a high-pressure oil burner.
2. Burners shall be capable of firing the boilers with No. 2 fuel oil and/or natural gas as indicated on the Contract Drawings.
3. Burners shall be arranged for LO-HI-LO-OFF or full modulation firing, as indicated on the Contract Drawings, with either gas or oil. The oil side shall employ a bypass nozzle system with return oil pressure regulator and shutoff valve to control oil firing rate and a three-way oil valve and spring loaded oil pressure actuated damper cylinder to control combustion air. The gas side shall employ slow opening fluid power gas shutoff with linkage to a movable combustion air damper. Either fuel shall allow control of fuel-air ratios for smooth lightoff and easy transition to high fire.
4. Operating gas pressure available at the first burner manual shut-off cock is as indicated on the Contract Drawings.
5. Burners provided shall be compatible with the available gas pressure.

I. Burner Controls

1. Equip burners with electronic safeguard system and scanner. Flame safeguard control shall be Honeywell LR414OL and UV scanner as manufactured by Honeywell, Inc., or EP160 Fireye Series, or approved equal.
2. General control interlocks and limit requirements shall be provided as a minimum:

a. Operating Temperature Control

b. High Limit Temperature Control with manual reset

c. Hi-Hi limit temperature control with manual reset

d. Combustion Air Flow Switch

e. Spark Ignited Gas Pilot

f. Trial for Pilot

g. Main Flame Trial

h. Main Flame Supervision

i. Valve Closing Time (2-4 sec)

j. Action on Flame Failure Lockout

k. Low Water cutoff with alarm contacts and audible alarm

3. Status lights and alarm indications shall be as follows:

a. Power on

b. Fuel type

c. Main flame failure

d. Pilot failure

e. Low water condition

f. High temperature condition

g. High pressure condition

4. Unit-mounted control panel, with communication capability with the Automatic Temperature Control System and the Building Management System, shall be provided.

5. The entire gas/oil burner shall conform to FM or IRI requirements as stipulated on the Contract Drawings. The gas train shall include, but not be limited to:

a. Lub-Type Test Cock(s)

b. Fluid Power Safety Shutoff Valve (Motorized)

c. High Gas Pressure Switch

d. Normally Open Vent Valve

e. Auxiliary Solenoid Gas Valve

f. Low Gas Pressure Switch

g. Main Gas Pressure Regulator

h. Main Manual Shutoff Valve(s)

i. Manual Pilot Shutoff

j. Pilot Regulator

k. Pilot Gas Valve

J. Trim

Provide boiler trim consisting of an ASME rated relief valve set at the pressure shown on the Contract Drawings, means for automatic cold water make-up, low water cutoff, a theraltimeter, and a flexible return yoke made up of precut lengths of pipe and fitting, all arranged to fit the two return tappings on the back section.

K. Provide vents for all gas elements requiring vents to atmosphere. The continuation of the vent pipe line shall run independently to and through the roof. Vent pipe size shall conform to IRI requirements. Provide a normally-open (fail-open) vent valve in accordance with IRI requirements.

L. Boilers shall be constructed and tested at a pressure equal to two-and-a-half times the setting of the pressure relief valve.

2.04 SHOP TESTS

Perform manufacturer's standard shop tests and tests required by the provisions of ASME Boiler and Pressure Vessel Code. The Contractor shall notify the Engineer at least one week in evidence of the scheduled tests.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install boilers level and plumb in accordance with the manufacturer's written installation procedures, rough-in drawings, and referenced standards, including NFPA 31 and 54.

B. Coordinate all the Work of this Section to ensure that the installation of the boilers is not in conflict with the Work performed under other Sections of these Specifications.

C. Flush and clean boilers upon completion of installation, in accordance with manufacturer's written instruction. Disposal of flushing and cleaning fluids/solutions shall be accomplished in accordance with governing codes, laws and ordinances.

D. Clean factory-finished surfaces and repair any marred or scratched surfaces with manufacturer's touchup paint.

E. Verify that the electrical wiring installation is in accordance with the manufacturer's submittal and in accordance with the installation requirements as specified in Division 16 Specifications.

3.02 FIELD TESTS

A. Start up and adjust boilers in accordance with the manufacturer's startup instructions.

B. Perform a field test of the boiler to verify its capacity and efficiency, in accordance with ASME Boiler and Pressure Vessel Code requirements.

C. Provide qualified technical representatives of the manufacturer to instruct the facility staff in the operation and maintenance of the boilers for a minimum period of 8 hours.

END OF SECTION

SECTION 15555

CAST IRON HOT WATER BOILERS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings / Product Data / Catalog Cuts

1. Cast Iron Hot Water Boilers

   a. Shop drawings indicating dimensions of selected models, weights (shipping, installed and operating), load distribution, required clearances and methods of assembly of components, including details of boiler sections and selected burner, burner manifolds, combustion operating and safety controls and boiler trim.

   b. Boiler capacity, pressure rating, and performance data.

   c. Catalog cuts.

   d. Electrical wiring diagrams for power supply, interlock and controls.

   e. Gas train components.

   f. Boiler trim components.

   g. Installation procedures.

   h. Shop test results.

B. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive detailed information for the specific approved equipment; including approved shop drawings and catalog cuts, troubleshooting, maintenance requirements, spare part lists, sequence of operations, test results, electrical/control devices and electrical/control wiring diagram(s).

C. Construction and Installation Procedures

1. Field test procedures.

D. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

CAST IRON HOT WATER BOILERS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following specified items in the text:

(1.02 B)	Design, performance requirements and pressure rating of boilers (in Boiler Schedule).
(2.03 A.1)	Sizes, arrangements and capacities (in Boiler Schedule).
(2.03 H.2)	Burners to be fired with No. 2 fuel oil and/or natural gas.
(2.03 H.3)	Burners to be arranged for LO-HI-LO-OFF or full modulation.
(2.03 H.4)	Operating gas pressure at first burner manual shut-off cock.
(2.03 I.5)	Entire gas/oil burner to conform to FM or IRI requirements.
(2.03 J)	Sitting of the relief valve.

B. Other Items

Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15590

FUEL OIL EQUIPMENT

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies requirements for No. 2 fuel oil equipment.

B. Types of fuel oil equipment specified in this Section are:

1. Storage Tank.
2. Day Tank.
3. Pumps.
4. Level Controls.

1.02 REFERENCES

Not Used.

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with the applicable provisions of the codes, standards, recommendations of the entities listed below.

Underwriters Laboratories Inc. (UL)

Building Officials & Code Administration (BOCA)

National Fire Protection Association (NFPA)

American Society of Mechanical Engineers (ASME)

American Petroleum Institute (API)

American Society for Testing & Materials (ASTM)

National Electrical Manufacturers Association (NEMA)

Occupational Safety and Health Administration (OSHA)

American National Standards Institute (ANSI)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Design and performance requirements of fuel oil equipment shall conform to the applicable codes, standards and recommendations of the organizations referenced in 1.03 A, and, for pumps, as specified in the Pump Schedules (hereinafter referred to as "SCHEDULES"), shown on the Contract Drawings.

1.04 QUALITY ASSURANCE

A. Fuel oil equipment, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Fuel oil equipment shall be subject to factory inspection prior to shipping.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver equipment with factory-installed wooden skids and lifting lugs; pack components in factory-fabricated protective containers.

B. Handle equipment carefully to avoid damage to components.

C. Store equipment in clean, dry spaces and protect them from weather.

D. Comply with manufacturer's rigging instructions for unloading equipment, and moving equipment to final location for installation.

1.06 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide factory-fabricated fuel oil equipment of one of the following manufacturers, or approved equal:

A. Storage Tank

Owens-Corning Fiberglas Corp.

B. Day Tank

A. L. Eastmond & Sons, Inc.

C. Pumps

Transamerica DeLaval, Inc.

D. Level Controls

Magnetrol International
McDonnel & Miller, ITT

2.02 MATERIALS

Materials for fuel oil equipment shall be as specified below.

A. Storage Tank

Double-wall fiberglass.

B. Day Tank

Steel

C. Pumps

Case:	Cast iron
Power Rotor:	Alloy steel
Idler Rotors:	Pearlitic iron

2.03 CONSTRUCTION FEATURES

A. Storage Tank

1. Provide storage tank of size and capacity as shown on the Contract Drawings.
2. UL labels shall be affixed to tank.
3. Install tank as shown on the Contract Drawings and in accordance with manufacturer's instructions.
4. Provide fittings for the following:
   a. Fill line.
   b. Supply line.
   c. Remote gauge line.
   d. Vent.
   e. Monitoring system.
5. Provide two 22 inch ID UL approved steel manways with gaskets, bolts and covers.
6. One manway cover shall have four 4 inch steel fittings welded in place at 90 degrees spacing. The other manway shall have one, 4 inch steel fitting welded in place at center of cover.
7. Provide suction line with a 2" foot valve as specified in Division 15 Section entitled "FUEL OIL PIPING AND APPURTENANCES".
8. Provide fill box and vent hood at locations shown on the Contract Drawings.
9. Provide one manway riser and one manway extension as shown on the Contract Drawings.
10. Provide lifting lugs on tank capable of withstanding weight of tank with a safety factor of 3 to 1.
11. Provide 4-inch diameter factory-installed fiberglass-reinforced plastic fill tube.

12. Provide carbon steel ladder. Ladder shall be located in tank under manway cover containing one 4 inch steel fitting.

13. Provide glass fiber-reinforced plastic anchor straps for tank installation. Number and location of straps shall be as shown on the Contract Drawings.

14. Provide tank with the following hydrostatic monitoring capabilities:

    a. Tank shall have a space between the primary and secondary shell walls to allow for the free flow and containment of all leaked product from the primary tank.

    b. The following continuous monitoring conditions shall be compatible with the cavity between the inner and outer tanks:

        (1) Vented to atmosphere.

        (2) Vacuum: 3" mercury maximum (1.5 psi maximum).

        (3) Positive air pressure: (3 psi maximum).

        (4) Hydrostatic pressure: 7-foot maximum groundwater head pressure over tank top.

    c. Tank shall have an integrally mounted reservoir installed on the tank for hydrostatic monitoring. The reservoir shall be constructed of fiberglass reinforced plastic materials and warranted for 30 years against failure due to internal/external corrosion and, against structural failure.

    d. Tank shall be designed with access to the tank bottom between the primary and secondary walls (annular space). Tank shall have one 4 inch NPT monitoring fitting in the reservoir. Tank shall also have one 4 inch NPT monitoring fitting located on each end of the tank.

    e. The double-wall tank monitor shall be capable of detecting a breach in the inner and/or outer tank under the following installed conditions:

        (1) When the inner tank is empty.

        (2) When the inner tank is partially or completely full and the groundwater table is below the tank bottom.

        (3) When the inner tank is partially or completely full and the tank is partially or completely submerged in groundwater.

    f. All monitoring equipment, including FRP reservoir and electronic control shall be UL listed.

    g. Solution used in the tank annular space shall have UL approval for compatibility with the tank.

    h. Hydrostatic monitoring accessories shall include brine antifreeze, reservoir sensor and electronic control panel.

    i. The control panel shall be constructed of UL listed, electronic components. Provide 120 volts power for the control panel and all associated wiring.

    j. Control panel shall include:

        (1) Panel lights.

        (2) Alarm test button.

(3) Warning bell.

(4) Transmission contacts (normally closed) for phone dialer.

(5) Panel housing materials - fiberglass.

(6) Two spare light bulbs.

(7) Wall mounting hardware.

(8) Alarm bell silence switch.

(9) Hasp for padlock.

B. Day Tank

1. Provide day tank of size and capacity as shown on the Contract Drawings.

2. Provide fittings for the following:

a. Liquid level control probe.

b. Vent line.

c. Two supply lines.

d. Return line.

e. Drain line.

3. Provide lifting lugs on tank.

C. Pumps

1. Provide positive displacement rotary gear type fuel oil pumps.

2. Provide pumps with motors, mounting brackets, flexible shaft couplings, shaft seals and bearings.

3. Provide motors with non-overloading characteristics on all portions of the pump curve.

4. Provide motors in accordance with requirements specified in Division 15 Section entitled "MOTORS AND MOTOR CONTROLLERS". Select the motor characteristics, the motor mounting and all accessories necessary to satisfy the requirements of the pump motor drive unit in all operating modes.

5. Provide vibration isolation in accordance with requirements specified in Division 15 Section entitled "VIBRATION ISOLATION AND CONTROL". Consult with the supplier of vibration isolation devices concerning the selection of the types required.

D. Level Controls

1. Day Tank

a. Provide level controls for the fuel oil day tank shown on the Contract Drawings.

b. Level controls shall be as follows:

(1) One Kotron Tri-point Level Sensor, Model 80-7023-302, Enclosure: Class I Group C & D, Class II Group E, F & G.

(2) Cast iron: as manufactured by Magnetrol International, or approved equal.

(3) One Kotron Rigid Probe with stilling well; Model 41-1027-020; Size: approx. 10 feet; Tube OD: 0.875 foot.

Probe Material: TFE covered 316; stainless steel: as manufactured by Magnetrol International, or approved equal.

c. Control System Description

The tri-point sensor, located in the day tank, shall turn on the fuel oil pump when the fuel oil level in the day tank drops to a preselected level. When tank is filled to a preselected high level, the sensor shall turn off pump. At a third higher fuel oil level, the sensor shall alarm in the event of an overfill.

2. Storage Tank

a. Provide a continuous level read out for the storage tank shown on the Contract Drawings. The level indicator shall be located in the fuel oil pump room.

b. Level read out controls shall be as follows:

(1) One Kotron two-wire level transmitter

Model: 82-7303-300

Enclosure: Explosion proof (NEMA 7/9) epoxy painted

Output: 4-20 MaDC, as manufactured by Magnetrol International, or approved equal.

(2) One Kotron Rigid Probe with stilling well,

Model: 41-1027-020, Size: Approx. 10 feet,

Tube OD: 0.875 foot

Probe Material: TFE covered 316, stainless steel, as manufactured by Magnetrol International, or approved equal.

(3) One Verse loop indicator with power supply and current trip.

Model: 88-1140-051

Power Input: 4-20 Ma supply for transmitter

Digital meter indicating 0-100% oil level,

Current trip module for low level alarm, as manufactured by Magnetrol International, or approved equal.

E. Control System Description

The storage tank shall have a continuous level read out of fuel oil level on an indicator in the oil pump room. A low-level switch shall indicate low fuel level in the storage tank and sound an alarm in the oil pump room. The low-level switch is adjustable.

2.04 SHOP TESTS

A. Equipment shall be tested according to manufacturer's standard shop tests.

B. All shop tests may be witnessed by the Engineer. Notify the Engineer 14 days in advance of scheduled tests.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install equipment in locations shown on the Contract Drawings, in accordance with manufacturer's installation procedures.

B. Field install all electrical devices furnished under this Section.

C. Verify that electrical wiring installation is in accordance with Engineer-approved manufacturer's submittal and in accordance with installation requirements of Division 16.

D. Coordinate all trades to ensure that the installation of the equipment is not in conflict with the Work specified under other Sections.

3.02 FIELD TESTS

A. Provide qualified technical representatives of the manufacturers to advise on field tests.

B. The leak detection performance of the fiberglass storage tank's monitoring system shall be tested and verified by a qualified independent consultant.

END OF SECTION

SECTION 15590

FUEL OIL EQUIPMENT

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Storage Tank

   a. Shop drawings showing storage tank details including, at a minimum, critical dimensions of selected models, weights (shipping, installed and operating) and locations of all fittings, tappings, ladders, manways, manway risers, anchor straps, hydrostatic monitoring systems and piping connections.

   b. Equipment materials and gauges.

   c. Electrical wiring diagrams for power supply, interlock and controls.

   d. Installation details.

2. Day Tank

   a. Shop drawings showing day tank details including, at a minimum, critical dimensions of selected models, weights (shipping, installed, and operating) and locations of all fittings, tappings, ladders, anchor straps, hydrostatic monitoring systems and piping connections.

   b. Equipment materials and gauges.

   c. Electrical wiring diagrams for power supply, interlock and controls.

   d. Installation details.

3. Pumps and Level Controls

   a. Shop drawings indicating dimensions of selected models, required clearances and methods of assembly of components.

   b. Certified pump performance characteristic curves with design points clearly indicated.

   c. Capacity and performance data.

   d. Electrical wiring diagrams for power supply, interlock and controls.

   e. Installation instructions.

   f. Shop test results.

B. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive detailed information for the specific approved equipment; including approved shop drawings and catalog cuts, troubleshooting, maintenance requirements, spare part lists, sequence of operations, test results, electrical/control devices and electrical/control wiring diagram(s).

C. Construction and Installation Procedures

1. Field test procedures.

D. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15590

FUEL OIL EQUIPMENT

INSTRUCTIONS TO SPECIFIER

USERS OF THIS SECTION ARE ADVISED THAT DETAILED INSTRUCTIONS ARE NOT AVAILABLE AT THIS TIME.

IN ORDER TO ENSURE PROPER COORDINATION WITH THE CONTRACT DRAWINGS, AND A BIDDABLE CONTRACT, THE TEXT MUST BE CAREFULLY READ AND THE ITEMS OR CHOICES INDICATED AS "AS SHOWN ON THE CONTRACT DRAWINGS" (OR SIMILAR LANGUAGE) MUST BE SHOWN ON THE CONTRACT DRAWINGS.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15625

GAS UNIT HEATERS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for gas unit heaters.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

Design and performance of components and methods specified herein shall comply with all applicable Federal, State, and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

American Gas Association (AGA)

American National Standards Institute (ANSI)

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
BOCA Basic Building Code

BOCA National Energy Conservation Code

National Fire Protection Association (NFPA)

New York City Building Code

New York State Energy Conservation Construction Code

Occupational Safety and Health Administration (OSHA)

Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein and as shown on the Contract Drawings shall govern for the associated specific application.

A. Design and performance requirements of gas unit heaters shall be as specified in the Gas Unit Heater Schedule as shown on the Contract Drawings.

1.03 QUALITY ASSURANCE

A. Gas unit heaters, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended in this Section for not less than three years.

B. Entities performing the Work of this Section shall have experience on at least two projects involving complexities similar to those required under this Contract

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver unit heaters with factory-installed wooden skids and lifting lugs; pack components in factory-fabricated protective containers.

B. Handle unit heaters carefully to avoid damage to components, enclosures, and finish.

C. Store unit heaters in clean, dry spaces and protect them from weather.

D. Comply with the manufacturer's rigging instructions for unloading unit heater and components, and moving them to final location for installation.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with the requirements of this Section, provide gas unit heaters of one of the following manufacturers or approved equal:

Reznor

The Trane Co.

Modine Manufacturing Co.

2.02 MATERIAL

A. Casing

Casing shall be die-formed, 20 gauge galvanized steel and finished in baked enamel.

B. Heat exchanger shall be 409 stainless steel.

C. Burner

1. Burner shall be die-formed, corrosion resistant 409 stainless steel.

2. Port protectors shall be stainless steel.

D. Fan

Fan shall be propeller or centrifugal type, as shown on the Contract Drawings. Fan shall be statically and dynamically balanced.

1. Propeller fans shall have aluminum blades with an aerodynamic contour. Provide a steel guard to cover the blades completely.

2. Centrifugal fans shall be of steel construction. Drive shall be direct or adjustable V-belt type as shown on the Contract Drawings.

E. Vibration Isolators

Unit shall be provided with rubber-in-shear isolators between the fan/motor combination and the casings.

F. Control

1. A factory-installed junction box shall be provided for all power connections.
2. Unit shall be provided with a 24-volt combination single stage redundant gas valve, consisting of a combination pilot solenoid valve, automatic electric gas valve, pilot filter, pressure regulator, pilot adjustment and manual shutoff.
3. The unit shall include a spark-ignited intermittent pilot system with electronic flame supervision.
4. A 24-volt control transformer high limit and fan time delay relay shall be provided. The fan time delay relay shall delay the fan start until the heat exchanger reaches a set temperature and the fan shall operate after burner shutdown, removing residual heat from the heat exchanger.
5. The unit shall include a low voltage two stage thermostat and a universal guard cover. First stage control of thermostat shall energize unit heater fan to recirculate any warm stratified ceiling air. The second stage control of thermostat shall energize and open the single stage gas valve.

G. Venting

Unit shall be gravity or power vented as indicated on the Contract Drawings.

2.03 CONSTRUCTION FEATURES

A. The bottom panel of the casing shall be easily removable to provide service access to the burners, pilot and orifices.

B. Unit shall be provided with independently adjustable horizontal louvers with stops to prevent total closure.

PART 3. EXECUTION

3.01 FACTORY REQUIREMENTS

A. Unit shall be completely assembled, piped, wired and test fired.

B. Unit shall be suitable for ceiling suspension or wall mounting as indicated on the Contract Drawings.

3.02 INSTALLATION

Install unit heaters in accordance with the manufacturer's installation procedures and as shown on the Contract Drawings.

3.03 FIELD TEST

Test and adjust in the presence of the manufacturer's representative.

END OF SECTION

SECTION 15625

GAS UNIT HEATERS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings / Product Data / Catalog Cuts

1. Gas Unit Heaters

   a. Unit construction features, including components, materials, gauges, weights (shipping, installed and operating), load distribution and dimensions of selected models. Include plan and elevations views of units, required clearances and data on ratings and capacities.

   b. Gas unit heater schedule.

   c. Catalog cuts, including product performance data.

   d. Electrical wiring diagrams for power supply and controls.

   e. Maintenance data.

   f. Installation procedures.

END OF APPENDIX "A"

SECTION 15625

GAS UNIT HEATERS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(1.02 B)	Design and performance requirements of gas unit heaters.
(2.02 D)	Fan type (propeller or centrifugal).
(2.02 D.1)	Centrifugal fan drive (direct or V-belt).
(2.02 G)	Venting type (gravity or power).
(3.01 B)	Mounting type (ceiling or wall).

B. Other Items

Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15686

PACKAGED HERMETIC RECIPROCATING LIQUID CHILLERS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for packaged hermetic reciprocating liquid chillers.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

New York State Energy Conservation Construction Code

New Jersey Uniform Construction Code

American Society of Mechanical Engineers (ASME)

Air-Conditioning and Refrigeration Institute (ARI)

American National Standards Institute (ANSI)

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

Underwriters Laboratories Inc. (UL)

National Electrical Code (NEC)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Design and performance requirements of the Chillers shall be as specified in the Chiller Schedule (hereinafter in this Section "Schedules"), shown on the Contract Drawings.

1.03 QUALITY ASSURANCE

A. Chillers, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Entities performing the work of this Section shall have experience on at least two project involving complexities similar to those required under this Contract.

C. Chillers shall be subject to factory inspection prior to shipping.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver chillers with factory-installed wooden skids and lifting lugs; pack components in factory-fabricated protective containers.

B. Handle chillers carefully to avoid damage to components, enclosures, and finish.

C. Store chillers in clean, dry spaces and protect them from weather.

D. Comply with the manufacturer's rigging instructions for unloading chillers and moving them to final location for installation.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with the requirements of this Section and the Contract Drawings, provide factory-assembled reciprocating condenserless chillers of one of the following manufacturers, or approved equal:

Carrier Corporation, Subsidiary of United Technologies Corp.
Trane Company
York International Corporation

2.02 CONSTRUCTION FEATURES

A. General

1. Chillers shall be of sizes, arrangements and capacities specified in the Schedules as shown on the Contract Drawings. Provide chillers with refrigerant R-22 (HCFC-22) unless otherwise noted on the Contract Drawings.

2. Chillers shall consist of, as a minimum, but not be limited to, compressor(s), cooler/evaporator, unit mounted control panel, control box, oil pressure safety switch, circuit breakers, control circuit transformer and refrigerant circuit valving.

B. Compressors

1. Provide reciprocating compressors of the hermetic type with an automatically reversible positive displacement oil pump, oil strainer, oil sight glass, oil filling connection, oil filter with magnetic plug, and a full operating oil charge.

2. Equip compressors with suction and discharge shutoff valves.

3. Mount compressors on spring vibration isolators.

4. Compressor motors shall be cooled by suction gas passing around the motor windings and shall be thermally insulated.

5. Provide each compressor with an insert-type crankcase heater to control oil dilution during shutdown.

6. Full operating charge of refrigerant.

7. To prevent cooler freezing, pump down cycle shall not be used.

C. Cooler

1. Provide direct-expansion shell-and-tube type cooler; refrigerant totally enclosed in the tubes; water totally enclosed in the shell.

2. Cooler shall have independent direct-expansion refrigerant circuits in number as required to meet load requirements.

3. Seamless copper tubes expanded into tube sheets with ribbed or smooth internal finish.

4. Removable carbon-steel heads

5. Baffle to ensure oil return.

6. Refrigerant working pressure: as shown on Contract Drawings

7. Water-side working pressure: as shown on Contract Drawings

8. Factory-insulate cooler, suction lines, and other surfaces subject to condensation accurance with 3/4-inch thick flexible elastomeric insulation.

D. Control Panel

Mount on the control panel the following: compressor indicator lights, a start-stop button, control power fuse or circuit breaker, a manual switch to change starting sequence of compressors from one refrigerant circuit to the other, and demand limit switch and chilled water flow protection switch.

E. Control Box

Provide the following switches and controllers in the control box: high-and-low pressure cutout switches for each refrigerant circuit, a manual reset low water temperature cutout switch, a multiple-step chilled water temperature controller to ensure staggered starting of the compressors and to provide the required number of steps of capacity control as indicated on the Contract Drawings.

F. Oil Pressure Safety Switch

Mount on each chiller an oil pressure safety switch for each compressor. By means of the chiller control system, this safety switch shall stop chiller operation if sufficient oil pressure is not available to permit compressor operation without damage.

G. Circuit Breakers

1. Provide each compressor with factory-installed circuit breakers.

2. Circuit breakers shall be calibrated, manual set and ambient-insensitive.

3. Circuit breakers shall open all 3 phases should an overload occur on any phase.

H. Control Circuit Transformer

Provide a control circuit transformer, with the chiller package. Control power shall be 115 volts, unless otherwise noted on the Contract Drawing.

I. Refrigerant Circuit Valving and Insulation

1. Provide the following in each refrigerant circuit:

a. Hot gas muffler.

b. Combination moisture indicator and sight glass.

c. Refrigerant filter drier with replaceable core.

d. Liquid line solenoid valve for each liquid line.

e. Thermal expansion valve.

f. Charging valve.

g. Manual shutoff valve for each liquid line.

h. Compressor isolation valves.

i. Cooler/evaporator isolation valves.

j. Refrigerant side and water side, safety relief valves.

k. Cooler drain and vent.

2. Provide discharge line check valves for field installation with remote condensers.

J. Provide electrically actuated, suction cutout type cylinder unloaders for compressor capacity control.

K. Vibration Isolation

Provide external vibration isolation for chillers attachment to the building, in accordance with requirements specified in Division 15 Section entitled "VIBRATION ISOLATION AND CONTROL". Consult with the supplier of vibration isolation devices concerning the selection of the types required.

L. Motors

Provide motors in accordance with requirements specified in Division 15 Section entitled "MOTORS AND MOTOR CONTROLLERS". Select the motor characteristics, the motor mounting and all accessories necessary to satisfy the requirements of the compressor drive unit in all operating modes.

2.03 SHOP TESTS

All shop tests may be witnessed by the Engineer. Notify the Engineer 14 days in advance of scheduled tests.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install chillers in accordance with the manufacturer's installation procedures and requirements.

B. Coordinate all Work to ensure that the installation of the chillers does not conflict with Work specified under other Sections.

C. Verify that electrical wiring installation is in accordance with manufacturer's submittal and in accordance with the installation requirements of the applicable Division 16 Specifications.

3.02 FIELD TESTS

A. Provide a qualified technical representative of the manufacturer to advise on field tests.

B. Start up, test, and adjust chillers and verify capacity and efficiency at full and part loads, in the presence of the manufacturer's representative.

C. Provide qualified technical representatives of the manufacturer to instruct and train Authority personnel in the operation and maintenance of the chillers for a minimum of 8 hours.

END OF SECTION

SECTION 15686

PACKAGED HERMETIC RECIPROCATING LIQUID CHILLERS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings / Product Data / Catalog Cuts

1. Packaged Hermetic Reciprocating Liquid Chillers

   a. Shop drawings indicating dimensions of selected models, weights (shipping, installed and operating), load distribution, required clearances, sizes and locations of field connections and methods of assembly of components.

   b. Product performance data.

   c. Catalog cuts.

   d. Electrical wiring diagrams for power supply, interlock and controls.

   e. Installation procedures.

   f. Shop test results.

B. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive detailed information for the specific approved equipment; including approved shop drawings and catalog cuts, troubleshooting, maintenance requirements, spare part lists, sequence of operations, test results, electrical/control devices and electrical/control wiring diagram(s).

C. Construction and Installation Procedures

1. Field test procedures.

D. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

PACKAGED HERMETIC RECIPROCATING LIQUID CHILLERS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(1.02 B); (2.02 A.1)	Packaged hermetic reciprocating liquid chillers schedules indicating design, performance, sizes, arrangements and capacities.
(2.01)	Chillers of type other than that specified in this Section.
(2.02 A.1)	Refrigerant other than R-22 (HCFC-22).
(2.02 C.6)	Refrigerant working pressure.
(2.02 C.7)	Water side working pressure.
(2.02 E)	Number of steps of capacity control.
(2.02 H)	Control transformed with control voltage other than 115 volts.

B. Other Items

1. Ensure that the following Sections are included in the Contract booklet:

(2.02 K)	"MOTORS AND MOTOR CONTROLLERS"
(2.02 L)	"VIBRATION ISOLATION AND CONTROL"

2. Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15741

AIR-COOLED CONDENSERS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for air-cooled condensers.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

New York State Energy Conservation Construction Code

New Jersey Uniform Construction Code

American Society of Mechanical Engineers (ASME)

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

Air-Conditioning and Refrigeration Institute (ARI)

Underwriters Laboratories, Inc. (UL)

National Electrical Code (NEC)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Design and performance requirements of the condensers shall be as specified in the Air-Cooled Condenser Schedule (hereinafter in this Section "Schedules") shown on the Contract Drawings.

1.03 QUALITY ASSURANCE

A. Condensers, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein, for not less than three years.

B. Entities performing the Work of this Section shall have experience on at least two projects involving complexities similar to those required under this Contract.

C. Condensers shall be subject to factory inspection prior to shipping.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver condensers with factory-installed wooden skids and lifting lugs; pack components in factory-fabricated protective containers.

B. Handle condensers carefully to avoid damage to components, enclosures, and finish.

C. Store condensers in clean, dry spaces and protect them from weather.

D. Comply with the manufacturer's rigging instructions for unloading condensers and moving them to final location for installation.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with the requirements of this Section, provide factory-fabricated condensers of one of the following manufacturers, or approved equal:

Carrier Air Conditioning Co./Carrier Corp.
Trane Co.
York International Corp.

2.02 CONSTRUCTION FEATURES

A. General

1. Condensers shall be of sizes, arrangements and capacities specified in the Schedules shown on the Contract Drawings.
2. Condensers shall be factory assembled and tested, and shall consist of casings, fans, fan motors, coils and head pressure controls.

B. Casings

1. Provide casings designed for outdoor installation, complete with weather protection for components and controls, and with removable access panels for required access to controls, fans, motors and drives.
2. Provide lifting lugs to facilitate rigging of units.
3. Provide factory-installed metal grilles for protection of condenser coils during shipping, installation and operation.
4. Provide a NEMA 3R rated control panel with hinged and gasketed door.

C. Fans

1. Provide direct-driven, propeller-type condenser fan(s).
2. Each fan shall be statically and dynamically balanced.
3. Provide guards for fan protection.

D. Fan Motors

1. Provide permanently lubricated fan motors with built-in overload protection.

2. Motors shall be in accordance with requirements specified in Division 15 Section entitled "MOTORS AND MOTOR CONTROLLERS".

3. Select motor characteristics, motor mounting and all accessories as is necessary to satisfy the requirements of the fan motor drive unit in all operating modes.

E. Coils

1. Coils shall be constructed of aluminum plate fins on mechanically expanded copper tubes.

2. Coils shall be cleaned, dehydrated, sealed, leak tested at 150 psig and pressure tested at 450 psig.

F. Head Pressure Control

Provide fan cycling or fan speed modulation type head pressure control in response to outdoor ambient temperature or condensing pressure as shown on the Schedules.

G. Vibration Isolation

Provide vibration isolation in accordance with the requirements specified in Division 15 Section entitled "VIBRATION ISOLATION AND CONTROL". Consult with the supplier of vibration isolation devices concerning the selection of the types required.

2.03 SHOP PAINTING

A. Fan shaft shall be corrosion protected.

B. Fan blades shall have an iridite or aluminum finish.

C. Condenser casing shall have baked enamel finish.

2.04 SHOP TESTS

All shop tests may be witnessed by the Engineer. Notify the Engineer 14 days in advance of scheduled tests.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install condensers in accordance with the manufacturer's installation procedures.

B. Coordinate the Work of this Section to ensure that the installation of the condensers is not in conflict with the Work performed under other Sections of these Specifications.

C. Verify that the electrical wiring installation is in accordance with the manufacturer's submittal and in accordance with the installation requirements as specified in Division 16.

3.02 FIELD TESTS

A. Provide a qualified technical representative of the manufacturer to advise on field tests.

B. Start up, test, adjust condensers, and verify capacity and efficiency in the presence of the manufacturer's representative.

C. Provide qualified technical representatives of the manufacturer to instruct and train the Authority's maintenance personnel in the operation and maintenance of the condensers for a minimum 8 hours.

END OF SECTION

SECTION 15741

AIR-COOLED CONDENSERS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings / Product Data / Catalog Cuts

1. Air-Cooled Condensers

   a. Shop drawings indicating dimensions of selected models, weights (shipping, installed and operating), load distribution, required clearances, methods of assembly of components and mounting details.

   b. Condenser performance data with rated capacities clearly indicated.

   c. Catalog cuts.

   d. Electrical wiring diagrams for power supply and controls.

   e. Installation procedures.

   f. Shop test results.

B. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive detailed information for the specific approved equipment; including approved shop drawings and catalog cuts, troubleshooting, maintenance requirements, spare part lists, sequence of operations, test results, electrical/control devices and electrical/control wiring diagram(s).

C. Construction and Installation Procedures

1. Field test procedures.

D. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15741

AIR-COOLED CONDENSERS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(1.02 B)	Air-Cooled Condenser Schedules containing design and performance requirements.
(2.01 A.1)	Air-Cooled Condenser Schedules containing sizes, arrangements and capacities of condensers.
(2.02 F)	Establish type and specifics of head pressure control on the schedules.

B. Other Items

1. Ensure that the following Specification Sections are included in the Contract Booklet as required:

(2.02 D.2)	Section 15939 "MOTORS AND MOTOR CONTROLLERS"
(2.02 G)	Section 15940 "VIBRATION ISOLATION AND CONTROL"

2. Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15830

FIN TUBE RADIATION (HOT WATER)

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for fin tube radiation.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State, and Local laws, ordinances, regulations and codes, and the latest industry standards, including, but not limited to the entities listed below.

Hydronics Institute (HYDI)

American Society of Mechanical Engineers (ASME)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Design and performance requirements of the fin tube shall be as specified in the Fin Tube Radiation Schedule (hereinafter in this Section "Schedules"), shown on the Contract Drawings.

1.03 QUALITY ASSURANCE

A. Fin tube radiation of types and sizes required, shall have performed satisfactorily for purposes similar to those intended herein, for not less than three years.

B. Entities performing the Work of this Section shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver fin tube and components in factory-fabricated protective packaging.

B. Handle fin tube and components carefully to prevent breaking, denting and scoring.

C. Store fin tube and components in clean, dry spaces and protect them from weather.

D. Comply with the manufacturer's rigging instructions for unloading fin tube and components and moving them to final location for installation.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with the requirements of this Section, provide fin tube radiation of one of the following manufacturers, or approved equal:

Slant/Fin
Vulcan Radiator Corp.
Sterling Heating Equipment, a Mestek Co.

2.02 MATERIALS

A. Material for fin tube assembly shall be as specified below:

1. Tubes: Copper.
2. Fins: Aluminum.
3. Enclosure and Accessories: Steel (16 gauge or as shown on the Contract Drawings).

2.03 CONSTRUCTION FEATURES

A. General

1. Fin tube radiation shall be of sizes, arrangements and capacities shown on the Schedules.
2. Fin tube radiation shall consist of heating elements, support elements, enclosures, accessories and manual or automatically-controlled valves as shown on the Contract Drawings and specified herein. For valves, refer to Division 15 Section entitled "HYDRONIC SPECIALTIES".

B. Heating Elements

Heating elements shall be manufactured of seamless tube permanently bonded to fins by a mechanical process.

C. Support Elements

1. Heating element hanger shall be of the ball bearing cradle type, or the sliding saddle type, providing for lengthwise movement of element during expansion and contraction as well as aligning element to prevent contact with bracket, wall or enclosure. Provide for vertical adjustment.
2. Hanger for pipe lines shall be of the roller bearing type, or the sliding saddle type, assuring noiseless operation of these pipe lines during expansion and contraction. Hanger shall be combination hanger/bracket with support cradle or saddle.

3. Enclosure bracket shall be die-formed for rigidity, and shall be designed to support the front skirt of the enclosure. Bracket shall incorporate a security lock for fastening the enclosure, eliminating removal of enclosure without tools.

D. Enclosure

1. Provide enclosures of types as shown on the Contract Drawings.
2. Enclosures shall be reinforced with welded gussets across the louvered area.
3. Ensure rigidity by joining enclosures with slip joints.
4. Secure enclosure to brackets with the security type lock preventing removal without tools.
5. Enclosures shall be chemically phosphatized before priming with baked enamel.
6. Provide a minimum of 6 inch by 6 inch hinged access door at each radiator valve location. Access doors shall be accurately placed to insure adequate access to the respective valves.

E. Accessories

Install enclosure continuously or as shown on the Contract Drawings. Provide matching end covers and corners as required to complete the enclosure.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install fin tube radiation in accordance with the manufacturer's installation procedures.

B. Coordinate the Work of this Section to ensure that the installation of the fin tube radiation is not in conflict with the Work performed under other Sections of these Specifications.

END OF SECTION

SECTION 15830

FIN TUBE RADIATION (HOT WATER)

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings / Product Data / Catalog Cuts

1. Fin Tube Radiation (Hot Water)

   a. Shop drawings indicating dimensions of selected models, required clearances and methods of assembly of components.

   b. Schedules of required fin tube radiation.

   c. Manufacturer's published product data indicating types, ratings and performance data.

   d. Catalog cuts of fin tube radiation and associated accessories.

   e. Unit construction components, including materials, gauges and finish.

   f. Electrical wiring diagrams for power supply and controls.

   g. Installation details.

B. Samples

1. Three samples of finishes of fin tube enclosures for approval.

END OF APPENDIX "A"

SECTION 15830

FIN TUBE RADIATION

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(1.02 B)	Fin Tube Radiation Schedules - sizes, arrangements and capacities.
(2.02 C)	Enclosure and accessory gauges if different from specified 16 gauge.
(2.03 A.1)	Schedules showing fin tube radiation sizes, arrangements and capacities.
(2.03 A.2)	Heating elements, support elements, enclosures and accessories.
(2.03 D.1)	Types of enclosures.
(2.03 E)	Required installed length of enclosure.

A. Other Items

1. Ensure that the following Specification Sections are included in the Contract Booklet as required:

   (2.03 A.2) Section 15515 " HYDRONIC SPECIALTIES "

2. Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15855

AIR HANDLING UNITS

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies requirements for packaged air handling units for indoor installation.

B. Types of air handling units specified in this Section are:

Heating, Ventilating and Air-Conditioning (HVAC) Units
Heating and Ventilating (HV) Units

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

Occupational Safety and Health Administration (OSHA)
Anti-Friction Bearing Manufacturers Association (AFBMA)
Air Movement and Control Association (AMCA)
American National Standards Institute (ANSI)
Air-Conditioning and Refrigeration Institute (ARI)
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
American Society for Testing and Materials (ASTM)
National Fire Protection Association (NFPA)
National Electrical Manufacturers Association (NEMA)
Steel Structures Painting Council (SSPC)
Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Design and performance requirements of air handling units shall be as specified in the Air Handling Unit Schedules (hereinafter in this Section "Schedules"), shown on the Contract Drawings.

1.03 QUALITY ASSURANCE

A. Air handling units, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Air handling units shall be subject to factory inspection prior to shipping.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver units with factory-installed wooden skids and lifting lugs; pack components in factory-fabricated protective containers.

B. Handle units carefully to avoid damage to components, enclosures, and finish.

C. Store units in clean, dry spaces and protect them from weather.

D. Comply with manufacturer's rigging instructions for unloading units, and moving units to final location for installation.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide factory-fabricated air handling units of one of the following manufacturers, or approved equal:

A. Heating, Ventilating and Air-Conditioning Units

Carrier Corp.
McQuay International
York International Corp.

B. Heating and Ventilating Units

Carrier Corp.
McQuay International
York International Corp.

2.02 MATERIALS

Materials for air handling units shall be as specified below.

A. Casing

Panel:	Galvanized or phosphatized steel
Insulation:	3-pound density, neoprene-coated glass fiber board

B. Centrifugal Fans

Wheel:	Steel
Shaft:	Forged steel
Variable Inlet Vanes:	Steel (if indicated on the schedules on the Contract Drawings)

C. Hot Water and Chilled Water Cooling Coils

Tubes:	Copper
Fins:	Aluminum or copper
Header:	Copper
Housing:	Galvanized steel
Tube Supports:	Galvanized steel

D. Direct Expansion Cooling Coils

Tubes:	Copper
Fins:	Aluminum or copper
Distributor::	Copper
Return Header:	Copper
Housing:	Galvanized steel
Tube Supports:	Galvanized steel

E. Non-Freeze Steam Heating Coils

Outer Tubes:	Copper
Inner Tubes:	Copper
Fins:	Aluminum or copper
Header:	Steel
Housing:	Galvanized steel
Tube Supports:	Galvanized steel

F. Filters

Filter Housing:	Galvanized steel
Replaceable Filters:	Blend of synthetic fibers or fiberglass (panel and bag)
Cleanable Filters:	Layers of corrugated wire mesh
Roll Filters:	Fiberglass

G. Drain Pans

Outer Pan:	Galvanized steel
Inner Pan:	Stainless steel liner

H. Electric Resistance Heating Coils

1. Open-Wire Type

Resistance Wires:	80 percent nickel/20 percent
Insulating Bushings:	Ceramic
Support Frame:	Aluminized or galvanized

2. Finned-Tubular Type

Resistance Wires:	80 percent nickel/20 percent
Element Holding Tubes:	Copper-plated steel
Insulating Filler Powder:	Magnesium oxide

Fins:	Copper-plated steel
Support Frame:	Aluminized or galvanized

I. Face and Bypass Dampers

Blades:	Galvanized steel
Operating Rods:	Steel
Bearings:	Bronze or nylon
Frame:	Galvanized steel

2.03 CONSTRUCTION FEATURES

A. General

1. Air handling units shall be of sizes, arrangements and capacities specified in the Schedules and as shown on the Contract Drawings.

2. HVAC units shall consist of casing, centrifugal fan, coils, filters, drain pan, mixing box, motor drive and accessories specified in the Schedules, shown on the Contract Drawings and specified herein.

3. Heating and ventilating units shall consist of casing, centrifugal fan, heating coils, filters, mixing box, face and bypass dampers, motor drive and accessories specified in the Schedules, shown on the Contract Drawings and specified herein.

B. Casings

1. Provide casings with reinforced and braced structural frame having sectionalized, removable panels on both sides of all coils, filters, and fans.

2. For HVAC units, apply insulation on the inside surface of all parts of the units, meeting requirements of the applicable energy conservation codes. However, as a minimum, apply one-inch thick insulation on inside of the entire fan and coil section with waterproof adhesive and permanent fasteners. Insulation shall meet NFPA 90A flame spread and smoke generation requirements.

3. Provide hinged, gasketed and latchable fully-insulated, double wall access doors on opposite sides of casings, at the following locations:

   a. Fan section.

   b. Air inlet and discharge of each coil.

   c. Air inlet and discharge of filter section.

4. Access doors shall have a full perimeter automotive type gasket to prevent air leakage. They shall be openable from unit interior.

   Direction of door opening shall be inward on pressure side and outward on suction side. Doors shall be minimum 12 inches long in direction of air flow and full height of the unit excluding framing.

5. Provide casings with lifting lugs, test connections, and taps for thermometers and pressure gauges.

C. Centrifugal Fans

1. Fans shall consist of housing, wheel, shaft, bearings, and support structure.

2. Provide curved scroll housing, with lockseam construction or continuous welding construction. Provide spun inlet cones and duct connections.

3. Provide forward-inclined, backward-inclined or backward-inclined airfoil blades. Weld blades to wheel rim and hub plate; key wheel to shafts. Wheel diameter and outlet areas shall be in accordance with AMCA Standard 99 for non-overloading fans.

4. Provide solid, accurately turned, ground and polished shafts.

5. Provide grease-lubricated, precision anti-friction ball or roller, self-aligning, pillow block type bearings to provide median (l-50) life rating of 200,000 hours in accordance with AFBMA Std. 9 for ball bearings or AFBMA Std. 11 for roller bearings. Bearings shall be equipped with grease fittings and extended grease lines to allow lubrication from one side of the fan.

6. Provide multiple matched V-belt drive with minimum 1.4 times rated motor horsepower. Provide adjustable pitch sheave on motor shaft, selected for midpoint at design conditions.

7. Provide access door in scroll housing, with latch-type handles, flush mounted.

8. Before shipment, fans shall be statically and dynamically balanced.

9. Provide ventilated belt guards with tachometer opening for fan speed measurements, on all units, in accordance with OSHA requirements.

10. Where specified in the Schedules shown on the Contract Drawings, provide fans with variable inlet vanes integral with the inlet bells of the fan. Connect vane rods to control ring by crank arms; provide vane rods supported at both ends by nylon bearings. Both sets of vanes shall be operated by a lever on the fan scroll with connecting shaft between inlets. Vane linkage shall be suitable for either manual or automatic operation.

D. Hot Water and Chilled Water Cooling Coils

1. Water coils shall consist of a single or multiple coils, as shown on the Contract Drawings. Mount and arrange components to permit expansion without strain on tubes, headers or casing, and with all guides and supports necessary to ensure proper alignment and unimpaired drainage. Mount coils on the steel frame of the air-handling unit. Coils shall be removable from coil's connection side, unless indicated otherwise on the Contract Drawings, without dismantling or unbolting any component of the unit, other than the coil section access panel.

2. Enclose coil headers completely within the insulated coil section casing. Extend the inlet and outlet connections a minimum of six inches beyond the exterior of the coil casing through pre-cut openings. Provide sealing collars at the openings for the coil connections. All coils must have some end connections regardless of the number of rows deep.

3. Do not space fins closer than eight fins per inch and bond fins mechanically to the tubes.

4. Coils shall be of serpentine, staggered, continuous tube, multiple row, water type and shall have non-trapping circuits. Coil tube outside diameter shall be 5/8 inch with a wall thickness not less than 0.025 inch. Ensure that water velocity does not exceed 7 fps.

5. Coils shall be completely drainable by gravity through the supply header. Provide drain and vent connections for each coil with the connections external to the unit for ease of access.

6. Coils shall be rigidly supported across the full face of coil. Provide intermediate tube sheet supports for all coils exceeding 54 inches in length or less as is necessary to ensure rigid coil support.

7. Provide cooling coils with drain troughs between stacked coils, and run drain lines from the trangles to the drain pan.

E. Direct Expansion Cooling Coils

1. Direct expansion-cooling coils shall consist of single or multiple coils assembled for horizontal or vertical air flow, as shown on the Contract Drawings. Coils shall be suitable for use with a continuously circulating refrigerant specified in the Schedules shown on the Contract Drawings.

2. Cooling coils shall be cartridge type, removable from coil connection side of casing and supported in tracks over the entire length of the coil.

3. Each coil shall be of serpentine, staggered, continuous tube, multiple row, refrigerant type. Coil tube outside diameter shall be 5/8 inch with a wall thickness not less than 0.025 inch. Provide each coil with a maximum of 12 circuits per distributor. Coils with more than 12 circuits, and split-circuit coils shall have two distributors.

4. Fins shall be plate or spiral type. Do not space fins closer than 12 fins per inch and bond fins mechanically to the tube.

5. Locate coil inlet and outlet connections on the same end of the coils.

6. Coils shall be rigidly supported across the full face of the coil. Provide tube supports at a maximum spacing of 42 inches, or less as is necessary to ensure rigid coil support.

7. Frame and support multiple coil banks so that individual coil removal is readily possible without removal of other coils in a bank. Coil tubes shall be free to expand and contract. Arrange coils within the coil casing so that refrigerant flow shall be counterflow to air flow for coils with more than a single row.

8. Provide coils with drain troughs between stacked coils, and run drain lines from the troughs to the drain pan.

F. Non-Freeze Steam Heating Coils

1. Non-freeze steam heating coils shall consist of single or multiple coils as shown on the Contract Drawings.

2. Heating coils shall be cartridge type, removable from coil connection side of casing and supported in tracks over the entire length of the coil.

3. Each heating coil shall be continuous tube, non-freeze distributing (tube within a tube), one or two row, steam type. Coil tube outside diameter shall be minimum one inch with 5/8-inch inner distributing tube. Tube wall thickness shall be not less than 0.025 inch.

4. Fins shall be plate type. Do not space fins closer than 10 fins per inch and bond fins mechanically to the tube.

5. Locate coil inlet and outlet connections on the same end of the coils.

6. Coils shall be rigidly supported across the full face of the coil. Provide tube supports at maximum spacing of 42 inches, or less as is necessary for rigid coil support.

7. Frame and support multiple heating coil banks so that individual coil removal is readily possible without removal of other coils in a bank. Coil tubes shall be free to expand and contract. Arrange coils within the coil casing so that steam flow shall be counterflow to air flow for two-row heating coils.

8. Heating coils shall be drainable.

9. Provide for even air temperature leaving the coil without stratification. At coil loads from 20% to 100% of full capacity, variations between maximum and minimum air temperature leaving the coil, measured at any point across the coil face shall not exceed 4 degrees F.

G. Electric Resistance Heating Coils

1. If specified in the Schedules shown on the Contract Drawings, the electric resistance heating coil shall be the open-wire type. It shall be in compliance with the National Electrical Code (NEC), and shall be UL listed for zero clearance to combustible surfaces. It shall be rated for the KW, voltage, phase and number of heating stages indicated on the Contract Drawings. The elements shall be uniformly distributed over the cross-sectional area of unit, with vertical support brackets to prevent coil element sag. Coil elements shall be insulated by means of insulating bushings and supported within a steel support frame.

2. If specified in the Schedules shown on the Contract Drawings, the electric resistance heating coil shall be finned-tubular construction. It shall be in compliance with the National Electrical Code (NEC), and shall be UL listed for zero clearance to combustible surfaces. It shall be rated for the KW, voltage phase and number of heating stages indicated on the Contract Drawings. The heating element shall be mounted inside an element tube and surrounded by compacted insulating filler powder. Tubes shall be spirally wound with fins that are continuously brazed to tubes. Coils shall be mounted inside a steel supporting frame.

3. Integral terminal box shall include primary automatic and secondary manual reset thermal protective devices, backup contactors, subcircuit fusing, fused disconnect switches, fan interlock relays, pressure differential air flow switch, fused control transformer and all other safety devices to meet UL and NEC requirements.

H. Face and Bypass Dampers

1. Internal face and bypass dampers shall be of the opposed blade type. Provide all required linkage; lock the blades to damper rods, rotating in rustproof bushings requiring no lubrication.

2. External face and bypass dampers shall consist of bypass dampers of the parallel blade type and face dampers of the opposed blade type. Provide all required linkage; lock the blades to damper rods, rotating in rustproof bushings requiring no lubrication.

I. Mixing Boxes

1. Where indicated on the Contract Drawings, provide mixing boxes with parallel blade damper sets for merging return air and outside air streams inside the box. Damper blade rods shall rotate on rustproof bushings requiring no lubrication.

2. Mixing box frame shall be fabricated and finished in the same manner as the casings.

3. Provide the frame with a flanged connection to match the air handling unit.

J. Filters

1. Filter Housing

a. Filter housing shall be side servicing type and shall be fabricated and finished the same as the casings.

b. Provide the housing with flanged connections on both inlet and outlet, sized to match the air handling unit.

c. Provide integral pre-filter tracks to accommodate two-inch throwaway or cleanable filters.

d. Provide quick-opening, hinged access doors with continuous gasketing on perimeter and positive locking devices.

2. Replaceable Panel Filters

a. Provide throwaway flat panel type air filters with holding frames.

b. Provide viscous-impingement filter media of two-inch thickness. Filter media shall be UL 900 Class rating specified in the Schedules shown on the Contract Drawings.

c. Provide filters with rated face velocity of 500 fpm, initial resistance of not greater than 0.30-inch w.g., final rated resistance of 0.50-inch w.g., and average efficiency not less than 20 percent based on "Determination of Atmosphere Dust Spot Efficiency" of ASHRAE Standard 52.

3. Bag Filters

a. Provide replaceable bag type air filters with holding frames.

b. Provide dry filter media formed into V-shaped pleats and held by self-supporting wire frames. Filter media shall be UL 900 Class rating specified in the Schedules shown on the Contract Drawings.

c. The rated face velocity, initial resistance, final resistance, and average dust spot efficiency shall be not less than the values specified in the Schedules shown on the Contract Drawings.

4. Cleanable Panel Filters

a. Provide cleanable (washable), flat panel type air filters with holding frames.

b. Provide viscous-impingement filter media of two-inch thickness. Filter media shall consist of layers of corrugated wire mesh and shall be UL 900 Class rating specified in the Schedules shown on the Contract Drawings.

c. The rated face velocity, initial resistance, final resistance, and average dust spot efficiency shall be not less than the values specified in the Schedules shown on the Contract Drawings.

5. Automatic Roll Filters

a. Provide automatic, motor-driven, self-renewing roll type air filters with gasketed holding casing.

b. Provide viscous-impingement filter media of two-inch thickness. Filter media shall be glass fiber of progressive density and progressive fiber diameter and shall be UL 900 Class rating specified in the Schedules shown on the Contract Drawings.

c. Provide electrically driven feed control mechanism with pressure differential sensor; provide filter drive with manual media advance and run-out switches for stopping media movement of filter bank and operating remote warning signal lights.

d. The rated face velocity, initial resistance, final resistance, and average dust spot efficiency shall be not less than the values specified in the Schedules shown on the Contract Drawings.

K. Drain Pans

1. Provide a drain pan under the complete fan and cooling coil sections of draw-through HVAC units and the coil and discharge plenum sections of blow-through HVAC units. The drain pan shall be of double floor construction, sandwiching a 1/2-inch polyurethane insulation board between the two layers of metal. Insulation and adhesive shall comply with NFPA No. 90A flame spread and smoke generation requirements. Provide drain pans with 1-1/4-inch IPS minimum size, outlet drain connections on both sides of units.

2. Extend the drain pans a minimum distance beyond the cooling coils equal to at least the finned height of the cooling coil or cooling coil banks, or more as required to capture moisture carry-over from the cooling coils at design conditions. Make provisions to permit free drainage from each section.

3. When two or more cooling coils are used, with one stacked above the other, provide individual drain troughs, piped to the main drain pan, below each of the upper coils.

L. Vibration Isolation

Provide vibration isolation in accordance with requirements specified in the Division 15 Section entitled "VIBRATION ISOLATION AND CONTROL". Consult with the supplier of vibration isolation devices concerning the selection of the types required.

M. Motors

Provide motors in accordance with requirements specified in the Division 15 Section entitled "MOTORS AND MOTOR CONTROLLERS". Motors shall be externally mounted on adjustable bases. Select the motor characteristics, the motor mounting and all accessories necessary to satisfy the requirements of the fan motor drive unit in all operating modes.

2.04 SHOP PAINTING

Fans, casings, and steel fabrication shall be given one coat of zinc chromate primer and one coat of machine enamel on both the exterior and interior surfaces.

2.05 SHOP TESTS

A. Balance fan wheels statically and dynamically, prior to final operating tests with motor and drive in place.

B. Test, rate and certify all coils in accordance with ARI Standard 410; fans shall bear ARI seals.

C. Test, rate and certify all air handling units, as complete units, in accordance with ARI Standard 430; fans shall bear ARI seals.

D. If specified in the Schedules shown on the Contract Drawings, the factory test shall be witnessed by the Engineer. The Contractor shall notify the Engineer 14 days in advance of the scheduling of said factory tests.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install units in accordance with manufacturer's installation procedures.

B. Coordinate all Work to ensure that the installation of the units is not in conflict with the Work specified under other Sections.

C. Verify that electrical wiring installation is in accordance with manufacturer's submittal and in accordance with the installation requirements of Division 16. Ensure that rotation is in direction indicated and intended for proper performance.

3.02 FIELD TESTS

A. Install filters at completion of air handling system work, and prior to equipment startup, testing, adjusting, and balancing.

B. Provide a qualified technical representative of the manufacturer to advise on field tests.

C. Start up, test, and adjust units in presence of the manufacturer's representative.

D. Following testing and adjustments, replace filters with new filters (spare filters) before final inspection by the Engineer.

END OF SECTION

SECTION 15855

AIR HANDLING UNITS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings / Product Data / Catalog Cuts

1. Air Handling Units

   a. Unit construction details including components, materials, gauges, dimensions of selected models, required clearances, weights (shipping, installed, and operating), load distribution and location and size of each field connection. Shop drawings shall be at a minimum of 1/4"=1'-0" scale.

   b. Air handling unit schedules.

   c. Certified fan performance pressure-volume, horsepower and efficiency curves, with system operating conditions indicated.

   d. Certified fan and compressor sound levels at rated capacity at each octave band.

   e. Certified coil performance ratings with system operating conditions indicated.

   f. Filter performance characteristics.

   g. Damper performance curves.

   h. Catalog cuts.

   i. Refrigerant piping diagram.

   j. Electrical wiring diagrams for power supply, interlock and controls.

   k. Motor ratings and electrical characteristics.

   l. Drive construction and rating.

   m. Installation procedures.

   n. Shop test results.

B. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive detailed information for the specific approved equipment; including approved shop drawings and catalog cuts, troubleshooting, maintenance requirements, spare part lists, sequence of operations, test results, electrical/control devices and electrical/control wiring diagram(s), bearings maintenance procedures, lubrication procedures and lubricant type.

C. Construction and Installation Procedures

1. Field test procedures.

D. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15855

AIR HANDLING UNITS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.03 A)	Arrangements of air handling units.

Contract Drawings shall clearly show the scope of work of this Section and the interface ductwork (including connection sizes) at inlet and outlet of the air handling unit(s).

(2.03 E.1)	Direct expansion cooling coil arrangements (horizontal or vertical).
(2.03 F.1)	Steam coil arrangement (single or multiple).

B. Air Handling Unit Schedules (shown on the Contract Drawings)

(1.02 B)	Design and performance requirements (overall).
(2.02 B)	Variable inlet vanes.
(2.05 D)	Factory inspection.
(2.03 A.1)	Sizes and capacities.
(2.03 A.2)	HVAC unit components.
(2.03 A.3)	Heating and ventilating unit components.
(2.03 C.10)	Variable inlet vanes.
(2.03 D.1)	Water coils consisting of a single or multiple coils; coils removable from a side other than coil connection side.
(2.03 E.1)	Refrigerant type for direct expansion cooling coils.
(2.03 G.1)	Electric heating coils of the open wire type; coil KW rating and other electrical characteristics.
(2.03 G.2)	Electric heating coils of finned-tubular construction; coil KW rating and other electrical characteristics.
(2.03 I.1)	Mixing boxes.
(2.03 J.2.b) (2.03 J.3.b) (2.03 J.4.b) (2.03 J.5.b)	UL rating, class of replaceable panel filters, bag filters, cleanable filters, and automatic roll filters, respectively.
(2.03 J.3.c) (2.03 J.4.c) (2.03 J.5.d)	Face velocity, initial and final pressure drops, and average dust spot efficiency for bag filters, cleanable filters, and automatic roll filters, respectively.

C. Other Items

1. Ensure that the following Specification Sections are included in the Contract Booklet as required:

(2.03 L)	"VIBRATION ISOLATION AND CONTROL"

(2.03 M) "MOTORS AND MOTOR CONTROLLERS"

2. Modify Appendix "A" - Submittlas as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15856

AIR HANDLING UNITS - GAS FIRED

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies requirements for packaged, gas fired, air handling units.

B. Types of air handling units specified in this Section are:

1. Rooftop, irect Expansion Type Heating, Ventilating and Air-Conditioning (HVAC) units.
2. Rooftop Heating and Ventilating (H&V) units.
3. Indoor Heating and Ventilating (H&V) units.

1.02 REFERENCES

Not Used.

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with the applicable provisions of the codes, standards, recommendations of the entities listed below.

Occupational Safety and Health Administration (OSHA)
Anti-Friction Bearing Manufacturers Association (AFBMA)
Air Movement and Control Association (AMCA)
American Gas Association (AGA)
American National Standards Institute (ANSI)
Air-Conditioning and Refrigeration Institute (ARI)
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
American Society of Mechanical Engineers (ASME)
Industrial Risk Insurers (IRI)
National Fire Protection Association (NFPA)
Steel Structures Painting Council (SSPC)
Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Design and performance requirements of air handling units shall be as specified in the Air Handling Unit Schedules (hereinafter in this Section "Schedules"), shown on the Contract Drawings.

1.04 QUALITY ASSURANCE

A. Air handling units, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Air handling units shall be subject to factory inspection by the Engineer prior to shipping.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver units with factory-installed wooden skids and lifting lugs; pack components in factory-fabricated protective containers.

B. Handle units carefully to avoid damage to components, enclosures, and finish.

C. Store units in clean, dry spaces and protect them from weather.

D. Comply with manufacturer's rigging instructions for unloading units, and moving units to final location for installation.

1.06 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide complete systems, with factory-fabricated air handling units of one of the following manufacturers:

Mammoth Div., Nortek Co.
Governair Corp.
Miller-Picking Corp.

2.02 MATERIALS

Materials for air handling unit components shall be as specified below.

A. Casings

Panel:	Hot zinc dip coated steel
Insulation:	1.5 lb. Per cubic foot density, mastic-coated fiberglass

B. Centrifugal Fans

Wheel:	Steel
Shaft:	Forged steel

C. Condenser Fans

Blades:	Aluminum
Shaft:	Forged steel

D. Direct Expansion Cooling Coils and Condenser Coils

Tubes:	Copper
Fins:	Aluminum or copper
Distributor:	Copper or brass
Return Header:	Copper
Housing:	Galvanized steel
Tube Supports:	Galvanized steel

E. Gas Fired Heaters

Heat Exchanger:	Series 300 stainless steel
Primary Drum and Secondary Tubes:	14-gauge high carbon steel or Series 400 stainless steel
Burner Blast Tubes:	Stainless steel
Frame:	Galvanized steel

F. Filters

Housing:	Galvanized steel
Replaceable Filters (panel & bag):	Blend of cotton and synthetic fibers
Cleanable Filters:	Layers of corrugated wire mesh

G. Drain Pans

Main Pan:	Galvanized steel
Secondary Pan:	Stainless steel

2.03 CONSTRUCTION FEATURES

A. General

1. Units shall be of sizes, arrangements and capacities specified in the Schedules and as shown on the Contract Drawings.

2. Rooftop HVAC units shall consist of casing, centrifugal fan, direct expansion cooling coils, indirect fired gas heaters, filters, drain pan, mixing box, motor drives, condenser fans, condenser coils, compressor(s), controls, and accessories specified in the Schedules, shown on the Contract Drawings and specified herein. A return air fan shall be provided in the unit where so indicated on the Contract Drawings.

3. Rooftop H&V units and Indoor H&V units shall consist of casing, centrifugal fan, indirect fired gas heaters, filters, mixing box, motor drives, controls, and accessories specified in the Schedules, shown on the Contract Drawings and specified herein. A return air fan for Rooftop H&V unit(s) shall be provided in the unit where so indicated on the Contract Drawings.

B. Casings

1. Provide casings with reinforced and braced structural frame having sectionalized, removal panels on both sides of all coils, filters, and fans.

2. Apply one-inch thick insulation on inside of the entire fan and coil section with waterproof adhesive and permanent fasteners. Insulation shall meet NFPA 90A flame spread and smoke generation requirements.

3. Provide hinged, gasketed and latchable access doors on opposite sides of casings, at the following locations:

   a. Fan section.

   b. Heater section.

   c. Air inlet and discharge of each coil.

   d. Air inlet and discharge of filter section.

   e. Compressor(s).

   f. Controls.

   Direction of door opening shall be inward on pressure side and outward on suction side. Doors shall be minimum 12 inches long in direction of air flow and full heights of the unit excluding framing.

4. Provide casings with lifting lugs, test connections, and taps for thermometers and pressure gauges.

C. Centrifugal Fans

1. Fans shall consist of housing, wheel, shaft, bearings, and side support structure.

2. Provide curved scroll housing, with lockseam construction for fan sizes 36 inches and smaller, and continuous welding construction for fan sizes 40 inches and larger. Provide spun inlet cones and duct connections.

3. Weld fan blades to wheel rim and hub plate; key wheel to shafts. Wheel diameter and outlet areas shall be in accordance with AMCA Standard 99 for non-overloading fans.

4. Provide solid, accurately turned, ground and polished shafts.

5. For fan sizes 22 inches and smaller, provide grease-lubricated, precision anti-friction ball or roller, self-aligning, pillow block type bearings to provide minimum L-10 life rating of 60,000 hours in accordance with AFBMA Std. 9 for ball bearings or AFBMA Std. 11 for roller bearings. For fan sizes 24 inches and larger, provide grease-lubricated, tapered double spherical roller, pillow block type bearings to provide minimum L-10 rating of 120,000 hours in accordance with AFBMA Std. 11. Extend grease lines from bearings to outside of inlet duct flange, and terminate with grease fittings.

6. Provide multiple matched V-belt drive with minimum 1.4 times rated motor horsepower. Provide adjustable pitch sheave on motor shaft, selected for midpoint at design conditions.

7. Provide access door in scroll housing, with latch-type handles, flush mounted.

8. Provide 3/4-inch threaded coupling drain connection at lowest point of the housing.

9. Fan motor shall be located within the fan section casing, or shall be provided with ventilated belt guard with tachometer opening for fan speed measurements, in accordance with OSHA requirements.

D. Gas Fired Heaters

1. Heaters shall be indirect fired type, designed for use with natural gas.

2. The burner shall be of the power firing type, and shall include a primary combustion air blower and ignition spark transformer.

3. The gas train shall be complete with all controls in accordance with A.G.A., or IRI requirements as indicated on the Contract Drawings and shall be factory mounted in the heater section of the unit.

4. Controls shall include main gas valve, flame supervision, positive burner safety switch, pilot cock, main gas, cock adjustable main and pilot pressure regulators.

E. Direct Expansion Cooling Coils

1. Direct expansion-cooling coils shall consist of single or multiple coils assembled for horizontal or vertical air flow, as shown on the Contract Drawings. Coils shall be suitable for use with a continuously circulating refrigerant specified in the Schedules shown on the Contract Drawings.

2. Direct expansion coils shall be aluminum plate fins with belled collars and bonded to minimum 1/2-in. OD copper tubes by mechanical expansion. Coils shall be provided with thermostatic expansion valves, adjustable superheat controls and external equalizers.

3. Coils for full-face active or face split operation shall have intertwined circuits for equal loading on each circuit. Suction and discharge connections shall be on the same end. Coils shall be designed and tested in accordance with ANSI/ASHRAE 15 "Safety Code for Mechanical Refrigeration".

4. Provide tube supports at a maximum spacing of 42 inches.

5. Frame and support multiple coil banks so that individual coil removal is readily possible without removal of other coils in a bank. Coil tubes shall be free to expand and contract.

6. Provide coils with drain troughs between stacked coils, and run drain lines from the troughs to the drain pans.

F. Mixing Boxes

1. Mixing box frame shall be fabricated and finished the same as the casings.

2. Provide the frame with a flanged connection to match the air -handling unit.

3. Mixing boxes shall have parallel blade damper, interconnecting outside air and return air dampers. Damper blades shall have parallel bends for stiffness and shall be welded to steel shaft rods rotating in nylon bushings and mounted in rigid galvanized steel frames. Dampers shall be sectionalized to limit blade length to no more than 50 in. to minimize blade warpage and to assure tight closure.

4. All dampers for mixing boxes shall be rated low-leakage dampers, having a leakage rate not to exceed 2% of air quantity calculated at 2000 fpm velocity through damper and 4.0-in. w.g. pressure difference. Damper blades shall be gasketed and perimeter-sealing strips shall be provided.

G. Filters

1. Filters shall be flat throwaway type, replaceable media type, or cleanable type, and shall be installed in the centrifugal fan section or in their own housing, as shown on the Contract Drawings.

2. Replaceable Panel Filters

   a. Each filter section shall be designed and constructed to house the specific type of filter specified in the Schedules.

   b. Flat filter sections shall accept filters of standard sizes. Sections shall include side access slide rails and hinged access door. Flat filter section shall be arranged with minimum depth in direction of airflow.

   c. Angle filter sections shall accept 2-in. filters arranged in horizontal V formation. Double walled hinged access doors shall be provided.

   d. Provide throwaway flat panel type air filters with holding frames.

   e. Viscous-impingement filter media shall be of two-inch thickness. Filter media shall be UL 900 Class rating specified in the Schedules.

   f. Filters shall have a rated initial resistance not greater than 0.30-inch w.g., at a rated face velocity of 500 fpm final rated resistance of 0.50-inch w.g., and average efficiency not less than 20 percent based on "Determination of Atmosphere Dust Spot Efficiency" of ASHRAE Standard 52.

3. Cleanable Panel Filters

   a. Provide cleanable (washable), flat panel type air filters with holding frames.

   b. Provide viscous-impingement filter media of two-inch thickness. Filter media shall consist of layers of corrugated wire mesh and shall be UL 900 Class rating specified in the Schedules.

   c. The rate face velocity, initial resistance, final resistance, and average dust spot efficiency shall be not less than the values specified in the Schedules.

H. Access Sections

1. Access sections shall be installed where shown on the Contract Drawings and shall be as specified in the Schedule.

2. Access sections shall have hinged doors.

I. Compressors

1. Compressors shall be field serviceable, semi-hermetic type, complete with oil sight glass, overload protection, oil pressure switch, crankcase heaters, and pumpdown cycle. Dual compressor units shall have two totally independent refrigeration circuits.

2. Capacity reduction shall be by hot gas by-pass, cylinder unloading, or combination cylinder unloading and hot gas by-pass.

3. Compressors shall be spring mounted. Suction and discharge line piping shall include braided wire flexible line isolators.

4. Provide liquid line solenoid valve, sight glass, and filter dryer.

J. Condenser Coils

Condenser coil tubes shall be expanded into fins. Each coil shall be provided with 15 degrees F subcooling circuit.

K. Condenser Fans

Condenser fans shall be propeller type.

L. Drain Pans

Provide a drain pan under each direct expansion cooling coil section. Provide 1/4-inch IPS minimum drain pipe connections.

M. Unit Temperature Control System

1. Each unit shall be furnished complete with all operational temperature controls. All controls shall be factory installed and wired, except for room sensors, duct sensors, operations sub-base smoke detectors and local control panels which shall be field installed.

2. The temperature control system shall be automatic, and shall consist of a dry-bulb type economizer, a seven day, spring power backup clock, room sensors, discharge sensors, outside air sensors, mixed air sensors, and a modulating spring return mixed air damper motor with a unit mounted integral minimum position adjustment potentiometer to operate the outside air, return air, and relief air dampers to achieve the sequence of operations indicated on the Contract Drawings.

3. Provide safety controls in accordance with AGA, IRI, UL, NFPA, and NEC requirements.

4. Provide a local control panel with each unit. The panel shall be located remote from the unit, where indicated on the Contract Drawings, and shall be supplied complete with the following:

   a. Auto/off system switch.

   b. Night setback switch.

   c. Dirty filter indicating light.

   d. Heating reset light.

   e. Cooling reset light.

   f. Fan system light.

   g. High pressure cutout light.

   h. Low pressure cutout light.

   i. Crankcase heater failure light.

   j. Heater high limit cutout light.

   k. Terminal strips, with spare contacts.

   A diagram of the system shall be located on front of the panel.

N. Vibration Isolation

Provide vibration isolation in accordance with requirements specified in Division 15 Section entitled "VIBRATION ISOLATION AND CONTROL". Consult with the supplier of vibration isolation devices concerning the selection of the types required.

O. Motors

Provide motors in accordance with requirements specified in Division 15 Section entitled "MOTORS AND MOTOR CONTROLLERS". Motors shall be mounted on adjustable bases. Select the motor characteristics, the motor mounting and all accessories necessary to satisfy the requirements of the motor drive in all operating modes.

2.04 SHOP PAINTING

Fan housings, casings and steel fabrication shall be given one coat of zinc chromate primer and one coat of machine enamel on both the exterior and interior surfaces.

2.05 SHOP TESTS

A. Balance fan wheels statically and dynamically, prior to final operating tests with motor and drive in place.

B. Test, rate and certify all coils in accordance with ARI Standard 410.

C. Test, rate and certify all air handling units, as complete units, in accordance with AGA Standards, IRI Standards, and ARI Standard 430; fans shall bear ARI seals.

D. Factory tests may be witnessed by the Engineer. Notify the Engineer 14 days in advance of scheduled tests.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install units in accordance with manufacturer's installation procedures.

B. Make all gas piping final connections to the unit in accordance with manufacturer's instructions.

C. Charge system with refrigerant in accordance with manufacturer's instructions.

D. Verify that electrical wiring installation is in accordance with manufacturer's submittal and in accordance with the installation requirements of Division 16. Ensure that rotation of motor driven equipment is in direction indicated and intended for proper performance.

3.02 FIELD TESTS

A. Install filters at completion of air handling system Work, and prior to testing, adjusting, and balancing.

B. Provide a qualified technical representative of the manufacturer to advise on field tests.

C. Start up, test, and adjust units in presence of the manufacturer's representative.

D. Test each system as a unit to obtain refrigeration and heating ratings in accordance with the ARI, AGA and IRI standards, and with manufacturer's instructions.

E. Following testing and adjustments, replace filters with new filters (spare filters) before final inspection by the Engineer.

END OF SECTION

SECTION 15856

AIR HANDLING UNITS - GAS FIRED

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings / Product Data / Catalog Cuts

1. Air Handling Units - Gas Fired

   a. Unit construction details including components, materials, gauges, dimensions of selected models, required clearances, weights (shipping, installed, and operating), load distribution and location and size of each field connection. Shop drawings shall be at a minimum of 1/4"=1'-0" scale.

   b. Air handling unit schedules.

   c. Certified fan performance pressure-volume, horsepower, and efficiency curves, with system operating conditions indicated.

   d. Certified fan and compressor sound levels at rated capacity at each octave band.

   e. Certified coil performance ratings with system operating conditions indicated.

   f. Gas-fired furnace heater performance data with system operating conditions clearly indicated.

   g. Filter performance characteristics.

   h. Damper performance curves.

   i. Catalog cuts.

   j. Refrigerant piping diagram.

   k. Schematics of the gas train including all valves, controls and wiring.

   l. Electrical wiring diagrams for power supply, interlock and controls.

   m. Motor ratings and electrical characteristics.

   n. Drive construction and rating.

   o. Installation procedures.

   p. Shop test results.

B. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive detailed information for the specific approved equipment; including approved shop drawings and catalog cuts, troubleshooting, maintenance requirements, spare part lists, sequence of operations, test results, electrical/control devices and electrical/control wiring diagram(s), bearings maintenance procedures, lubrication procedures and lubricant type.

C. Construction and Installation Procedures

1. Field test procedures.

D. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15856

AIR HANDLING UNITS - GAS FIRED

INSTRUCTIONS TO SPECIFIER

USERS OF THIS SECTION ARE ADVISED THAT DETAILED INSTRUCTIONS ARE NOT AVAILABLE AT THIS TIME.

IN ORDER TO ENSURE PROPER COORDINATION WITH THE CONTRACT DRAWINGS, AND A BIDDABLE CONTRACT, THE TEXT MUST BE CAREFULLY READ AND THE ITEMS OR CHOICES INDICATED AS "AS SHOWN ON THE CONTRACT DRAWINGS" (OR SIMILAR LANGUAGE) MUST BE SHOWN ON THE CONTRACT DRAWINGS.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15860

CENTRIFUGAL FANS

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies requirements for centrifugal fans.

B. Types of centrifugal fans specified in this Section are:

1. Centrifugal Fans and Utility Sets.
2. Tubular (inline) Fans.
3. Roof Ventilators.
4. Wall Ventilators.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

Air Movement and Control Association (AMCA)
American National Standards Institute (ANSI)
American Society for Testing and Materials (ASTM)
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
Anti-Friction Bearing Manufacturers Association (AFBMA)
National Electrical Manufacturers Association (NEMA)
Occupational Safety and Health Administration (OSHA)
Steel Structures Painting Council (SSPC)
Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Design and performance requirements of centrifugal fans shall be as specified in the Centrifugal Fan Schedules, (hereinafter in this Section "Schedules") shown on the Contract Drawings.

1.03 QUALITY ASSURANCE

A. Centrifugal fans, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Entities performing the Work of this Section shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans with factory-installed wooden skids and lifting lugs; pack components in factory-fabricated protective containers.

B. Handle fans carefully to avoid damage to components, enclosures, and finish.

C. Store fans in clean, dry spaces and protect them from weather.

D. Comply with manufacturer's rigging instructions for unloading fans, and moving fans to final location for installation.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PR0DUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide fans of one of the following manufacturers, or approved equal:

A. Centrifugal Fans/Utility Sets

Buffalo Forge Co.
New York Blower Co.
Trane Co.
Cook (Loren) Co.

B. Tubular (Inline) Fans

Cook (Loren) Co.
Greenheck Fan Corp.
Penn Ventilator Co., Inc.

C. Roof Ventilators

Penn Ventilator Co., Inc.
Greenheck Fan Corp.
Cook (Loren) Co.

D. Wall Ventilators

Carnes Co., Inc.
Cook (Loren) Co.
Greenheck Fan Corp.

2.02 MATERIALS

Materials for fans shall be as specified below.

A. Centrifugal Fans/Utility Sets

Wheel:	Steel or aluminum
Shaft:	Forged steel
Housing:	Galvanized or coated steel

B. Tubular (Inline) Centrifugal Fans

Wheel:	Aluminum or steel
Shaft:	Forged steel
Housing:	Aluminum, galvanized or coated steel

C. Roof and Wall Ventilators

Wheel:	Aluminum
Shaft:	Forged steel
Housing:	Aluminum

2.03 CONSTRUCTION FEATURES

A. Centrifugal Fans/Utility Sets

1. Fans shall be of sizes, arrangements and capacities specified in the Schedules and as shown on the Contract Drawings.
2. Fans shall consist of housing, wheel, shaft, bearings, motor, and support structure.
3. Provide curved scroll housings, with lockseam construction for fan sizes 36 inches and smaller, and spot welded construction for fan sizes 40 inches and larger. Provide horizontally split housings, bolted together for fan sizes 66 inches and larger. Provide spun inlet cones and duct connections.
4. Provide the types of wheels specified in the Schedules shown on the Contract Drawings. Weld blades to wheel rim and hub plate; key wheel to shafts. Wheel diameter and outlet areas shall be in accordance with AMCA Standard 99 for non-overloading fans.
5. Provide solid, accurately turned, ground and polished shafts.
6. For fan sizes 22 inches and smaller, provide grease-lubricated, precision anti-friction ball or roller, self-aligning, pillow block type bearings to provide minimum L-10 life rating of 60,000 hours in accordance with AFBMA Std. 9 for ball bearings or AFBMA Std. 11 for roller bearings. For fan sizes 24 inches and larger, provide grease-lubricated, tapered double spherical roller, pillow block type bearings to provide minimum L-10 life rating of 120,000 hours in accordance with AFBMA Std. 11. Extend grease lines from bearings to outside of inlet duct flange, and terminate with grease fittings.

7. If "Belt Drive" fans are specified in the Schedules shown on the Contract Drawings, provide multiple matched V-belt drive for motors less than 50hp, and fixed pitch sheave for 50hp motor and larger. V-belt drives to be rated minimum 1.4 times rated motor horsepower. Provide adjustable pitch sheave on motor shaft, selected for midpoint at design conditions.

8. Provide access door in scroll housing, with latch-type handles, flush mounted for uninsulated housings, and raised-mounted to the thickness of insulation for insulated housings.

9. Provide 3/4-inch threaded coupling drain connection with plug at lowest point of the housing.

10. Provide removable flanged screens at inlets or outlets where no connecting ductwork is shown on the Contract Drawings.

11. Provide ventilated belt guards with tachometer opening for fan speed measurements, in accordance with OSHA requirements.

12. If specified in the Schedules shown on the Contract Drawings, provide fans with variable inlet vanes integral with the inlet bells of the fan. Connect vane rods to control ring by crank arms; provide vane rods supported at both ends by non-rusting nylon bearings. For double-inlet fans, both sets of vanes shall be operated by a lever on the fan scroll with connecting shaft between inlets. Vane linkage shall be suitable for either manual or automatic operation.

B. Tubular (Inline) Fans

1. Fans shall be of sizes, arrangements and capacities specified in the Schedules and as shown on the Contract Drawings.

2. Fans shall consist of housing, wheel, shaft, bearings, straightening vanes, and motor support.

3. Provide housings with continuous-weld construction, braced to prevent vibration or pulsation.

4. Provide backward-inclined or airfoil blades, of welded wheel construction. Fan wheel diameter and outlet areas shall be in accordance with AMCA Standard 99 for non-overloading fans.

5. Provide solid, accurately turned, ground and polished shafts.

6. Provide grease-lubricated, precision anti-friction ball or roller, self-aligning, pillow block type bearings to provide minimum L-10 life rating of 40,000 hours in accordance with AFBMA Std. 9 for ball bearings or AFBMA Std. 11 for roller bearings. Extend grease lines from bearings to outside of inlet duct flange, and terminate with grease fittings.

7. If "Belt Drive" fans are specified in the Schedules shown on the Contract Drawings, provide multiple matched V-belt drive for motors less than 50 hp, and fixed pitch sheave for 50 hp and larger. V-belt drives to be rated minimum 1.4 times rated motor horsepower. Provide adjustable pitch sheave on motor shaft, selected for midpoint at design conditions.

8. Provide access door in housing, located over wheel in accessible position, with latch-type handles, flush mounted for uninsulated housing, and raised-mounted to the thickness of insulation for insulated housings.

9. Provide 3/4-inch threaded coupling drain connection with plug at lowest point of housing.

10. Provide heavy mesh, removable screens on fan inlets and outlets where no connecting ductwork is shown on the Contract Drawings.

11. Provide belt guards with tachometer opening for fan speed measurements, in accordance with OSHA requirements.

12. For "Belt Drive" fans, provide inner tube construction to isolate bearings and drive from air stream; provide removable cover for access to bearing and drive.

13. If specified in the Schedules shown on the Contract Drawings, provide variable inlet vanes in fan inlet with a linkage suitable for either manual or automatic operation.

14. If outdoor location is specified in the Schedules shown on the Contract Drawings, provide protective weather hood with ventilation slots over motor and drive compartment.

15. If ceiling-hung fans are specified in the Schedules shown on the Contract Drawings, provide structural angles welded to housing to accommodate load hangers for ceiling-hung fans.

C. Roof and Wall Ventilators

1. Ventilators shall be of sizes, arrangements and capacities as specified in the Schedules and as shown on the Contract Drawings.

2. Ventilators shall consist of housing, wheel, shaft, bearings, drive assembly, curb base, and accessories.

3. Wheels shall be backward inclined, non-overloading, centrifugal.

4. Provide solid, accurately turned, ground and polished shafts.

5. Provide grease-lubricated, precision anti-friction self-aligning ball bearings, to provide minimum L-10 life rating of 40,000 hours, in accordance with AFBMA Standard 9.

6. If "belt drive" ventilators are specified in the Schedules shown on the Contract Drawings, provide multiple matched V-belt drive with minimum 1.4 times rated motor horsepower. Provide adjustable pitch sheave on motor shaft, selected for midpoint at design conditions.

7. Provide removable 1/2-inch mesh aluminum bird screen at fan discharge.

8. Provide prefabricated curbs for roof ventilators, unless otherwise shown on the Contract Drawings.

9. Furnish wall ventilators with pre-punched plates for attachment to wall.

10. Furnish ventilators with gravity dampers and factory-wired disconnect switches, unless otherwise shown on the Contract Drawings.

D. Vibration Isolation

Provide vibration isolation in accordance with requirements specified in Division 15 Section entitled "VIBRATION ISOLATION AND CONTROL". Consult with the supplier of vibration isolation devices concerning the selection of the types required.

E. Motors

Provide motors in accordance with requirements specified in Division 15 Section entitled "MOTORS AND MOTOR CONTROLLERS". Select the motor characteristics, the motor mounting, and all accessories necessary to satisfy the requirements of the fan motor drive unit in all operating modes.

F. Explosion-Proof Construction

Where fans are specified on the Contract Drawings to be of explosion-proof construction, they shall be provided with non-sparking wheel and bearings, and shall have explosion-proof motor. Belt-driven fans shall be provided with antistatic belts. Explosion-proof construction fans shall be AMCA Design "A" with all parts in contact with the air stream of non-ferrous construction.

2.04 SHOP PAINTING

A. Fans and steel fabrication shall be factory coated with one coat of zinc chromate primer and one coat of machine enamel on both the exterior and interior surfaces.

B. For roof mounted fans, all steel components shall be coated with thermally fused epoxy.

2.05 SHOP TESTS

A. Balance fan wheels statically and dynamically prior to final operating tests with motor and drive in place.

B. Test, rate and certify fans in accordance with AMCA Standard 210 at an AMCA approved laboratory; fans shall bear AMCA seals. In lieu of shop performance tests, unless otherwise specified in the Schedules shown on the Contract Drawings, certified performance characteristic curves of prototype fans of similar units may be submitted for approval.

C. Sound rate fans in accordance with AMCA Standard 300; fans shall bear AMCA seals. Sound rating shall be based upon actual fan tests or upon prototype tests of similar units.

D. If specified in the Schedules shown on the Contract Drawings, the factory tests shall be witnessed by the Engineer. The Contractor shall notify the Engineer 14 days in advance of the scheduling of said factory tests.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install fans in accordance with manufacturer's installation procedures and recognized industry practices.

B. Coordinate all Work to ensure that the installation of fans is not in conflict with the work specified under other Sections.

C. For split construction fans, the installation shall be inspected by the manufacturer after field assembly who shall certify that the fans have been properly installed and are ready for proper operation.

D. Verify that electrical wiring installation is in accordance with manufacturer's submittal and in accordance with installation requirements of Division 16. Ensure that rotation is in direction indicated and intended for proper performance.

3.02 FIELD TESTS

A. Provide a qualified technical representative of the manufacturer to advise on field tests.

B. Start up, test, and adjust fans in presence of manufacturer's authorized representative.

END OF SECTION

SECTION 15860

CENTRIFUGAL FANS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings / Product Data / Catalog Cuts

1. Centrifugal Fans

   a. Details of fan construction components, dimensions of selected models, materials, gauges, finishes, weights, load distribution, required clearances and locations and sizes of field connections.

   b. Fan schedules.

   c. Certified performance operating curves for pressure-volume relation for each fan.

   d. Certified sound power levels at rated capacity at each octave band.

   e. Catalog cuts of fans, specialties, accessories and other items specified in this Section.

   f. Specialties and accessories.

   g. Electrical wiring diagrams for power supply, interlock and controls.

   h. Motor and electrical operating data.

   i. Belt drive construction and rating.

   j. Installation procedures.

   k. Shop test results.

B. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive detailed information for the specific approved equipment; including approved shop drawings and catalog cuts, troubleshooting, maintenance requirements, spare part lists, sequence of operations, test results, electrical/control devices and electrical/control wiring diagram(s), bearings maintenance procedures, lubrication procedures and lubricant type.

C. Construction and Installation Procedures

1. Field test procedures.

D. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15860

CENTRIFUGAL FANS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following specified items in the text:

1. Contract Drawings

(2.03 A.1) (2.03 A.10) Arrangements of fans.
(2.03 B.1) (2.03 B.10)
(2.03 C.1)

Contract Drawings shall clearly show the scope of work of this Section and the interface ductwork (including connection sizes) at inlet and/or outlet of the fan(s).

2. Centrifugal Fan Schedules (shown on the Contract Drawings)

For All Fans

(1.02 B)	Design and performance requirements (overall).
(2.05 B)	Certified performance curves of prototype fans.
(2.05 D)	Witnessing of factory tests ("Required" or "Not Required").

For Centrifugal Fans

(2.03 A.1)	Sizes and capacities.
(2.03 A.4)	Type of wheels.
(2.03 A.7)	Belt drive and Motor requirements for "Belt Drive" fans.
(2.03 A.10)	Removable flanged screens.
(2.03 A.12)	Variable inlet vanes.

For Tubular (Inline) Centrifugal Fans

(2.03 B.1)	Sizes and capacities.
(2.03 B.7)	Belt drive requirements for "Belt Drive" fans.
(2.03 B.10)	Removable inlet/outlet screens.
(2.03 B.13)	Variable inlet vanes.
(2.03 B.14)	Weather hood for outdoor location.
(2.03 B.15)	Ceiling-hung fans.

For Centrifugal Roof and Wall Ventilators

(2.03 C.1)	Sizes and capacities.
(2.03 C.6)	Belt drive requirements for "Belt Drive".
(2.03 C.8)	Cases where pre-fabricated curb is not required for roof ventilators.
(2.03 C.10)	Cases where gravity damper and factory wired disconnect switch are not required.

For Motor Types

(2.03 E) Ensure that the Contract Drawings indicate type of motor/ enclosure if other than open drip-proof type.

For Explosion-proof Construction of Fans

(2.03 F) Explosion-proof construction.

B. Other Items

1. Ensure that the Specifications include the following Sections referenced in this Section:

   (2.03 D) "VIBRATION ISOLATION AND CONTROL"

   (2.03 E) "MOTORS AND MOTOR CONTROLLERS"

2. Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15865

AXIAL FANS

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies requirements for axial fans.

B. Types of axial fans specified in this Section are:

1. Vaneaxial Fans up to 30 inches in diameter.
2. Tubeaxial Fans.
3. Propeller Fans.
4. Axial Roof Ventilators.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State, and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

Occupational Safety and Health Administration (OSHA)
Anti-Friction Bearing Manufacturers Association (AFBMA)
Air Movement and Control Association (AMCA)
American National Standards Institute (ANSI)
American Society for Testing and Materials (ASTM)
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
National Electrical Manufacturers Association (NEMA)
Steel Structures Painting Council (SSPC)
Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Design and performance requirements of axial fans shall be as specified in the Axial Fan Schedules, (hereinafter in this Section "Schedules") shown on the Contract Drawings.

C. Fans shall be designed to preclude a resonant condition resulting from speeds, number of blades and number of fixed supports.

1.03 QUALITY ASSURANCE

A. Axial fans, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Entities performing the work of this Section shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans with factory-installed wooden skids and lifting lugs; pack components in factory-fabricated protective containers.

B. Handle fans carefully to avoid damage to components, enclosures, and finish.

C. Store fans in clean, dry spaces and protect them from weather.

D. Comply with manufacturer's rigging instructions for unloading fans, and moving fans to final location for installation.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide fans of one of the following manufacturers, or approved equal:

A. Vaneaxial Fans

Buffalo Forge Co.
Flakt/Aerovent
Joy Technologies, Inc.

B. Tubeaxial Fans

Buffalo Forge Co.
New York Blower Co.
Flakt/Aerovent

C. Propeller Fans

Buffalo Forge Co.
Industrial Air
New York Blower Co.

D. Axial Roof Ventilators

New York Blower Co.
Greenheck Fan Corp.
Cook (Loren) Co.

2.02 MATERIALS

Materials for fans shall be as specified below.

A. Vaneaxial Fans

Wheel (blade):	Steel or cast aluminum
Hub:	Steel or cast aluminum
Shaft:	Forged steel
Housing:	Galvanized or coated steel

B. Tubeaxial Fans

Wheel (blade):	Steel or cast aluminum
Hub:	Steel or cast aluminum
Shaft:	Forged steel
Housing:	Galvanized or coated steel

C. Propeller Fans

Blades:	Steel or cast aluminum
Shaft:	Forged steel
Housing:	Galvanized or coated steel

D. Axial Roof Ventilators

Blades:	Steel or cast or extruded aluminum
Shaft:	Forged steel
Housing:	Galvanized or coated steel or cast aluminum

2.03 CONSTRUCTION FEATURES

A. Vaneaxial Fans

1. Fans shall be of sizes, arrangements and capacities specified in the Schedules and as shown on the Contract Drawings.
2. Fans shall be single speed or multi-speed, as specified in the Schedules shown on Contract Drawings; and shall be single direction of rotation unless indicated otherwise on Contract Drawings.
3. Blade pitch shall be manually or automatically adjustable as specified in the Schedules shown on the Contract Drawings.
4. Provide all welded construction housing; provide housing with end flanges.
5. Provide airfoil shaped blades with curved vanes to straighten the air flow leaving the fan.
6. Provide solid, accurately turned, ground and polished shafts. Key wheel to shafts and secure with locking type nut.
7. Provide access door in housing, with latch-type handles, flush-mounted for uninsulated housings, and raised-mounted to the thickness of insulation for insulated housings.

8. Provide 3/4-inch threaded coupling drain connection with plug at lowest point of housing of all horizontally mounted fans.

9. Provide screened inlet bells, if no inlet duct is required.

10. If "Direct Drive" fans are specified in the Schedules shown on the Contract Drawings,

    a. Install motor inside the fan housing; attach fan rotor assembly directly to motor shaft; motor flange shall recess into motor mounting plate.

    b. Provide housing of sufficient length so that neither the blades nor the motor will protrude beyond the housing.

    c. Provide motor bearings with external lubrication fittings, (bearings shall be rated for L-10, 40,000 hours in accordance with AFBMA Standard 9 for ball bearings or AFBMA Standard 11 for roller bearings).

11. If "Belt Drive" fans are specified in the Schedules shown on the Contract Drawings,

    a. Provide grease-lubricated, precision anti-friction ball or roller, self-aligning, pillow block type bearings to provide minimum L-10 life rating of 40,000 hours in accordance with AFBMA Standard 9 for ball bearings or AFBMA Standard 11 for roller bearings; extend grease lines from bearings to outside of inlet duct flange, and terminate with grease fittings.

    b. Provide multiple V-belt drive with minimum 1.4 times rated motor horsepower and provide adjustable pitch sheave, selected for midpoint at design conditions.

    c. Provide inner tube to isolate bearings and drive from air stream.

    d. Provide ventilated belt guard and tachometer access to enclose drive completely in accordance with OSHA requirements.

12. If fans are specified to be roof-mounted in the Schedules shown on the Contract Drawings, provide the fans with stack hoods and weatherproof covers.

13. If specified in the Schedules shown on the Contract Drawings, provide fans with controllable pitch as follows:

    a. Fan blades shall be controllable through a pitch range of sufficient angularity to vary volume and pressure characteristics across design range.

    b. Each blade shall be index-marked for various pitch settings and shall be capable of stepless control across the complete pitch range while the motor is operating at full speed.

    c. The pitch of the blades in the controllable pitch rotor shall be varied by a pneumatic or electric actuator as indicated on Contract Drawings. Actuator furnished and mounted by the fan manufacturer.

    d. The actuator shall be controlled by a signal from a remote controller, furnished and installed by control manufacturer.

    e. Controllable pitch mechanism shall be equipped with safety stop to prevent blade pitch setting from being increased beyond maximum design setting and from overloading the motor.

B. Tubeaxial Fans

1. Fans shall be of sizes, arrangements and capacities specified in the Schedules and as shown on the Contract Drawings.

2. Fans shall be single speed or multi-speed, as specified in the Schedules shown on Contract Drawings; and shall be single direction of rotation, unless specified otherwise on Contract Drawings.

3. Provide all welded construction housing; provide housing with end flanges.

4. Provide airfoil shaped blades.

5. Provide solid, accurately turned, ground and polished shafts. Key wheel to shafts and secure with locking type nut.

6. Provide access door in housing, with latch-type handles, flush-mounted for uninsulated housing, and raised-mounted to the thickness of insulation for insulated housings.

7. Provide 3/4-inch threaded coupling drain connection with plug at lowest point of housing of all horizontally mounted fans.

8. Provide screened inlet bells, if no inlet duct is required.

9. If "Direct Drive" fans are specified in the Schedules shown on the Contract Drawings,

   a. Install motor inside the fan housing; attach fan rotor assembly directly to motor shaft; motor flange shall recess into motor mounting plate.

   b. Provide housing of sufficient length so that neither the blades nor the motor will protrude beyond the housing.

   c. Provide motor bearings with external lubrication fittings, (bearings shall be rated for L-10, 40,000 hours in accordance with AFBMA Standard 9 for ball bearings or AFBMA Standard 11 for roller bearings).

10. If "Belt Drive" fans are specified in the Schedules shown on the Contract Drawings,

    a. Provide grease-lubricated, precision anti-friction ball or roller, self-aligning, pillow block type bearings to provide minimum L-10 life rating of 40,000 hours in accordance with AFBMA Standard 9 for ball bearings or AFBMA Standard 11 for roller bearings; extend grease lines from bearings to outside of inlet duct flange, and terminate with grease fittings.

    b. Provide multiple V-belt drive with minimum 1.4 times rated motor horsepower and provide adjustable pitch sheave, selected for midpoint at design conditions.

    c. Provide inner tube to isolate bearings and drive from air stream.

    d. Provide ventilated belt guard and tachometer access to enclose drive completely in accordance with OSHA requirements.

11. If fans are specified to be roof-mounted in the Schedules shown on the Contract Drawings, provide the fans with stack hoods and weatherproof covers.

C. Propeller Fans

1. Fans shall be propeller type wall fans of sizes, arrangements and capacities specified in the Schedules and as shown on the Contract Drawings.

2. Fans shall be single speed or multi-speed, single direction of rotation or reversible, as specified in the Schedules shown on the Contract Drawings.

3. Provide airfoil blades securely attached to the hub.

4. Provide solid, accurately turned, ground and polished shafts.

5. Provide fans with factory-wired disconnect switch, and built-in overload protection.

6. Provide removable motor screen guard.

7. Provide exterior louvers of perimeter flanged type for direct bolting to a structural frame; provide louvers with bird screen.

8. If "Direct Drive" fans are specified in the Schedules shown on the Contract Drawings, conform to the requirements specified in 2.03 A.10.

9. If "Belt Drive" fans are specified in the Schedules shown on the Contract Drawings, conform to the requirements specified in 2.03 A.11.

D. Axial Roof Ventilators

1. Fans shall conform to the requirements specified in 2.03 C for Propeller Fans, with the following additions and modifications:

   a. Bearings shall be sealed and pre-lubricated.

   b. Removable aluminum bird screens shall be provided.

   c. Fans shall be furnished with prefabricated curbs, gravity damper and factory-wired disconnect switch.

E. Vibration Isolation

Provide vibration isolation in accordance with requirements specified in Division 15 Section entitled "VIBRATION ISOLATION AND CONTROL". Consult with the supplier of vibration isolation devices concerning the selection of the types required.

F. Motors

Provide motors in accordance with requirements specified in Division 15 Section entitled "MOTORS AND MOTOR CONTROLLERS". Select the motor characteristics, the motor mounting, and all accessories necessary to satisfy the requirements of the fan motor drive unit in all operating modes.

G. Explosion-Proof Construction

Where fans are specified on Contract Drawings to be of explosion-proof construction, they shall be provided with non-sparking wheel and bearings, and shall have explosion-proof motor. Belt-driven fans shall be provided with antistatic belts. Explosion-proof construction fans shall be AMCA Design "A" with all parts in contact with the air stream of non-ferrous construction.

2.04 SHOP PAINTING

A. Fans and steel fabrication shall be factory coated with one coat of zinc chromate primer and one coat of machine enamel on both the exterior and interior surfaces.

B. For roof mounted fans, all steel components shall be coated with thermally fused epoxy.

2.05 SHOP TESTS

A. Balance fan wheels statically and dynamically prior to final operating tests with motor and drive in place.

B. Test, rate and certify fans in accordance with AMCA Standard 210 in an AMCA approved laboratory; fans shall bear AMCA seals. In lieu of shop performance tests, unless otherwise specified in the Schedules shown on the Contract Drawings, certified performance characteristic curves of prototype fans of similar units may be submitted for approval.

C. Sound rate fans in accordance with AMCA Standard 300; fans shall bear AMCA seals. Sound rating shall be based upon actual fan tests or upon prototype tests of similar units.

D. If specified in the Schedules shown on the Contract Drawings, the factory tests shall be witnessed by the Engineer. The Contractor shall notify the Engineer 14 days in advance of the scheduling of said factory tests.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install fans in accordance with manufacturer's installation procedures and recognized industry practices.

B. Coordinate all Work to ensure that the installation of fans is not in conflict with the Work specified in other Sections.

C. Verify that electrical wiring installation is in accordance with manufacturer's submittal and in accordance with installation requirements of Division 16. Ensure that rotation is in direction indicated and intended for proper performance.

3.02 FIELD TESTS

A. Provide a qualified technical representative of the manufacturer to advise on field tests.

B. Start up, test, and adjust fans in the presence of the manufacturer's representative.

END OF SECTION

SECTION 15865

AXIAL FANS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings / Product Data / Catalog Cuts

1. Axial Fans

a. Details of fan construction components, dimensions of selected models, materials, gauges, finishes, weights, load distribution, required clearances and locations and sizes of field connections.

b. Fan schedules.

c. Certified performance operating curves for pressure-volume relation for each fan.

d. Certified sound power levels at rated capacity at each octave band.

e. Catalog cuts of fans, specialties, accessories and other items specified in this Section.

f. Specialties and accessories.

g. Electrical wiring diagrams for power supply, interlock and controls.

h. Motor and electrical operating data.

i. Belt drive construction and rating.

j. Installation procedures.

k. Shop test results.

B. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive detailed information for the specific approved equipment; including approved shop drawings and catalog cuts, troubleshooting, maintenance requirements, spare part lists, sequence of operations, test results, electrical/control devices and electrical/control wiring diagram(s), bearings maintenance procedures, lubrication procedures and lubricant type.

C. Construction and Installation Procedures

1. Field test procedures.

D. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15865

AXIAL FANS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

1. Ensure that the Contract Drawings show the following items specified in the text:

(2.03A.1); (2.03 B.1); (2.03 C.1); (2.03 D)	Arrangements (and components) of required fans.

Contract Drawings shall clearly show the scope of work of this Section and the interface ductwork (including connection sizes) at inlet and/or outlet of the fan(s).

2. Axial Fans Schedules (shown on the Contract Drawings)

<u>For All Fans</u>

(1.02 B)	Design and performance requirements (overall)
(2.05 B)	Certified performance curves of prototype fans
(2.05 D)	Factory Inspections ("Required" or "Not Required")

<u>For Vaneaxial Fans and Tubeaxial Fans</u>

(2.03 A.1) (2.03 B.1)	Sizes and capacities
(2.03A.2) (2.03 B.2)	Single speed or multi-speed
(2.03 A.2) (2.03 B.2)	Single direction or reversible rotation
(2.03 A.3)	Blade pitch (manual or automatic)
(2.03 A.10) (2.03 B.9)	Direct drive
(2.03 A.11) (2.03 B.10)	Belt drive
(2.03 A.12) (2.03 B.11)	Roof-mounted

<u>For Vaneaxial Fans (only)</u>

(2.03 A.13)	Controllable pitch

<u>For Propeller Fans and Axial Roof Ventilators</u>

(2.03 C.1) (2.03 D)	Sizes and capacities
(2.03 C.2) (2.03 D)	Single speed or multi-speed
(2.03 C.2) (2.03 D)	Single direction or reversible rotation
(2.03 C.8) (2.03 D)	Direct drive
(2.03 C.9) (2.03 D)	Belt drive

<u>For Motor Types</u>

(2.03 F)	Ensure that Contract Drawings indicate type of motor/enclosure if other than open drip-proof type

<u>For Explosion-Proof Construction of Fans</u>

(2.03 G) Explosion-proof construction

B. Other Items

1. Ensure that the following Specification Sections are included in the Contract Booklet as required:

   (2.03 E) "VIBRATION ISOLATION AND CONTROL"

   (2.03 F) "MOTORS AND MOTOR CONTROLLERS"

2. Is sparks-proof construction required?

3. Is special construction required for fume handling?

4. Where options for material are given, do we wish to be specific?

5. Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15875

AIR CURTAINS - INDIRECT GAS FIRED

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for indirect gas-fired, air curtains.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to, the entities listed below.

New York City Building Code
New Jersey Uniform Construction
New York State Energy Conservation Construction Code
Occupational Safety and Health Administration (OSHA)
Anti-Friction Bearing Manufacturers Association (AFBMA)
Air Movement and Control Association (AMCA)
American Gas Association (AGA)
American National Standards Institute (ANSI)
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
American Society of Mechanical Engineers (ASME)
National Electrical Manufacturers Association (NEMA)
Industrial Risk Insurers (IRI)
Factory Mutual Engineering Corp. (FM)
National Fire Protection Association (NFPA)
Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Design and performance requirements of each air curtain shall be as specified in the Air Curtains Schedules (hereinafter in this Section "Schedules"), shown on the Contract Drawings.

1.03 QUALITY ASSURANCE

A. Air curtains, of types and sizes required, shall have performed satisfactorily for purposes similar to those intended herein, for not less than three years.

B. Entities performing the Work of this Section shall have experience on at least two projects involving complexities similar to those required under this Contract.

C. Air curtains shall be subject to factory inspection by the engineer prior to shipping.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver air curtains with factory-installed wooden skids and lifting lugs; pack components in factory-fabricated protective containers.

B. Handle air curtains carefully to avoid damage to components, enclosures, and finish.

C. Store air curtains in clean, dry spaces and protect them from weather.

D. Comply with the manufacturer's rigging instructions for unloading air curtains, and moving air curtains to final location for installation.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with the requirements of this Section, provide air curtains of one of the following manufacturers, or approved equal:

Berner International Corporation
Dynaforce Corporation
King Company

2.02 MATERIALS

Materials for air curtain components shall be as specified below.

A. Casings

Panel (frame):	Galvanized steel, minimum 14 gauge, prime coated, baked on

B. Motor Mounts

Motor mounts:	Steel, prime-coated, baked-on enamel

C. Fans

Wheel and Scroll:	Steel, galvanized inside and outside

D. Gas Heaters

Heat Exchanger:	Aluminized steel
Burners:	Aluminized steel

E. Filters

Housing:	Galvanized steel
Replaceable Filters:	Blend of cotton and synthetic fibers

Cleanable Filters: Layers of corrugated wire mesh

2.03 CONSTRUCTION FEATURES

A. General

1. Air curtains shall be of sizes, arrangements and capacities specified in the Schedules and as shown on the Contract Drawings.
2. Air curtains shall consist of casing, centrifugal fan, indirect fired gas heater section, air discharge chamber, air outlets, controls, filters, motors, couplings, and accessories specified in the Schedules, shown on the Contract Drawings and specified herein.

B. Casings

Provide a casing sufficiently reinforced and braced that it can be supported from both ends without intermediate support.

C. Centrifugal Fans

1. Fans shall be dynamically balanced, forward curved, double inlet type, and shall consist of housings, wheels, shafts, bearings, and side support structure. Multiple fans may be driven by a single common motor or by individual motors.
2. Provide housing with matching inlet venturies for maximum performance.
3. Fan ratings shall be certified per AMCA Air Curtain Test Procedure Standard 220. Each air curtain shall bear the AMCA seal.
4. Provide solid, accurately turned, ground and polished shafts.
5. Fans shall be direct motor-driven, via flexible couplings or direct motor driven with wheels mounted on motor shaft.

D. Indirect Fired Gas Heaters (Furnaces)

1. The heaters shall be AGA approved and operation of heaters shall comply with AGA and IRI requirements as shown on the Contract Drawings.
2. The heaters shall be completely factory-wired units and shall have burners, heat exchangers, gas valves and controls, transformers, and all required accessories.

E. Gas Controls

Gas controls shall be an electronic modulation control system with a regulated combustion redundant gas valve and a manual (match-lit) pilot, main gas manual shutoff, pilot solenoid valve, pilot regulator, and a pilot manual shutoff. Provide all required limit and safety controls, including an energy cutoff (ECO) device, and blocked vent shutdown system. All gas controls shall be factory installed and wired and shall be AGA certified.

F. Motor Controls

Motor controls shall include disconnect switches, motor starter, power fuses, and motor overloads.

G. Control Panel

Control panel shall be a UL listed panel. The control panel shall consist of a NEMA 12 enclosure with neoprene door gasket and shall be mounted on the air curtain. Included in the panel shall be UL listed components consisting of gas controls, motor controls, control transformer with 120 volt fused secondary, all factory-wired. Terminal strips with contacts for wiring by the manufacturer of the Automatic Temperature Control System shall also be provided on the panel. The panel shall accept the power supply of characteristics shown on the Contract Drawings.

H. Vibration Isolation

Provide vibration isolation in accordance with requirements specified in Division 15 Section entitled "VIBRATION ISOLATION AND CONTROL". Consult with the supplier of vibration isolation devices concerning the selection of the types required.

I. Motors

Provide motors in accordance with requirements specified in Division 15 Section entitled "MOTORS AND MOTOR CONTROLLERS". Motors shall be totally enclosed air-over type.

J. Air Discharge High Temperature Control

To prevent burnout of the heat exchanger as a result of low air flow due to air filter clogging, provide a temperature controller to sense air curtain air outlet temperature. When the sensed air temperature is at or above its set point, it shall override the combustion controls and prevent heater operation and indicate the condition at the control panel. Manual reset of this indication shall be required.

2.04 SHOP PAINTING

Fan wheels and housings, fabrication shall be given one coat of zinc chromate primer and one coat of machine enamel on both the exterior and interior surfaces. Casings and motor mounts shall be given one prime coat, followed by a finish coat.

2.05 SHOP TESTS

A. Balance fan wheels statically and dynamically, prior to final operating tests with motor in place.

B. Test, rate and certify all air curtains, as complete units, in accordance with AGA Standards and in accordance with the AMCA Air Curtain Test Procedure Standard 220. Each air curtain shall bear the AGA label and the AMCA Certified Ratings Seal.

C. Factory tests may be witnessed by the Engineer. Notify the Engineer 14 days in advance of scheduled tests.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install air curtains in accordance with manufacturer's installation procedures, and to meet applicable code requirements.

B. Verify that electrical wiring installation is in accordance with the installation requirements of Division 16 Sections of these Specifications. Ensure that rotation of air curtain fan is in the direction indicated and intended for proper performance.

3.02 FIELD TESTS

A. Install filters at completion of air curtains installation Work, and prior to testing, adjusting, and balancing.

B. Provide a qualified technical representative of the manufacturer to advise on field tests.

C. Start up, test, and adjust units in presence of the manufacturer's representative.

D. Following testing and adjustments, replace filters with new filters (spare filters) before final inspection by the Engineer.

END OF SECTION

SECTION 15875

AIR CURTAINS - INDIRECT GAS FIRED

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings / Product Data / Catalog Cuts

1. Air Curtains - Indirect Gas Fired

   a. Shop drawings indicating dimensions of selected models, weights, load distribution, required clearances and methods of assembly of components.

   b. Air curtain manufacturer's product performance data, design capacities and construction characteristics.

   c. Certified performance operating curves for pressure-volume relation for each fan.

   d. Performance data for each gas heater.

   e. Performance data for coupling and motor system.

   f. Certified sound power levels at rated capacity at each octave band.

   g. Filter performance characteristics.

   h. Unit construction components, materials and gauges.

   i. Catalog cuts.

   j. Gas piping schematics, including all valves, controls and wiring.

   k. Electrical wiring diagrams for power supply, interlock and controls.

   l. Motor and electrical operating data.

   m. Drive construction and rating.

   n. Installation procedures.

   o. Shop test results.

B. Operation and Maintenance Manuals

1. Operation and maintenance manuals providing comprehensive detailed information for the specific approved equipment; including approved shop drawings and catalog cuts, troubleshooting, maintenance requirements, spare part lists, sequence of operations, test results, electrical/control devices and electrical/control wiring diagram(s).

C. Construction and Installation Procedures

1. Field test procedures.

D. Site Inspection Results

1. Field test results.

END OF APPENDIX "A"

SECTION 15875

AIR CURTAINS - GAS FIRED

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(1.02 B)	Schedules - Design and performance requirements.
(2.03 A.1)	Schedules - sizes, arrangements, capacities and components.
(2.03 D.1)	Indirect fired gas heaters AGA and IRI requirements.

B. Other Items

1. Ensure that the Contract booklet contains the following Specifications:

   "VIBRATION ISOLATION AND CONTROL"
   "MOTORS AND MOTOR CONTROLLERS"

2. Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15890

METAL DUCTWORK AND ACCESSORIES

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies requirements for metal ductwork (including flexible ducts) and accessories.

B. Ductwork accessories specified in this Section are:

1. Flexible Connectors.
2. Gravity (Backdraft) Dampers.
3. Manual volume Control Dampers.
4. Fire Dampers.
5. Ceiling (fire) Dampers.
6. Smoke Dampers.
7. Combination Smoke/Fire Dampers.
8. Ductwork Access Doors.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, as though the Authority were a private corporation, and the latest industry standards including, but not limited to those of the entities listed below.

New York City Building Code

New York City Board of Standards and Appeals (BSA)

New Jersey Uniform Construction Code

Air Movement and Control Association (AMCA)

American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)

American Society for Testing and Materials (ASTM)

American Welding Society (AWS)

National Fire Protection Association (NFPA)

Sheet Metal and Air-Conditioning Contractors National Association (SMACNA)

Steel Structures Painting Council (SSPC)

Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

1.03 QUALITY ASSURANCE

A. Ductwork accessories, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Ensure that entities performing the Work of this Section have experience on at least two projects involving complexities similar to those required under this Contract.

1.04 DELIVERY, STORAGE, AND HANDLING

Protect ductwork and accessories against damage during shipping, receiving, storing, and handling. Place guards over damageable parts. Mark each package for identification.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MATERIALS

Materials for ductwork and accessories shall be as specified below. All materials furnished shall comply with NFPA 90A.

Galvanized Steel Ductwork	ASTM A 527 with zinc coating conforming to ASTM A 525, coating designation G 90
Stainless Steel Ductwork (indicated on the Contract Drawings)	ASTM A 167, Type 304
Aluminum Ductwork (indicated on the Contract Drawings)	ASTM B 209, Alloy 3003, Temper to suit material thickness and tensile strength
Boiler Breeching	Black steel ASTM A 366 or A 569
Kitchen Exhaust Ductwork	Black steel, ASTM A 366 or A 569 for concealed area Stainless steel, ASTM A 167, Type 304 for exposed area
Hangers and Supports(including fasteners, anchors, rods, straps, trimand angles)	Matching materials of ductwork furnished
	Flexible Duct
Core	Spiral-wound steel spring with flameproof vinyl sheathing, complying with UL 181 or corrugated aluminum, complying with UL 181
Moisture Barrier	One-inch thick, continuous, flexible fiberglass sheath with vinyl vapor barrier jacket

	Acoustical Duct Liner
Liner	Insulation minimum density shall be 1.5 pounds per cubic foot. Insulation thickness, one inch.
Adhesives	ASTM C 916
Flexible Connectors	Double layer of 30-ounce per square yard, finished weight, fire retardant, glass cloth; double-coated with neoprene
	Gravity (Backdraft) Dampers
Frame	Aluminum, ASTM B 221, Alloy 6063, Temper 5
Blade	Aluminum, ASTM B 221, Alloy 6063, Temper 5
Tie Bars & Brackets	Aluminum
Blade Edge Seals	Extruded vinyl
Pivot Pins	Nonferrous
Bearings	Oil impregnated bronze or nylon
	Fire Dampers (To meet UL-555 requirements)
Frame	Galvanized steel
Closure Spring	Stainless steel
Blades	Galvanized steel
Perimeter Angle	Galvanized steel
	Ceiling (Fire) Dampers (To meet UL-555 requirements)
Frame	Galvanized steel
Blade	Galvanized steel with non-asbestos refractory insulation
	Smoke Dampers (To meet UL-555S requirements)
Frame	Galvanized steel
Blades	Galvanized steel
Bearings	Stainless steel sleeve, pressed into frame
Axles	Plated steel
Blade Seals	Silicone rubber
	Combination Smoke/Fire Dampers (To meet UL-555 and UL- 555S requirements)
Frame	Galvanized steel
Blades	Galvanized steel
Bearings	Stainless steel sleeve, pressed into frame
Axles	plated steel
Blade Seals	Silicone rubber
	Access Doors
Frame	Same material as ductwork
Gasket	Neoprene rubber
Double Wall Casing Core Insulation	Fiberglass or rock wool, 2.5 lb. per cubic foot minimum density

2.02 FABRICATION

A. Ductwork, Casings and Plenums

1. Unless otherwise shown on the Contract Drawings or specified herein, gauges, reinforcement, and fabrication of all ductwork, casings and plenums, including hangers and supports, shall be in accordance with SMACNA "HVAC Duct Construction Standards - Metal and Flexible".

2. Ductwork sizes shall conform to the dimensions shown on the Contract Drawings.

3. All ductwork sizes shown on the Contract Drawings are clear inside dimensions. Where internal acoustical lining is required, sheet metal duct sizes shall be correspondingly increased to accommodate the liner thickness so that net cross-sectional flow areas will not be reduced.

4. Furnish all ductwork, elbows, vanes, transition pieces, branch takeoffs, and manual volume dampers as shown on the Contract Drawings.

5. Unless otherwise indicated on the Contract Drawings, limit angular tapers to 30 degrees for diverging concentric transition and 60 degrees for converging concentric transition. Unless otherwise shown on the Contract Drawings, limit eccentricity angles for eccentric transitions and offsets to those recommended by SMACNA "HVAC Duct Construction - Metal and Flexible".

6. Radius elbows shall have a center line radius equal to 1-1/2 times duct width. Provide turning vanes in elbows whose centerline radius is less than 150 percent of duct width or where indicated on the Contract Drawings. Fabricate turning vanes of single thickness of similar material as duct. Square elbows shall have double thickness turning vanes.

7. Do not use friction clamps for hangers and supports. Provide all supplementary steel required for installation of ductwork hangers and supports. All structural welding for hangers and supports shall be in accordance with AWS D 1.1.

8. Flexible duct shall be of length not exceeding limitations in NFPA 90A and local codes, and shall have no intermediate seams. Provide moisture barrier where the flexible duct is located in unconditioned space other than within return air plenums.

9. Install acoustical duct liner for the distance shown on the Contract Drawings. Noise reduction coefficient for one-inch thick lining shall be not less than 0.70 based on ASTM C 423 test method. Installing two layers of liner to meet a minimum liner thickness will not be acceptable. Liner shall be fastened with adhesive and welded pin type mechanical fasteners.

10. Provide sleeves and flanges at ductwork penetrations of inside walls, except where fire dampers are installed. Extend ductwork insulation and vapor barrier through the ductwork sleeve. Sleeves shall be two inches larger than the ductwork plus its insulation. Provide counterflashing for all penetrations through exterior walls or roof.

11. Provide airtight penetrations where shown on the Contract Drawings.

12. Provide double wall casing, with two-inch thick insulated core, where shown on the Contract Drawings.

13. Air inlets and outlets shall be connected to the ductwork with collars so that neither the air inlet/outlet nor its damper will extend into the duct.

14. Instrument Test Ports

    Cast iron or cast aluminum to suit duct material, including screw cap and gasket and a flat mounting gasket. Size to allow insertion of pitot tube and other testing instruments, and provided in length to suit duct insulation thickness.

B. Kitchen Exhaust Ductwork

Provide kitchen exhaust ductwork in accordance with SMACNA "HVAC Duct Construction Standards - Metal and Flexible", and NFPA 96. All welding of kitchen exhaust ductwork shall be in accordance with AWS D 9.1.

C. Boiler Breeching

1. Unless otherwise shown on the Contract Drawings, gauges, reinforcements, and fabrication of boiler breeching shall be in accordance with SMACNA "HVAC Duct Construction Standards - Metal and Flexible".

2. All breeching shall have continuous weld joints and seams. All welding shall be in accordance with AWS D 9.1.

3. Maintain the required minimum distance from combustible materials as required by applicable codes.

4. Blind flanged cleanout shall be installed as shown on the Contract Drawings. Doors shall be double panel, insulated with two-inch calcium silicate and shall be gasketed.

5. Provide test holes and access doors in breeching as required for testing and cleaning. Test holes shall be sealed with plugs.

2.03 ACCESSORIES

A. Flexible Connectors

1. Provide flexible connectors at inlet and discharge of all fans and locations shown on the Contract Drawings.

2. Flexible connectors shall be in accordance with NFPA 90A or 96, as applicable.

B. Backdraft Dampers

1. Backdraft dampers shall be parallel blades, counterbalanced, heavy-duty type capable of withstanding maximum spot velocities of up to 3500 fpm.

2. Counterbalance setting shall be adjustable so that the damper can be operated in the range of 0.25 to 0.75-inch water gauge differential pressure, unless otherwise shown on the Contract Drawings.

C. Manual Volume Control Dampers

1. Unless otherwise indicated on the Contract Drawings, volume dampers shall be provided with the general configuration, materials and application limits indicated in SMACNA "HVAC Duct Construction Standards - Metal and Flexible".

2. Provide volume dampers in each branch takeoff where shown on the Contract Drawings, and additionally where required for balancing the air flow in the systems.

3. Dampers installed in ducts up to 12 inches high shall be single blade type.

4. Dampers installed in ducts over 12 inches high shall be opposed multiple-blade type.

5. Dampers shall be stable under operating conditions. Stiffen damper blades by forming or by other method if required for the duty.

6. Provide single blade dampers with a locking device to hold dampers in a fixed position without vibration, pulsation, rattling or similar reaction to system pressure variations.

7. Close damper component penetration of duct as is consistent with the sealing classification applicable for the pressure class of the duct. End bearings or other seals shall be provided on 3-inch w.g. static pressure class.

8. The installation of damper in lined duct shall not damage liner or cause liner erosion.

9. Provide damper quadrants. They shall be fitted with sheet metal stools where installed in insulated ductworks, so that device is flush with outer insulation surface.

D. Fire Dampers

1. Provide fire dampers in accordance with UL 555.

2. Fire dampers shall bear a UL label and shall be approved by New York City Board of Standards and Appeals for projects located in New York City.

3. Fire resistance ratings of fire dampers shall comply with NFPA 90A and the New York City Building Code Reference Standard RS 13 for projects located in New York City.

4. Fire dampers shall be curtain-type with damper curtain located outside of air stream unless otherwise indicated on the Contract Drawings.

5. Fire dampers placed in vertical position shall be gravity-operated. Fire dampers placed in horizontal position shall be provided with all necessary springs and latches.

6. Provide fire dampers with fusible links rated at 165 degrees F, unless otherwise shown on the Contract Drawings.

7. Expansion clearance requirements between the sleeve and protected openings shall be as shown on approved manufacturer's drawings.

8. Provide access doors in the ductwork to permit inspecting, testing and resetting the damper.

9. Install fire dampers in duct extension sleeves with perimeter (mounting) angles and breakaway joints in accordance with NFPA 90A, SMACNA "Fire Damper and Heat Stop Guide" and the requirements below.

10. Extension sleeves shall not extend more than six inches beyond the fire wall or partition, or floor on each side where it connects to ductwork.

11. Secure sleeves by perimeter angles on four sides of the sleeve on both sides of opening.

12. Breakaway joints shall be Engineer-approved S-slip type.

E. Ceiling (Fire) Dampers

1. Construct and test ceiling dampers in accordance with UL 555.

2. Ceiling dampers shall bear a UL label and shall be approved by New York City Board of Standards and Appeals for projects located within New York City.

3. Fire resistance ratings of ceiling dampers shall comply with NFPA 90A and UL 555, and with New York City Building Code, RS13 for projects located within New York City.

4. Provide ceiling dampers with fusible links rated at 165 degrees F, unless otherwise shown on the Contract Drawings.

5. Ceiling dampers shall be suitable for installation inside ductwork and surface mounting of diffusers or grilles. Hanger straps for mounting ceiling dampers, if utilized, shall be of minimum gauge and size, consistent with UL.

6. Provide volume adjustment features in the fusible link to permit adjustment of damper blades to balance airflow through the damper.

F. Smoke/Fire and Smoke Dampers and Actuators

1. Dampers and actuators designated on the Contract Drawings as "S/F" shall comply with the following:

   a. Dampers shall be electrically operated combination fire and smoke dampers. They shall conform to UL Standards 555 as fire dampers and 555S as leakage rated smoke dampers for use in a smoke purge system; and when closed shall have the same fire resistance rating as the fire rated partition in which they are installed, or as required by code. Unless indicated otherwise on the Contract Drawings, leakage shall conform to Class II with maximum leakage of 10 CFM/Square Feet at 1-inch w.g. differential pressure.

   b. Dampers shall be controlled from smoke detector(s) installed remotely in ducts as indicated on the Contract Drawings and shall be provided with heat sensors that shall close and lock the respective dampers in the event of a fire.

   c. Each damper shall be provided with position indicator switches to enable remote status monitoring of its open/closed position.

   d. S/F damper actuators and heat sensors shall remain operational regardless of the operational status of the associated HVAC system.

2. Dampers and actuators designated on the Contract Drawings as "S/D" are smoke dampers. They shall comply in all respects to S/F damper description above, including position indicating switches, except they shall not be provided with a heat sensor or fusible link assemblies.

3. S/F and smoke dampers shall comply with NFPA 90A, in addition to Local Code requirements.

4. Each S/F and smoke damper shall bear UL label.

5. S/F and smoke dampers shall be suitable for the mounting position indicated on the Contract Drawings.

G. Ductwork Access Doors

1. Install hinged access doors in ductwork where shown on the Contract Drawings.

2. Where hinged access doors cannot be provided with a clear 180-degree swing, removable access doors shall be used.

3. Provide gasketed, insulated double-panel access doors in insulated ducts. For kitchen exhaust ductwork, the insulation shall be two-inch thick calcium silicate. Access doors in uninsulated ducts may be of single panel construction.

4. Install access doors in ductwork with separate frames.

H. Accessories Hardware

1. Splitter Damper Accessories

Zinc-plated damper blade bracket, 1/4-inch, zinc-plated operating rod, and a duct-mounted, ball-joint bracket with flat rubber gasket and square-head set screw.

2. Flexible Duct Clamp

Stainless steel band with cadmium-plated hex screw to tighten band with a worm-gear action.

3. Adhesives

High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

2.04 SHOP PAINTING

A. Prepare exterior surfaces of black steel ductwork, except edges prepared for field welding, in accordance with SSPC-SP 6. Apply one shop coat of primer.

B. Do not paint finished surfaces, polished areas, galvanized steel, stainless steel, and aluminum materials.

2.05 SHOP TESTS

For gravity dampers, furnish a certificate of compliance with AMCA Standard 500.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install ductwork and accessories in accordance with SMACNA "HVAC Duct Construction Standards - Metal and Flexible" and ductwork accessory manufacturers' installation recommendations.

B. Contract Drawings show general intent for routing the ductwork. all indicated locations are approximate, and in that respect, the duct routing as shown on the Contract Drawings shall be deemed schematic. It shall be Contractor's responsibility to coordinate with Work of other Sections to ensure that no conflict exists in installation of ductwork and no ceilings, equipment or other materials are supported from ductwork or the ductwork hanger and support system.

C. Coordinate as necessary, to ensure that access doors or indicator buttons have been provided in hung ceilings for proper operation and maintenance of the installation.

D. Provide adequate space around ducts to assure proper support and to allow the installation of insulation if specified.

E. Route ductwork to minimize unnecessary directional changes and abrupt transitions. Use fabricated fittings for all changes in directions, changes in size and shape, and connections.

F. Where duct size does not conform to nearest standard accessory size (e.g. volume control damper), transform duct to match the next larger accessory size.

G. Maintain the interior of ductwork free of dirt and debris. Close off temporarily all openings in the ducts during construction of the building. Clean thoroughly all ducts before installing any filters or operating fans. Never operate fans unless filters are installed. After tests, but before acceptance, wash all cleanable filters and replace all renewable media.

H. Provide for thermal expansion of kitchen hood exhaust ductwork through 2,000^{o}F temperature range. Install this ductwork without dips or traps that may collect residues. Provide an access opening at each change in direction, and at 50-foot intervals, and locate on side of duct 1-1/2 inches minimum from bottom of duct.

I. Support horizontal ducts per SMACNA and within 2 feet of each elbow, and within 4 feet of each branch intersection.

J. Support vertical ducts per SMACNA and at maximum intervals of 16 feet, and at each floor.

K. Connect equipment to ductwork with flexible connectors.

3.02 FIELD TESTS

A. Perform a leakage test of the ductwork in accordance with SMACNA "HVAC Air Duct Leakage Test Manual".

B. The Contract Drawings indicate the pressure classes of ductwork; they also indicate which pressure classes are to be leak tested. Contractor shall, at the beginning of the work, construct, erect and leak test a sample, to be selected at random by the Engineer, of the duct construction to be used at each pressure class scheduled for testing.

C. The leakage amount shall not exceed the following allowable amount for the pressure class.

Duct Construction Class	Leakage Class
10" w.g.	3
6" w.g.	6
4" w.g.	6
3" w.g.	12

Note: See Section 4 of the SMACNA leakage test manual for normal classification.

D. Leakage test procedures shall follow the outlines and classifications in the SMACNA HVAC Duct Leakage Test manual.

E. If specimen fails to meet allotted leakage level, the Contractor shall modify it to bring it into compliance, and shall retest it. Modifying and re-testing shall be repeated until acceptable leakage is demonstrated.

F. Tests and necessary repair shall be completed prior to concealment of ducts.

END OF SECTION

SECTION 15890

METAL DUCTWORK AND ACCESSORIES

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Ductwork Shop Drawings

   Shop and coordination drawings shall be double-line and shall be at a minimum of 3/8"=1'-0" scale.

   a. Ductwork layout and installation drawings including, at a minimum, the following:

      (1) Plans, elevations and sections.

      (2) Hangers, support locations and details. Indicate methods of attachment to building structure.

      (3) Duct elevations and dimensions from main duct runs to a reference point.

      (4) Penetrations through fire-rated and other partitions.

      (5) Locations for duct accessories, including dampers, turning vanes and access doors.

   b. Ductwork coordination drawings showing plan views, sections and ductwork elevations, drawn to scale, on which all items are shown and coordinated with Work of other Sections.

B. Product Data / Catalog Cuts

1. Ductwork construction standards including, at a minimum, the following:

   a. Longitudinal and transverse joining methods and details.

   b. Standard details indicating all aspects of assembly, fittings and accessories.

   c. Reinforcement and spacing.

2. Ductwork and Accessories

   a. Product performance data including, at a minimum, materials, components, dimensions of individual components, finishes, weights, loadings, required clearances, methods of field assembly, profiles and location and size of each field connection for all items furnished under this Contract, including the following at a minimum:

      (1) Acoustical duct liners.

      (2) Flexible duct.

(3) Ductwork access doors, including locations and sizes.

(4) Duct turning vanes.

(5) Accessories hardware.

b. Catalog cuts for all types of furnished accessories.

c. Shop test results.

3. Dampers

a. Product performance data including but not limited to materials, components, dimensions of individual components, finishes, weights, loadings, required clearances, methods of field assembly, profiles, and location and size of each field connection for the following items:

(1) Dampers (manual volume, gravity backdraft, fire, ceiling fire, smoke, combination smoke/fire).

C. Manufacturer Test Reports

1. Certified test data on airflow performance including pressure losses, self-noise power levels and dynamic insertion losses, as applicable for the various components and accessories.

D. Construction and Installation Procedures

1. Field test procedures.

E. Site Inspection Reports

1. Field test results.

END OF APPENDIX "A"

SECTION 15890

METAL DUCTWORK AND ACCESSORIES

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.01)	Stainless steel ductwork - Aluminum ductwork.
(2.02 A.1)	Ductwork fabrication not in accordance with SMACNA.
(2.02 A.4)	Elbows, vanes, transition pieces, branch takeoffs, and manual volume dampers.
(2.02 A.5)	Special angular tapers of transition pieces (other than specified and/or recommended by SMACNA).
(2.02 A.6)	Turning vanes in elbows.
(2.02 A.9)	Acoustic duct liner (distance).
(2.02 A.11)	Airtight penetrations.
(2.02 A.12)	Double wall casing.
(2.02 C.1)	Special gauges of boiler breeching other than SMACNA Standards.
(2.02 C.4)	Blind flanged cleanouts for boiler breeching.
(2.03 A.1)	Flexible connectors.
(2.03 B.2)	Backdraft damper setting range other than 0.25 to 0.75 inch water gauge differential pressure.
(2.03 C.1)	Volume dampers not in accordance with SMACNA.
(2.03 C.2)	Volume dampers in branch takeoffs.
(2.03 D.4)	Fire damper other than curtain type.
(2.03 D.6)	Fire damper fusible link rating other than 165 deg F.
(2.03 E.4)	Ceiling (Fire) damper fusible link rating other than 165 deg F.
(2.03 F.1)	Smoke/Fire dampers (S/F).
(2.03 F.1.A)	S/F damper leakage other than Class II.
(2.03 F.1.B)	Locations of smoke detectors.
(2.03 F.2)	Locations of smoke dampers (S/D).
(2.03 F.5)	Mounting positions of S/F and smoke dampers.
(2.03 G.1)	Ductwork access doors.
(3.02 B)	Pressure Classes of ductwork - which Pressure Classes are to be tested.

B. Other Items

Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15931

AIR OUTLETS AND INLETS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for air outlets and inlets.

1.02 PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, as though the Authority were a private corporation, and the latest industry standards including, but not limited to those of the entities listed below.

Air Conditioning and Refrigeration Institute (ARI)

Air Diffusion Council (ADC)

American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)
National Fire Protection Association (NFPA)

Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. Unless otherwise shown on the Contract Drawings, sound levels and noise criteria for all air outlets and inlets shall not exceed the following levels measured at a location 42 inches below the center of the unit:

Noise Criterion Curve – N C	Sound Meter Readings dBA
35	40

C. All air outlets and inlets shall distribute the design flow rate of air shown on the Contract Drawings evenly over the space intended, without causing noticeable drafts or dead spots anywhere in the ventilated area.

1.03 QUALITY ASSURANCE

Air outlets and inlets, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver air outlets and inlets wrapped in factory-fabricated, fiberboard-type containers. Identify, on outside of container, type of air outlets or inlets and location to be installed. Avoid crushing or bending and prevent dirt and dust from entering and settling in devices.

B. Store air outlets and inlets, in original cartons, in clean, dry spaces and protect them from weather.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide air outlets and inlets of one of the following manufacturers, or approved equal:

Anemostat Products Div./Dynamics Corp. of America
Carnes Company, Inc.
Krueger Division of Philips Industries
Titus Products

2.02 MATERIALS

Materials for air inlets and outlets shall be aluminum or steel as shown on the Contract Drawings.

2.03 CONSTRUCTION FEATURES

A. General

Provide air outlets and inlets of type, capacity and size where shown on the Contract Drawings and as specified below.

B. Supply Diffusers

Unless otherwise shown on the Contract Drawings, provide all air diffusers with the following:

1. Multi-blade volume damper, adjustable from face of diffuser.
2. Air-equalizing deflectors, fully adjustable for horizontal to vertical air flow.
3. Removable core.

C. Linear Diffusers

1. Provide linear diffusers with fully adjustable air pattern controlling vanes, capable of deflecting the air pattern in a 180-degree radius. The air pattern shall be manually adjustable from the face of the diffuser.

2. The unit shall be capable of dampening the air flow rate without changing the air pattern or of changing the pattern without changing the air flow rate. Provide single leaf type damper with each slot opening throughout the entire diffuser length.

3. Screw holes or welded corners shall not be visible on diffusers or frames.

4. Where the diffusers require sectional installation, provide key strips in each extrusion to ensure positive alignment of all adjacent sections.

5. Provide inactive sections and mitered corners with black blankoff baffles.

D. Registers

1. Unless otherwise shown on the Contract Drawings, furnish all registers with the following:

   a. Opposed blade volume damper with key operator, adjustable through the face of the register. Damper blades shall be linked to operate in unison and shall be capable of positive positioning from fully open to fully-closed with the register installed in space.

   b. Removable core.

2. Unless otherwise shown on the Contract Drawings, provide supply registers with the following:

   a. Double deflection grilles having horizontal face bars.

   b. Multi-blade control grid at the duct branch or duct collar.

3. Provide return and exhaust registers with 40-degree horizontal fixed bars. Net effective free area of the register shall not be less than 75 percent of overall area.

E. Return Grilles

Provide return grilles with 40-degree horizontal fixed bars.

F. Transfer Grilles

Provide transfer grilles of the aluminum grid core type complete with mounting frame.

G. Dual Plenum Ceiling Diffusers for Linear Metal Type Ceiling

1. Interconnect plenums with a crossover duct sized to provide equal air distribution in both plenums.

2. Provide an oval inlet of 6-inch round equivalent size in the side of one plenum.

3. Space plenums to match the increment of the ceiling panels.

4. Provide plenum with an adjustable pattern diffuser outlet having 5/8-inch wide by approximately 46-inch long slot type opening with 1-inch wide face tie bars attached longitudinally to each side of slot opening and extending full length of the diffuser.

5. Provide diffusers to hang independently and securely so as not to transmit any vibration to the ceiling.

6. Provide adjustable pattern deflectors to have incremental air discharge pattern, from horizontal left or right to vertical.

H. Air Diffusers for Combination Light Fixtures

Air diffusers for combination light fixtures furnished and installed under Division 16 Section entitled "LIGHTING FIXTURES", shall meet the following requirements:

1. Supply air diffusers shall consist of single or dual supply plenums with crossover bridge and 3-inch high, oval, side or top air connection sized for connection to a 6-inch round flexible duct. Diffusers shall have adjustable pattern deflectors in each outlet slot and a volume damper in the inlet collar. Both adjustments shall be accessible through the diffuser outlet slot without disturbing the fixture lens or ceiling construction. Pattern deflectors shall lock positively in all set positions and shall permit a vertical discharge or a horizontal discharge pattern, the direction of which can be changed 180 degrees. Inlet static pressure and volume shall remain constant under all positions of pattern adjustment.

2. The side trim rails of the fixtures shall be continuously slotted for either supply or return air. The end trim rails shall be similarly slotted for return air through the fixture lamp cavity. Slot in the air diffuser plenum shall be compatible in size and location with the discharge slot in the side trim rails. A positioning socket or recess shall also be provided in the rail which shall receive the neck of the plenum and hold it securely in position over the slot without the use of screw-type fasteners.

3. When installed on the fixture, the highest point of the air diffuser assembly shall be not more than 7-1/2 inches above the finished ceiling and the clearance between the top of the fixture housing and the bottom of the crossover bridge shall not be less than 1/4-inch. Holding brackets designed to accept the mounting buttons on the diffuser plenum, shall be furnished on the fixture housing and shall hold the entire air diffuser assembly firmly in position on the fixture. A minimum of two such brackets shall be provided on each plenum.

4. The connection between the crossover bridge and the two diffuser plenums shall be airtight and the assembly of the air diffuser unit and the mounting of the unit on the light fixture shall be accomplished without the use of screw-type fastenings, tape or other mechanical fasteners which are not an integral part of either the lighting fixture or the air diffuser. The entire assembly shall be compatible with the proposed ceiling construction and shall provide adequate clearance for duct connections to the diffuser air inlet.

5. Dual plenum supply air diffusers shall be capable of delivering up to 180 cfm of air in a horizontal pattern with an inlet static pressure not exceeding 0.21-inch water gauge. Single plenum supply diffusers shall be capable of delivering up to 90 cfm of air in a horizontal pattern with an inlet static pressure not exceeding 0.15-inch water gauge.

6. Coordinate the design and installation details of supply air diffuser units with the lighting fixture manufacturer furnishing said fixtures under this Contract and furnish to the manufacturer all drawings, details and information required for this purpose.

7. Complete air handling lighting fixture units shall meet UL requirements for use as a cooled or heated air outlet and a return air inlet.

2.04 SHOP PAINTING

Unless otherwise shown on the Contract Drawings, finishes for all air outlets and inlets, except for linear diffusers, shall be baked white enamel. Linear diffusers shall have white anodized finishes unless otherwise shown on the Contract Drawings. Finishes shall match the approved color samples submitted.

2.05 SHOP TESTS

Test and rate all air outlets and inlets in accordance with ADC 1062. Air outlets and inlets shall bear ADC seals.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install air outlets and inlets in accordance with manufacturer's installation procedures.

B. Coordinate all Work to ensure that the installation of air outlets and inlets is not in conflict with the work specified under other Sections.

3.02 FIELD TESTS

Arrange for a qualified technical representative of the manufacturer to advise on the field tests specified in Division 15 Section entitled "TESTING, ADJUSTING, AND BALANCING OF AIR AND HYDRONIC SYSTEMS".

END OF SECTION

SECTION 15931

AIR OUTLETS AND INLETS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Product Data / Catalog Cuts

1. Air Outlets and Inlets

   a. Each type, model number, size, service, blade setting angle, CFM, pressure drop and accessories furnished.

   b. Catalog cuts, including product performance data.

   c. Floor/room designation of each air outlet and inlet.

   d. Sound power levels at design flow rates.

   e. Throw and drop at design flow rates.

   f. Material of unit, finish and mounting details.

   g. Installation procedures.

   h. Shop test results.

B. Samples

1. Three samples of finishes of air outlets and inlets for approval

END OF APPENDIX "A"

SECTION 15931

AIR OUTLETS AND INLETS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(1.02 B)	Sound levels other than specified.
(1.02 C)	Design cfm.
(2.02)	Aluminum or steel.
(2.03 A)	Type, capacity and size of air outlets and inlets (if necessary, Manufacturer's Model Number).
(2.03 B)	Accessories for supply diffusers (other than specified).
(2.03 D.1)	Accessories for registers (other than specified).
(2.03 D.2)	Accessories for supply registers (other than specified).
(2.04)	Shop painting (other than specified).

B. Other Items

1. Ensure that the Specifications include the following Sections referenced in this Section:

(2.03 H)	"LIGHTING FIXTURES"
(3.02)	"TESTING, ADJUSTING, AND BALANCING OF AIR AND HYDRONIC SYSTEMS"

2. Modify Appendix "A" - Submittals per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15939

MOTORS AND MOTOR CONTROLLERS

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies requirements for electric motors of up to 200 horsepower.

B. This Section specifies requirements for furnishing motor controllers and associated accessories needed.

C. The following related work is specified in the Division 16 Section entitled "MOTOR POWER AND CONTROL WIRING", and is not part of that required under this Section:

1. Installation of motor controllers and associated accessories (1.01 B above).
2. Field wiring between electrical components.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes and the latest industry standards including, but not limited to the entities listed below.

New York City Building Code

New York State Energy Conservation Construction Code

New Jersey Uniform Construction Code

American National Standards Institute (ANSI)

Institute of Electrical and Electronic Engineers (IEEE)

National Electrical Manufacturers Association (NEMA)

National Fire Protection Association (NFPA)

Underwriters Laboratories, Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. All motors shall be "Premium Efficiency" type, as described in NEMA MG-12.54-2. Test shall be performed in accordance with IEEE 112, Method B. Additionally, provide standard efficiency design motors for equipment that run infrequently, if specifically indicated on the Contract Drawings.

1.03 QUALITY ASSURANCE

A. Motors, motor controllers and associated accessories, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Entities performing Work shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Delivery motors (if not delivered with motor-driven equipment) with factory-installed wooden skids and lifting lugs; pack motor controllers and accessories in factory-fabricated protective containers.

B. Handle motors, motor controllers, and accessories carefully to avoid damage to components, enclosures and finish.

C. Store motors, motor controllers, and accessories in clean, dry spaces and protect them from weather.

D. Comply with manufacturer's rigging instructions for unloading motors, and moving motors to final location for installation.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide motors and motor controllers of one of the following manufacturers, or approved equal, unless otherwise specified in other Sections:

A. Motors

1. General Electric Co.
2. Westinghouse Electric Corp.
3. Siemens-Allis Inc.
4. Reliance Electric Co.

B. Motor Controllers

1. Westinghouse Electric Corp.
2. Square D Co.
3. Allen-Bradley Co.
4. Cutler-Hammer Inc.
5. General Electric Co.

6. ABB Industrial Systems, Inc.

2.02 CONSTRUCTION FEATURES

A. Motors

1. Motor characteristics shall be as specified below unless otherwise specified in other Sections or shown on the Contract Drawings.

2. All motors, with the exception of severe duty motors as defined below, shall be designed to operate continuously at 40 degrees C ambient temperature with a service factor of 1.15, unless otherwise specified in other Sections. Severe duty motors shall have a service factor of 1.0 at 65 degrees C ambient. In rating the motors, no portion of a motor's service factor above 1.0 shall be used for the continuous operation of the motor.

3. Polyphase motors shall be NEMA MG 1 Design B torque, unless the load justifies another NEMA Design starting characteristic. Motors shall have a motor input with "Locked Rotor KVA Code Letter" specified in Tables I, II or III, as applicable. Fractional horsepower motors below 3/4 horsepower shall meet NEMA requirements for minimum torque and maximum current.

4. Motors 1/2 horsepower and larger shall be 460-volt, three-phase, 60 Hertz, squirrel cage induction type. Motors below 1/2 horsepower shall be 120-volt, single-phase, 60 Hertz, capacitor-start, induction-run or split-phase type.

5. Use open drip-proof type motors for general indoor applications. The motors shall have minimum Class "B" insulation.

6. Use totally enclosed, fan-cooled type motors for special indoor applications such as inside return air plenums, for inline direct-driven fans and when floor-mounted near hose down areas or for other applications as shown on the Contract Drawings. The motors shall have minimum Class "B" insulation.

7. Use totally enclosed, fan-cooled type motors for all outdoor applications. Motor shall be severe duty, with minimum Class "F" insulation.

8. Bearings for integral horsepower motors shall be antifriction, open type with grease fittings and shall have a minimum rated life of 125,000 hours for direct coupled motors and 25,000 hours (50,000 hours for severe duty motors) for belt or chain driven loads. Bearings for fractional horsepower motors shall be permanently sealed ball type, suitable for continuous duty.

9. Horsepower and frame relationship shall conform to NEMA MG 1 for T-frame motors.

10. The no-load sound pressure level, for high efficiency motors, based on the A-weighted scale at 3 feet when measured in accordance with IEEE 85, shall not exceed 85 dBA.

11. Provide solderless lugs of proper sizes at the ends of motor leads.

12. Where shown on the Contract Drawings, provide motors with space heaters, rated 115-volt, single-phase, sized to maintain motor internal temperature above the dew point when motor is at rest. Space heater leads shall be terminated in a box separate from the main leads.

13. All motors shall be labeled by the manufacturer with NEMA minimum efficiency marking standard in accordance with NEMA standard MG-1-12.53b.

14. Where a solid state motor starter is called for, provide verification that the submitted motor is suitable for operation with a solid state motor starter. All motor manufacturer's special enhancement requirements to solid state motor starters shall be incorporated into the solid state starter by the starter's manufacturer.

15. All motors shall have minimum power factors, at 100% full load, as follows:

    a. Single-Phase Induction Motors; Squirrel-Cage Rotor

       1/20 to 1 hp, power factor .68

       Above 1 to 10 hp, power factor .82

    b. Polyphase Induction Motors; Squirrel-Cage Rotor

       1 to 10 hp, power factor .85

       Above 10 to 50 hp, power factor .89

    c. Polyphase Induction Motors; Phase-Wound Rotors

       5 to 20 hp, power factor .86

       Above 20 to 100 hp, power factor .87

B. Motor Controllers

1. Motor controllers and controls shall be as specified below unless otherwise specified in other Sections or shown on the Contract Drawings.

2. All motor controllers shall be combination controllers suitable for wall mounting.

3. All controllers shall comply with the following:

    a. Controllers for motors 1/2 horsepower and larger shall be combination, magnetic, full voltage across-the-line starting, with circuit breaker, designed for operation on 460-volt or 208-volt, 3-phase, 60 Hertz service. Single speed controllers shall be provided with three overload relays, one in each phase.

       (1) When thermal overload devices are provided they shall be ambient temperature compensated. The coil interrupting overload contacts shall be on the phase side of the coil.

       (2) Provide two additional spare auxiliary contacts in each controller.

       (3) Two-speed starters shall have six overload relays, one in each phase for the two speeds.

    b. Controllers for motors less than 1/2 horsepower shall be of the toggle, switch, manual type with integral overload protection and pilot light in the cover, and shall be designed for 120-volt, single-phase, 60 Hertz service. Where interlocks or automatic controls are required, provide magnetic across-the-line combination starters.

c. All magnetic controllers subject to manual start shall have momentary contact start-stop pushbuttons, pilot light and reset button built into cover. All magnetic controllers requiring electrical interlocks or automatic control shall have "Hand-Off-Automatic" switch, pilot light, stop and reset buttons built into the cover, unless subject to cycling control, in which case the pilot light shall be omitted.

(1) Hand position on "Hand-Off-Automatic" switches shall permit local starting of the motor by shunting all automatic controls. "Hand" position shall not bypass safety controls.

(2) Combination controllers shall be capable of being locked in the open position. All controllers shall have manual reset on the overload relay.

d. Where required to prevent simultaneous starting of motors, provide interlocked controllers with time delay devices.

e. All individually mounted motor controllers, installed indoors, shall be furnished in a NEMA Type 1 general purpose enclosure. All individually mounted motor controllers, installed indoors in an industrial environment, shall be furnished in a NEMA ICS 6, Type 12 enclosure.

f. Controllers mounted outdoors shall be furnished in NEMA ICS6 Type 4X watertight enclosures.

g. The minimum controller size, for three-phase motors, shall be NEMA ICS 2, Size 1.

h. In addition to NFPA 70 (NEC) requirements for safety disconnect switches, where controllers are not directly adjacent to the motors they control, or where a safety disconnect switch is not specified to be furnished with motor-driven equipment, a heavy-duty, unfused disconnect switch, arranged for being padlocked in the open position, and also capable of interrupting the motor locked rotor current, shall be furnished for installation within sight of the motor.

i. All controllers for 460-volt or 208-volt service shall have 460/120 volt or 208/120 volt, respectively fused transformers built-in in each controller housing to serve all control circuits within the controller. Each controller subject to electrical interlock and/or automatic control shall have the necessary auxiliary contacts to perform the required operations. One set of terminals shall be provided for each control circuit.

j. Where interposing relays are required, they shall be furnished in separate enclosures adjacent to the controllers.

k. Where controllers are interlocked, a separate disconnect switch shall be mounted adjacent to the lead controller in order to disconnect all control voltages to the controllers.

l. All parts subject to wear or arcing, shall be renewable.

m. All electrical control devices shall be heavy-duty oil tight construction.

n. All motor controllers, disconnect devices and other control devices shall be labeled as to use and function, utilizing engraved plastic nameplates with white letters on black background. Inscriptions shall be as shown on the Contract Drawings.

C. Electro-Mechanical Devices

Electro-mechanical devices required for interlocking or sequencing or safety control of motors such as pneumatic solenoids, float switches, high and low limit switches, and aquastats, are furnished and installed under other Sections of the Specifications.

D. Factory Wired Equipment

1. Equipment with Factory Wired Motors (FWM) shall have all starting and control equipment furnished and installed with motors, and completely wired unless otherwise specified in other Sections or shown on the Contract Drawings.

2. Factory Wired Control Panels (FWCP) shown on the Contract Drawings shall include combination controllers with disconnect switches.

3. Provide all motor control panels, including the hinged door, fabricated of minimum 12-gauge sheet steel, properly finished to prevent corrosion. As a minimum, the cabinets shall be thoroughly cleaned, primed with zinc phosphate and finished with two coats of baked enamel or an equivalent finish coat, or as otherwise specified on the Contract Drawings. Control devices shall be mounted on the door, completely wired and neatly cabled back to terminal strips. A four-inch minimum wiring gutter on all four sides of the panel shall be provided.

4. Where two or more controllers in a single enclosure are grouped for duplex or triplex operation, each controller shall have a control transformer with secondary pullout fuses. Each controller fused disconnect switch shall be capable of de-energizing its associated control transformer and controller circuit.

5. Devices shall have individual nameplates plus a nameplate for a group indicating the motor or motors controlled. Panels shall be degreased and painted with zinc chromate primer and factory-finished grey enamel finish coat.

2.03 SHOP TESTS

Minimum efficiency values of furnished motors shall be confirmed by testing in accordance with IEEE-112, Method B, to be in conformance with NEMA MG-1 tables of efficiencies applicable to premiums efficiency motors, or to standard efficiency motors as is applicable.

PART 3. EXECUTION

3.01 INSTALLATION

A. Provide non-adjustable base for motors directly connected to driven equipment and adjustable sliding base for motors connected to driven equipment via belt or chain.

B. Provide slotted mounting holes in base for fractional horsepower motors.

C. Install independently mounted motor control devices in accordance with manufacturer's written instructions, and in compliance with applicable requirements of NEC, UL and NEMA standards.

D. Locate motor controllers as indicated, and within sight of respective controlled motors.

E. Remove paint splatters and other spots, dirt and debris. Touch up scratches and mars of finish to match original finish. Clean devices internally using methods and materials as recommended by manufacturer.

END OF SECTION

SECTION 15939

MOTORS AND MOTOR CONTROLLERS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirement of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Product Data / Catalog Cuts

1. Motors and Motor Controllers: Submissions shall be clearly identified with the pertinent motor numbers and the proper control equipment to be wired into the control circuits.

   a. Motor schedules with full nameplate data including, at a minimum, horsepower, voltage, FLA, LRA, speed (rpm), efficiency, phase, frequency and type of insulation.

   b. Motor controller schedules.

   c. Product data for motors, motor controllers and all other products specified in this Section. Include dimensions of selected models, required clearances, ratings, operating data and data on features and components.

   d. Catalog cuts, including product performance data.

   e. Power and control wiring diagrams showing connections to power panels, feeders and equipment. Differentiate between manufacturer-installed and field-installed portions of wiring.

   f. Coordination curves of overcurrent protection equipment and interrupting capacities of equipment.

   g. Listing of proposed inscriptions for labeling all motor controllers, disconnect devices and other control devices.

   h. Installation procedures.

   i. Maintenance data.

   j. Shop test results.

END OF APPENDIX "A"

SECTION 15939

MOTORS AND MOTOR CONTROLLERS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(1.02 B)	Standard efficiency design motors.
(2.02 A.1)	Special motor characteristics other than specified (if not specified in the motor-driven equipment Sections).
(2.02 A.6)	TEFC motors.
(2.02 A.12)	Motors with special space heater requirements.
(2.02 B.1)	Special motor controllers and control requirements other than specified (if not specified in the motor-driven equipment Sections).
(2.02 D.1)	Special FWM requirements other than specified (if not specified in the motor-driven equipment Sections).
(2.02 D.2)	Special FWCP requirements.
(2.02 D.3)	Control panels with special painting requirements.

B. Other Items

Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15940

VIBRATION ISOLATION AND CONTROL

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for vibration isolation and control, applicable to piping, ductwork and equipment.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

Design and performance of components and methods specified herein shall comply with all applicable Federal, State, and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

Air-Conditioning and Refrigeration Institute (ARI)
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
American Society of Plumbing Engineers (ASPE)
American Society of Mechanical Engineers (ASME)
American Society for Testing and Materials (ASTM)

In addition, specific provisions cited herein shall govern for the associated specific application.

1.03 QUALITY ASSURANCE

A. Vibration isolation and control devices, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Entities performing the Work of this Section shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver isolators in manufacturer's original, unopened, protective packaging. Packaging and packed devices shall be both labeled and tagged to properly identify device and its proper location for installation on the construction site.

B. Store devices in original packaging in clean, dry spaces and protect them from weather.

C. Inspect all isolators for damage before moving them from storage to a location for installation on the construction site.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide vibration isolation systems of one of the following manufacturers, or approved equal:

Mason Industries Inc.
Vibration Mountings and Controls/Korfund Dynamics
Vibration Eliminator Co., Inc.
Amber-Booth Co.

All isolation systems, including mountings and hangers, shall be designed and furnished by the same manufacturer, except for equipment furnished with internal isolation.

2.02 MATERIALS

All concrete used in inertia bases shall be Class B (3000 to 4000 psi strength specified in applicable Section of Division 3), steel reinforced for load and temperature stresses.

2.03 CONSTRUCTION FEATURES

A. General

1. Piping and Ductwork Isolation Types

   Unless otherwise shown on the Contract Drawings, selection of isolation types for piping and ductwork shall be as specified in 3.02 C and D.

2. Equipment Isolation Systems

   Unless otherwise shown on the Contract Drawings, select vibration isolation systems for all mechanical equipment having vibration/motion, including but not limited to the following equipment:

   Refrigeration machines
   Reciprocating compressors and engines
   Air-cooled condensers or condensing units
   Boilers and steam generating units
   Pumps
   Cooling towers
   Fans, air handling equipment and unit heaters
   Packaged air-conditioning equipment
   Packaged roof top air-conditioning units (if not provided with internal isolation)
   Packaged emergency generators

a. Systems selected shall be of the proper types and design such that they are compatible with the building structural framing spans and floor construction and provide the isolation and deflection required.

b. Systems selected shall comply with ASHRAE 1984 Systems Volume, Chapter 32, and shall be in accordance with recommendations of equipment manufacturers, in conjunction with the vibration isolator manufacturer.

B. Isolation Mountings

1. Elastomer isolators shall have a stiffness range of 30 to 70 durometers. All metal surfaces shall be covered with the elastomer material to avoid corrosion. Mountings shall be Mason type ND, or approved equal.

2. Spring isolators shall be provided with an elastomer acoustical barrier designed with a horizontal stiffness of at least 75 percent of the vertical stiffness and a 50 percent travel capability beyond rated load. All isolators shall have leveling bolts for rigid bolting to the equipment. Mountings shall be Mason type SLF, or approved equal.

3. Restrained spring isolators shall be the same as the spring isolators specified above, except a housing shall be provided that includes vertical limit stops to prevent spring extension when weight is removed. Mountings shall be Mason type SLR, or approved equal.

C. Isolation Hangers

1. Isolation hangers (regular) shall have elastomer elements, springs or a combination of springs and elastomer elements. Hangers shall be designed for a minimum of 30 degrees angular hanger rod misalignment and a 50 percent travel capability beyond rated load. Means shall be provided to prevent direct contact of hanger rod with housing and short-circuiting the spring vibration dampening effect. Hangers shall be Mason type 30N, or approved equal.

2. Position (precompressed) isolation hangers shall be the same as the regular isolation hangers specified above, except that the hangers shall be precompressed to the rated deflection so as to keep the piping at a fixed elevation during installation. The hangers shall be provided with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Hangers shall be Mason type PC30N, or approved equal.

3. Ductwork isolation hangers shall have springs in elastomer cups and provisions to attach the hanger housings to the flat iron duct straps. Provide a steel washer inside the cup to properly distribute the load on the elastomer and prevent its extrusion. Hangers shall be designed for a minimum of 30 degrees angular hanger rod misalignment and a 50 percent travel capability beyond rated load. Hangers shall be Mason type W30, or approved equal.

D. Flexible Pipe Connectors

1. Flexible synthetic elastomer connectors shall be manufactured of multiple plies of nylon tire cord fabric and synthetic elastomers, both molded and cured in hydraulic "rubber" presses. No steel wire or rings shall be used as pressure reinforcement. Connectors up to and including 2-inch diameter shall be hose type, with threaded ends and 12 inches in length. Connectors 2 1/2 inches and larger shall be arched or spherical type in standard lengths and shall be manufactured with floating steel flanges recessed to lock the connector's raised face elastomer flanges. Connectors shall be rated minimum 150 psi at 220 degrees F. Connectors shall be properly pre-extended and restrained as recommended by the manufacturer to prevent additional elongation under pressure. Connectors shall be Mason type MFNEC, MFTFU or MFTNC (as applicable), or approved equal.

2. Where temperature of the fluid exceeds 220 degrees F, flexible stainless steel hoses shall be used. Flexible hoses shall be stainless steel braid with carbon steel fittings. Sizes 2 1/2 inches and larger shall be flanged. Sizes 2 inches and smaller shall have male nipples. Lengths shall be as follows:

Flanged		Male Nipples	
2 1/2 x 13	8 x 22		
3 x 14	10 x 26	1/2 x 9	1 1/2 x 13
4 x 15	12 x 28	3/4 x 10	2 x 14
	14 x 30	1 x 11	
6 x 20	16 x 32	1 1/4 x 12	

Flexible stainless steel hoses shall be Mason type BSS, or approved equal.

E. Equipment Bases

1. Structural Steel Bases and Rails

a. Provide structural steel members welded to height saving brackets for spring isolator attachments to cradle machines having legs or bases that do not require a complete supplementary base. Members shall be sufficiently rigid to prevent strain in the equipment. Inverted saddles shall be Mason type ICS, or approved equal.

b. Where the equipment requires a complete supplementary base, provide a fabricated structural steel base. Structural steel bases shall be rectangular in shape for all equipment other than centrifugal refrigeration machines and pump bases that may be "T" or "L" shaped. Pump bases for split case pumps shall include supports for suction and discharge base "ells". All perimeter members shall be beams with a minimum depth equal to 1/10th of the longest dimension of the base. Beam depth shall not exceed 14 inches provided that deflection and misalignment are kept within acceptable limits. Height saving brackets shall be employed in all spring isolator mounting locations to provide a base clearance of one inch. Bases shall be Mason type WF, or approved equal.

2. Concrete Inertia Bases

Provide concrete inertia bases formed with rectangular structural channel concrete forms. Bases for split case pumps shall be large enough to provide support for suction and discharge base "ells". The base depth shall not exceed 12 inches unless specifically recommended by the base manufacturer for mass or rigidity. In general, base depths shall be a minimum of 1/12th of longest dimension of the base, but not less than 6 inches. Forms shall include minimum concrete reinforcement consisting of half-inch bars or angles welded in place on 6-inch centers running both ways in a layer 1-1/2 inches above the bottom, or additional steel as required by the structural conditions. Forms shall be furnished with drilled members with sleeves welded below the holes to receive equipment anchor bolts where the anchor bolts fall in concrete locations. Height saving brackets shall be employed in all spring mounting locations to maintain a one-inch clearance below the base. Bases shall be Mason type K, or approved equal.

3. Curb Type Isolation Bases for Rooftop Equipment

For rooftop equipment, not furnished with internal vibration isolators, provide curb type vibration isolation aluminum bases that fit over the roof curb and under the vibration isolated equipment. The extruded aluminum top member shall overlap the bottom member to provide water runoff independent of the seal. The aluminum members shall house cadmium-plated springs having a one-inch minimum deflection with 50 percent additional travel to "solid". Spring diameters shall be no less than 0.8 of the spring height at rated load. Wind resistance shall be provided by means of resilient snubbers in the corners with a minimum clearance of 1/4 inch, so as not to interfere with the isolation action except in high winds. The weather seal shall consist of continuous, closed cell, sponge materials both above and below the base and a waterproof, flexible, duct like, synthetic elastomer connection joining the outside perimeter of the aluminum members. Foam or other contact seals are unacceptable at the spring cavity closure. Caulking shall be kept to a minimum. Curb type isolation bases shall be Mason type CMAB, or approved equal.

2.04 SHOP PAINTING

A. Corrosion resistance coatings shall be factory-applied to all vibration control devices and isolators. No field applications will be permitted. Shop prime coats, compatible with architectural treatment field paintings, shall be applied after the applications of corrosion resistance coatings are completed.

B. Where exposed to outdoors, steel parts shall be hot-dipped galvanized and springs shall be cadmium plated.

PART 3. EXECUTION

3.01 PREPARATION

A. Coordinate all trades in the use of approved detailed shop drawing templates for all equipment foundations and supports. Verify that all bolts, anchors, supports and appurtenances, required for proper installation of the equipment and isolators, are in place and that the necessary concrete and steel are in place.

B. Do not proceed with installation of isolation devices and their supports and anchors until required permanent building structural steel and concrete are in place. Correct inadequacies including proper placement of inserts, anchors and other building structural attachments.

3.02 INSTALLATION

A. General

1. Install all vibration isolation systems in accordance with manufacturer's installation procedures and ASHRAE recommendations.
2. Perform all concrete work required for installation of vibration isolation systems.
3. Erect all floor-mounted equipment and pipe supports on 4-inch high concrete pads extending 4 inches beyond the completed floor area of the equipment. Mount vibration-attenuating devices on 4-inch high concrete pads unless otherwise shown on the Contract Drawings.
4. Install isolation systems so as not to physically interfere with operation of mechanical equipment or access for maintenance.
5. Provide inspection services by vibration isolation systems manufacturer's representative for final installation. Provide written report that installation is in accordance with this Section and manufacturer's recommendations.

B. Equipment Isolation

1. Set accessory and isolator steel bases for required clearance between concrete pads and equipment base.
2. Utilize suitable hold-downs and limit-stop devices to maintain equipment isolators at correct static deflection while connecting piping and ductwork. After pipe, conduit, and duct hangers are installed and adjusted, equipment shall be permitted to float free. Limit-stops shall be out of contact during start-up and operation of equipment.

C. Piping Isolation

1. Suspended Piping

a. Install isolation hangers for all piping in equipment rooms and for 50 feet from a connection to equipment, where the 50-foot length extends beyond the equipment room.

b. A minimum of the three closest hangers to an equipment connection shall provide the same deflection as the equipment isolation devices, with a maximum of 2-inch deflection.

c. The closest two hangers to an equipment connection shall be position (or precompressed) isolation hangers, adjusted to prevent load transfer to the equipment flanges when the pipe system is filled or drained.

d. The remaining isolation hangers shall be regular isolation hangers with a 0.75-inch deflection for piping up to 8 inches in size. Position isolation type hangers shall be used for piping 8 inches in size and larger.

2. Floor Supported Piping

a. Isolate floor-supported piping from the building structure by floor mounting spring isolators.

b. The two supports closest to an equipment connection shall consist of restrained spring isolators with a blocking feature that prevents load transfer to equipment flanges as the piping is filled or drained.

c. Provide a slide plate of Teflon or graphite where large thermal movement will result.

3. Flexible Pipe Connectors

a. Provide all piping connections to rotating and reciprocating equipment with flexible pipe connectors.

b. Install connectors on the equipment side of the shut-off valves.

c. Install connectors in accordance with the weight distribution of the equipment to provide a stable mounting decoupled system.

d. Install each connector so that the equipment support base remains level during deflection.

e. Incorporate end thrust restraint into the design of all connectors or add end thrust restraint to piping systems, externally.

D. Ductwork Isolation

All discharge ductwork for a distance of 50 feet from the connected equipment shall be isolated from the building structure by ductwork isolation hangers. Floor supported ductwork shall be isolated from the building structure by floor-mounting restrained spring isolators.

3.03 FIELD TESTS

A. After installation, the Engineer may perform tests of vibration isolation systems to check deflections.

B. Make adjustments, replacements and alterations as necessary to reduce transmitted amplitude to no more than plus or minus 10 percent of the originating equipment vibration amplitudes, over the full range of operating speeds and loads.

END OF SECTION

SECTION 15940

VIBRATION ISOLATION AND CONTROL

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of DIVISION 1 - GENERAL PROVISIONS:

A. Shop Drawings / Catalog Cuts

1. Vibration Isolation and Control

   a. Assembly-type shop drawings for each type of isolator indicating dimensions of selected models, required clearances and methods of assembly and field installation of all components.

   b. Detailed shop drawings and templates for all equipment foundations and supports indicating all required bolts, anchors, supports and appurtenances required for proper installation of the isolators at the equipment and the required concrete and steel work.

   c. Shop drawings showing isolator locations, load on each isolator, deflection, inertia slab dimensions of selected models, details of supports and required field installation instructions.

   d. Schedules showing manufacturer's figure number, size, location and any specific features for each vibration isolation device.

   e. Catalog cuts, including product performance data, of all furnished vibration isolation devices.

   f. Installation procedures for each type of isolation device.

   g. Maintenance data for each type of isolation device.

B. Site Inspection Reports

1. Certified installation inspection report by isolation systems manufacturer.

END OF APPENDIX "A"

SECTION 15940

VIBRATION ISOLATION AND CONTROL

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.03 A.1)	Piping and ductwork isolation types (and locations) other than the specified.
(2.03 A.2.a)	Equipment to be provided with isolation systems other than listed.
(3.02 A.3)	Isolation devices not to be mounted on 4-inch high concrete pads.

B. Other Items

Modify Appendix "A" - Submittals per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15945

HVAC INSULATION

PART 1. GENERAL

1.01 SUMMARY

This Section specifies insulation requirements for heating, ventilation, and air-conditioning (HVAC) sheet metal ductwork, piping and equipment.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Design and performance of components and methods specified herein shall comply with all applicable Federal, State, and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to, the entities listed below.

New York City Building Code
New York State Energy Conservation Construction Code
New Jersey Uniform Construction Code
American Society of Heating, Refrigerating and Air-Conditioning Engineers
American Society for Testing and Materials (ASTM)
National Fire Protection Association (NFPA)
Underwriters Laboratories Inc. (UL)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. All insulation, including jackets or facings, adhesives, mastics, cements, tapes and glass cloth for fittings shall have composite fire and smoke hazard ratings as tested by ASTM E 84, NFPA 255, and UL 723 procedures, not exceeding a "Flame Spread" of 25 and "Smoke Developed" of 50.

C. Any treatment of jackets or facings to impart flame and smoke safety shall be permanent. The use of water-soluble treatments is prohibited.

1.03 QUALITY ASSURANCE

A. Insulation materials and accessories, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Entities performing the Work of this Section shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver insulation, coverings, cements, adhesives, and coatings to the construction site in manufacturer's sealed containers with manufacturer's stamp or label affixed, showing fire hazard indexes of products.

B. All insulation components shall be stored at the construction site on pallets or raised platforms with suitable shed enclosures to protect against foreign matter and rain.

C. Before moving insulation materials from storage to the construction site, all insulation sections and component materials shall be inspected for damage. Remove damaged materials from the construction site and replace damaged materials, to the satisfaction of the Engineer, at no additional cost to the Authority.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide insulation materials of one of the following manufacturers, or approved equal:

Schuller International, Inc., Mechanical Insulations Div.
Certain - Teed Corp./Insulation Group
Owens - Corning Fiberglas Corp.
Knauf Fiber Glass

As standard, catalog numbers/trade names of Schuller are indicated herein as basis for quality of insulation desired.

2.02 MATERIALS

A. Sheet Metal Ductwork Insulation

1. HVAC Supply, Return and Transfer Air Ductwork - concealed in hung ceilings, shafts and furred spaces.

a. Insulation shall be two-inch thick flexible blanket fiberglass with factory-applied foil-scrim-kraft (FSK) facing.

b. Flexible blanket fiberglass insulation shall conform with ASTM C 553, Type I, Class B-3.

c. The insulation shall be Schuller "MICROLITE" Type 75 ductwrap with FSK facing, or approved equal.

2. HVAC Supply, Return, Transfer Air, Outside Air Supply Ductwork and Plenums-exposed in mechanical equipment rooms, crawl spaces, all unconditioned areas, and outdoors

   a. Insulation shall be 1-1/2-inch thick rigid fiberglass board with factory-applied all purpose (AP) white facing for indoors, and two-inch thick for outdoors.

   b. Rigid fiberglass board insulation shall conform with ASTM C 612, Class 1 except that the density shall not be less than 6 lbs. per cubic foot.

   c. The insulation shall be Schuller "817 SPIN-GLAS" with AP white facing, or approved equal.

   d. Finish and weatherproofing are specified in 3.02 B.2.

3. Kitchen Exhaust Duct, Boiler Breeching, and Kitchen Exhaust Fan Insulation

   a. Insulation shall be two-inch thick calcium silicate block.

   b. Calcium silicate block insulation shall conform with ASTM C 533, Type I, and shall be Schuller "THERMO-12 GOLD" with 200 psi compression strength, or approved equal.

   c. Finish is specified in 3.02 B.3.

4. Insulation for Built-Up Central Station HV and HVAC Units

   a. Casing insulation shall be two-inch thick fiberglass duct liner with an acrylic surface coating.

   b. Insulation shall have a density of 1.5 lbs. per cubic foot with a thermal conductivity k = 0.25 at 75 degrees F mean temperature and suitable for air velocities up to 5000 fpm. Noise reduction coefficient (NCR) of insulation shall be 0.7 or greater with type A mounting, in accordance with ASTM Std. E 795.

   c. Insulation shall be Schuller "PERMACOTE LINACOUSTIC STANDARD", or approved equal.

B. HVAC Piping Insulation

1. Insulation Thickness

PIPE, FITTINGS AND VALVES
Insulation Minimum Thickness (inches)

		PIPE SIZES (NPS)				
Piping System	Fluid Temp Range, Deg. F	Run-Out* Up to 2"	Up to2"	2-1/2" to 4"	5"-6"	8" and Larger
		Heating Systems (**)				
High Temp Hot Water High Press. Steam	306-450	1.5	2.5	3.0	3.5	3.5
Medium Press. Steam	251-305	1.5	2.5	2.5	3.0	3.5
Low Press. Steam Heating Hot Water	201-250	1.0	1.5	2.0	2.0	2.5
Steam	Any	1.0	1.5	2.0	2.0	2.5

Condensate incl. Drip Assembly (For Feed Water)						
		Cooling Systems				
Chilled Water Make-up, City & Cold Water	40-60	0.5	1.0	1.0	1.0	1.0
Refrigerant	Below 40	1.0	1.5	1.5	1.5	1.5

*Maximum Length 12 ft; above 12 ft. length, insulation thickness shall comply with adjacent columns.

**Heating Systems in outdoor locations shall have an additional thickness of 1/2-inch insulation above the thickness specified in this TABLE for indoor locations.

2. All Heating and Cooling Systems - Indoor Locations

   a. Insulation shall be molded fiberglass insulation with factory-applied all purpose (AP) facing or aluminum jacket (ASTM B 209, 3003 Alloy, H-14 temper) as specified in c. and d., below.

   b. Molded fiberglass insulation shall conform with ASTM C 547, Class 1.

   c. Insulation, except for High Temperature Hot Water piping, shall be Schuller "MICRO-LOK" with APT facing, or approved equal.

   d. For High Temperature Hot Water piping, provide 0.016-inch thick aluminum jacket for pipes 2-1/2 inches and larger, and 0.010-inch thick aluminum jacket for pipes 2 inches and smaller, with a built-in isolation felt.

   e. Fitting, valve, and flange insulation requirements are specified in 3.02 C.1.

3. Heating Systems - Outdoor Locations

   a. Insulation shall be calcium silicate with aluminum jacket (ASTM B 209, 3003 Alloy, H-14 Temper).

   b. Calcium silicate insulation shall conform with ASTM C 533, Type I, and shall be Schuller "THERMO-12 GOLD" with 200 psi compression strength, or approved equal.

   c. Insulation jacket shall be 0.016-inch thick aluminum for pipes 2-1/2 inches and larger, and 0.010-inch thick for pipes 2 inches and smaller with a built-in isolation felt. All seams and joints shall be weatherproof.

4. Cooling Systems - Outdoor Locations

   a. Insulation shall be molded fiberglass with aluminum jacket (ASTM B 209, 3003 Alloy, H-14 Temper).

   b. Molded fiberglass insulation shall conform with ASTM C 547, Class 1, and shall be Schuller "MICRO-LOK" with APT facing, or approved equal.

   c. Insulation jacket shall be 0.016-inch thick aluminum for pipes 2-1/2 inches and larger, and 0.010-inch thick for pipes 2 inches and smaller with a built-in isolation felt. All seams and joints shall be weatherproof.

5. Emergency Generator Exhaust Piping, Tail Pipe Exhaust Ductwork, and Fan Insulation

a. Insulation shall be four-inch minimum thickness and shall achieve a resulting operating exterior surface temperature not to exceed 150 degrees F.

b. Insulation shall be calcium silicate with aluminum jacket for piping and ductwork or with finish specified in 3.02 C.2 for fittings, silencers and exhaust fans.

c. Calcium silicate insulation shall conform with ASTM C 533, Type I, and shall be Schuller "THERMO-12 GOLD" with 200 psi compression strength, or approved equal.

d. Insulation jacket shall be 0.016-inch aluminum, factory-applied, with a built-in isolation felt. All seams and joints shall be sealed.

C. Equipment Insulation

1. Insulation Thickness

		Insulation	
Equipment	Fluid Temp., Degrees F	Thickness (inches)	Material Type
Steam Fash Tank and Condensate	Up to 275	2	A
Compression or Expansion Tanks for Heating	Up to 250	2	A
Hot Water Exchanger - Water to Water	Up to 375	3	A
Heat Exchanger - Steam to Water	Up to 375	3	A
Hot Water Generator	Up to 375	3	A
Expansion Tank - Chilled Water	Up to 55	2	A
Refrigerant Equipment	Up to 40	1.5	A
Hot Water Pumps	Up to 250	3	B
Chilled Water Pumps	Up to 55	3	B

2. Insulation Material

a. Type A: Calcium silicate, curved or scored block insulation

Calcium silicate block shall conform with ASTM C 533, Type I, and shall be Schuller "THERMO-12 GOLD" with 200 psi compression strength, or approved equal.

b. Type B: Rigid fiberglass board insulation

Rigid fiberglass board insulation shall conform with ASTM C 612, Class 1 except that the density shall not be less than 6 lbs. per cubic foot. The insulation shall be Schuller "817 SPIN-GLAS", or approved equal.

PART 3. EXECUTION

3.01 PREPARATION

A. Duct insulation shall be applied after testing of duct system has been completed and approved by the Engineer. Piping insulation shall be applied only after the piping systems have been hydrostatically tested and approved by the Engineer.

B. Install insulation subsequent to installation of heat tracing and any coating or painting.

C. Surfaces shall be clean of rust, scale, dirt, dust, grease and other foreign matter and shall be dry before application of insulation.

D. All metal fasteners shall be made of galvanized steel or other approved corrosion-resistant materials.

3.02 INSTALLATION

A. General

1. Install insulation products in accordance with this Section and manufacturer's installation procedures.
2. Install insulation materials with smooth and even surfaces. Insulation shall be continuous and be carefully fitted with side and end joints butted tightly and staggered. Install each continuous insulation course with full-length units of insulation, with single cut piece to complete run. Do not use multiple cut pieces or scraps abutting each other.
3. All openings, joints, laps and end strips shall be sealed against moisture penetration with fire-retardant vapor barrier.
4. Maintain integrity of vapor barrier jackets on insulation, and protect to prevent puncture or other damage. Staples and similar fastening methods are prohibited for securing vapor barriers on insulation.
5. Extend insulation without interruption through walls, floors, roofs, ceilings and similar penetrations.
6. Where ducts and pipes pass through walls, floors or partitions, the space around the insulated duct or pipe shall be sealed with Thermafiber semi-rigid blanket manufactured by U.S. Gypsum, or approved equal.
7. For double layer insulation, apply each layer of insulation using staggered joint method. Apply each layer of insulation separately.
8. Do not apply seal or cement until all previous application of cements and adhesives have thoroughly dried.
9. Fill in scored block, seams, chipped edges and depressions, and cover over wire netting and joints with insulation cement of sufficient thickness to remove surface irregularities and properly embed netting.
10. The finish, including any vapor barrier treatment, shall lap adjacent sections at both the transverse and longitudinal joints.

11. When supplementary load-bearing material is required at hangers and supports to resist compression of the insulation, the load-bearing thermal insulation shall be the same thickness as the normal pipe thermal insulation. The material shall conform to the flame spread and smoke developed ratings as specified in 1.02 B.

12. Do not insulate boiler manholes or equipment end head pivots, handholes, cleanouts, ASME stamp, and manufacturer's nameplate. Provide neatly beveled edge at interruptions of insulation.

13. Provide removable insulation sections to cover parts of equipment which must be opened periodically for maintenance. These shall include metal vessel covers, fasteners, flanges, frames and accessories.

14. All ductwork angle joints and reinforcement shall be insulated.

15. Where internal ductwork insulation is required, the exterior duct insulation may be omitted, provided that the equivalent "R" factor for the internal duct insulation is the same as the external duct insulation requirements.

16. Valves, fittings, strainers, and other piping appurtenances shall be insulated to match those of the systems to which they are connected.

17. All insulation and exterior jackets that are damaged shall be replaced with new material as specified, to the satisfaction of the Engineer.

18. Insulation on all piping at hangers and supports shall be provided with galvanized protection shields or saddles to prevent crushing of insulation and damage to vapor barrier.

19. Hangers and supports that are directly connected to cold surfaces must be adequately insulated and vapor-sealed to prevent condensation.

B. Sheet Metal Ductwork Insulation

1. Flexible (Blanket) Fiberglass Insulation

a. Wrap insulation tightly on ductwork with all transverse joints butted and longitudinal joints overlapped a minimum of 2 inches.

b. Seal all joints with 3-inch wide vapor barrier strips using an approved adhesive. All cuts and tears shall be sealed with strips of vapor barrier jacket applied with adhesive.

c. Secure insulation in place with 18-gauge copper clad wire loops, 12 inches on centers. All joints shall be lapped and sealed in place with Foster (H.B. Fuller Co./Foster Products Div.) "85-20" adhesive, or approved equal. Adhesive shall be applied so that insulation conforms to duct surfaces uniformly and firmly.

d. In addition to the requirements of a, b, and c above, secure all ductwork larger than 36 inches in width or depth with welded or adhesive type clips on top and bottom or sides of duct, spaced 18 inches on centers along the center line of duct. Cut off exposed portion of fastening pin as close to the clip as possible and seal with 3-inch wide vapor barrier with Foster "85-20" adhesive, or approved equal.

2. Rigid Fiberglass Board Insulation

   a. All insulation shall be applied with edges tightly butted.

   b. Impale insulation over stick clips or pins welded to duct with protruding ends of pins cut off flush, after the stick clips have been applied.

   c. Spacing of pins, to hold insulation firmly in place, shall be a minimum of one pin per square foot.

   d. Seal all joints and penetrations with a three-inch wide strip of the same material, applied with approved adhesive to both surfaces.

   e. Where welded pins cannot be installed, the insulation shall be secured to the duct with approved adhesive and 18-gauge copper clad wire loops.

   f. Finish

      Apply a tack coat of approved adhesive on all corners. Embed reinforcing mesh into wet adhesive and smooth out to eliminate wrinkles. Overlap all reinforcing mesh seams a minimum of two inches. Apply finish coat of approved mastic to entire reinforcing mesh fabric.

   g. Weatherproofing of Outdoor Ductwork

      (1) Apply a coat of Schuller "INSULKOTE PRIMER E" to duct surface.

      (2) Install a one inch galvanized steel wire mesh tightly stretched and secured over the duct insulation. All steel mesh edges shall be bound together with wire.

      (3) Apply two successive 1/8-inch thick coats of Schuller "INSULKOTE ET". Embed coating completely and cover all of the wire mesh.

3. Calcium Silicate Block Insulation

   a. Insulation shall be securely banded in place with tightly butted joints, staggered and secured with 12-gauge annealed stainless steel wire, 12 inches on centers. Where required, provide welded studs, clips or angles as anchors for wires.

   b. Finish

      (1) Over the insulation install a one-inch hexagonal copper clad steel wire mesh tightly stretched in place and secured by wiring to anchors. All steel mesh edges shall be bound together with wire.

      (2) Apply two coats of 1/4-inch thick hydraulic insulating finish cement trowelled to a smooth finish.

4. Duct Liner for Built-Up Central Station HV And HVAC Units

   a. Insulation shall be installed on the inside surfaces of the unit. All metal to metal contacts and joints shall be sealed with a continuous bead of an approved sealant.

   b. Apply insulation to interior of casing with 100 percent coverage of an approved adhesive.

   c. The acrylic-coated surface of the liner shall face the air stream. All joints shall be snug and neatly butted. Insulation shall be fastened to casing interior with mechanical fasteners spaced 12 inches on centers. All mechanical fasteners shall be flush with the perforated liner surface, and coated.

d. All exposed edges and joints shall be sealed with approved adhesive and reinforced with fiberglass mesh. A sheet metal nosing shall be installed on all leading edges of the liner.

e. Install a galvanized steel perforated panel over the entire interior surface secured with the insulation mechanical fasteners.

C. Piping Insulation

1. Molded Fiberglass Insulation

a. Longitudinal lap joints and butt joints shall be sealed with approved adhesive. Butt joints shall be wrapped with a minimum three-inch wide strip of same material as pipe jacket.

b. Fittings, valves, flanges and accessories shall be insulated with compressed fiberglass of two lbs. per cubic foot density and of the same thickness as pipe insulation, wired in place with 18-gauge galvanized steel wire. Apply a uniform coat of fire retardant vapor barrier coating to the entire surface, then cover with a factory-fabricated pre-formed insulated fitting cover, with sealed joints. The fire retardant vapor barrier shall be compatible with said insulation cover material.

c. For high temperature hot water systems in indoor locations, apply outer metal jacket over the insulation. All seams and joints shall be waterproof. Fittings, valves and flanges shall be covered with either a fabricated metal jacket or matching aluminum fitted cover, with sealed joints.

d. For cooling systems in outdoor locations, apply outer metal jacket over insulation. All seams and joints shall be weatherproof. Fittings, valves, flanges and accessories shall be covered with either a fabricated metal jacket or matching aluminum fitted cover, with sealed weatherproof joints.

2. Calcium Silicate Insulation

a. Circumferential and longitudinal joints shall be tightly butted and the half sections wired in place with 16-gauge stainless steel wire, 12 inches on centers. Where multi-layer application is required, all joints shall be staggered and the outer layers wired on as specified above.

b. Fittings, valves, flanges, and accessories including emergency generator exhaust components, shall be insulated with mitered sections of same material and thickness as pipe insulation, wired in place with 18-gauge galvanized wire. Apply an exterior coat of insulating cement with an embedded layer of fiberglass tape.

c. Apply outer metal jacket over the insulation. All seams and joints of jacket shall be weatherproofed for outdoor location and sealed for indoor location.

D. Equipment Insulation

1. Type A

a. Cut, score or miter calcium silicate insulation to fit contour of equipment and secure with 1/2-inch by 0.015-inch galvanized steel bands or 16-gauge galvanized wire, 12 inches on centers.

b. Weld pins or stick clips spaced 18 inches on centers may be used on flat surfaces.

c. Provide stationary anchors for all wires and bands.

d. Stagger all joints and fill all small voids with insulating cement.

e. Over the insulation, one-inch galvanized wire mesh shall be tightly stretched in place over the entire surface and finished with 1/4-inch thick coat of insulating cement trowelled to a hard and smooth finish.

2. Type B

Insulate pumps with removable aluminum boxes, insulated with 3-inch insulation, mechanically fastened to the metal enclosure. All joints and exposed edges shall be sealed and reinforced with a glass cloth and approved adhesive. An aluminum nosing shall be installed on all exposed edges of the enclosure to protect the insulation.

Removable aluminum boxes shall be of required size to clear all components of the pumps. All holes and slots shall have hemmed edges.

END OF SECTION

SECTION 15945

HVAC INSULATION

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Catalog Cuts / Product Data

1. HVAC Insulation

   a. Catalog cuts of insulation.

   b. Product performance data for each type of insulation.

   c. Schedule showing product number, k-value, material thickness and furnished accessories for each HVAC system requiring insulation.

   d. Installation procedures.

B. Samples

1. Sample of each insulation type required. Affix label on sample, completely describing product.

END OF APPENDIX "A"

SECTION 15945

HVAC INSULATION

INSTRUCTIONS TO SPECIFIER

A. Modify Appendix "A" - Submittals as per project specific requirements.

END OF INSTRUCTIONS

DIVISION 15

SECTION 15992

TESTING, ADJUSTING, AND BALANCING OF AIR AND HYDRONIC SYSTEMS

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies requirements for testing, adjusting and balancing of all air and hydronic fluid distribution systems, including the equipment and devices associated with each system.

B. The Work includes setting speed and flow, adjusting equipment and devices installed for systems, recording data, conducting tests, preparing and submitting reports, and recommending modifications to the mechanical installations specified in other Sections of the Specifications.

C. The following related work is specified in other Sections of the Specifications, and is not part of the Work of this Section:

1. Installation and start-up of equipment and devices to be tested, adjusted, and balanced.
2. Pressure testing of piping and ductwork systems.
3. Testing of boilers and pressure vessels.
4. Specifications for materials and installation of adjusting and balancing devices. If devices must be added to achieve proper balancing, refer to the respective system Sections for materials and installation requirements.
5. Piping and ductwork system leakage tests.
6. Electrical hook-up and wiring of equipment and devices to be tested, adjusted, and balanced.

1.02 PERFORMANCE REQUIREMENTS

A. Procedures, measurements, instruments and test reports for testing, adjusting and balancing work shall comply with all applicable Federal, State and Local laws, ordinances, regulations and codes, and the latest industry standards including, but not limited to the entities listed below.

American Society of Heating, Refrigerating and Air- Conditioning Engineers (ASHRAE)

Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

National Environmental Balancing Bureau (NEBB)

Associated Air Balance Council (AABC)

In addition, specific provisions cited herein shall govern for the associated specific application.

B. The air delivery or intake of each diffuser, grille and register shall be as designed or within five percent of the air flow rates shown on the Contract Drawings.

C. The fan air flow rate and static pressure rise across the fan shall be within 10 percent above the design value at design speed.

1.03 JOB CONDITIONS

A. The Contractor shall have the testing and balancing specialist review his work with the respective manufacturers of the equipment and devices involved, and shall coordinate and schedule all Work.

B. The Contractor shall furnish and install balancing dampers, pressure taps, gauges, valves, and other components as required for a properly balanced system, whether or not specified herein or shown on the Contract Drawings, all at no additional cost to the Authority. Adjustment or replacement of parts recommended by the testing and balancing specialist shall be made in strict accordance with the respective equipment manufacturer's recommendations.

C. The Contractor shall have the control manufacturer's representative set the adjustment of the automatically operated dampers and control valves to operate as required.

1.04 QUALITY ASSURANCE

A. Entities performing the Work of this Section shall have had experience similar to that required for this Project for not less than three years.

B. Entities performing the Work of this Section shall be certified by NEBB or AABC and shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 PATCHING MATERIALS

Unless otherwise shown on the Contract Drawings, use same products as originally installed for patching holes in insulation, ductwork and housings which have been cut or drilled for test purposes, including access for test instruments, attaching jigs, and similar purposes.

PART 3. EXECUTION

3.01 EXAMINATION

A. Obtain design drawings and specifications (or as-built drawings and specifications, if such exist), and become thoroughly acquainted with design intent.

B. Obtain copies of approved shop drawings of all air handling and hydronic equipment, air outlets (supply, return and exhaust), manual valves, automatic valves and the temperature control diagrams, including intended sequence of operation.

C. Examine installed work and conditions under which testing is to be done to ensure that work has been completed, cleaned, and is operable. Do not proceed with testing, adjusting and balancing until unsatisfactory conditions have been corrected in a manner approved by the testing and balancing specialist.

D. Examine the air systems to see that they are free from obstructions. Determine that all dampers and registers are open, moving equipment is lubricated, clean filters are installed, and automatic controls are functioning; and perform other inspection and maintenance activities necessary for proper operation of the systems.

E. Examine the hydronic systems to see that they are free from abnormal obstructions, and that all piping, valves and equipment have been properly made fully operational. Determine that all equipment and control systems are performing correctly by functional testing.

3.02 TESTING, BALANCING, AND ADJUSTING

A. Cut insulation, ductwork and piping for installation of test probes to the minimum extent necessary to allow adequate performance of test procedure.

B. Testing and balancing specialist shall perform tests and compile test data for all air systems and hydronic systems.

C. Data shall include a schematic diagram locating the air inlets, outlets, fans, equipment, dampers and regulating devices for air systems, and a schematic diagram for location of balancing valves, flow indicators, equipment, and devices for hydronic systems.

D. All instruments used shall be provided by the entity performing the Work of this Section, and shall be accurately calibrated and maintained in good working order.

E. Air Systems

The testing, adjusting and balancing of air systems shall be in accordance with the detailed procedures outlined in the referenced standards; and shall include but not be limited to the following:

1. Test, record and adjust fan rpm to design requirements.
2. Test and record motor full load amperes.
3. Make pitot tube traverse of main supply ducts and obtain design flow rate at fans.
4. Test and record system static pressure, velocity pressure and total pressure.
5. Test and adjust system for design supply, transfer and return air flow rate.

6. Test and adjust system for minimum and maximum design flow rates of outside air.

7. Test and record return air temperatures.

8. Test and record entering mixed air temperatures.

9. Test and record coil and fan leaving air temperatures.

10. Adjust all main supply, return, relief, and exhaust air ducts to proper design flow rate.

11. Adjust all zones to proper design flow rate for supply, return, transfer, relief and exhaust air.

12. Test and adjust each diffuser, grille and register.

13. Each grille, diffuser and register shall be identified as to location and area on the schematic diagram.

14. Size, type and manufacturer of diffusers, grilles and registers and all tested equipment shall be identified and listed in the final report. Manufacturer's data on all equipment shall be used to make required calculations for testing, adjusting and balancing. Readings and tests of diffusers, grilles and registers shall include design required velocity and test resultant velocity, required flow rate and test resultant flow rate after adjustments.

15. All diffusers, grilles and registers shall be adjusted to minimize drafts in all areas.

16. Dampers shall be permanently marked after air balance is complete so that they can be restored to their correct position, if disturbed later.

17. Openings in ductwork for pitot tube insertion shall be sealed with snap-in plugs after air balance is complete.

F. Hydronic Systems

The testing, adjusting and balancing of hydronic systems shall be in accordance with the detailed procedures outlined in the referenced standards; and shall include but not be limited to the following:

1. Preliminary procedure prior to balancing:

   a. Examine water in systems and determine if water has been treated and cleaned.

   b. Check expansion tank to determine that it is not air bound and the system is completely full of water.

   c. Purge all air vents at high points of water systems, check automatic air vents and determine if they are operating properly.

   d. Coordinate with control manufacturer for required cooling and heating temperature controls and corresponding, automatic valve operation settings.

   e. Open all normally open valves to full open position. Set automatic valves to full coil flow.

   f. Complete air balance shall have been accomplished before final water balance begins.

   g. Check water pumps for pump rotation and for proper flow rate delivery against manufacturer's pump curves.

h. Set all balancing valves for required flow delivery at mains and branch mains to cooling and heating elements.

i. Upon completion of flow readings and adjustments of balancing valves, mark all settings and record data, so that they can be restored to their correct "balanced" position, if disturbed later.

2. Final balancing shall include the following:

a. After required cooling and heating temperature controls and automatic valve operation settings are made, recheck pump flow requirements and readjust system as required.

b. Record pressure drop through coil at set flow rate of coil for full cooling and on full heating. Set pressure drop across bypass valve to match coil pressure drop.

c. Record and check the following items at each cooling and heating element:

(1) Inlet water temperatures and static pressure at connections.

(2) Leaving water temperatures and the pressure drop of each coil.

(3) Flow rate through coil with control valve stroked manually wide open.

d. Record operating suction and discharge pressures of each pump and final total dynamic head and rated amperage versus actual amperage of pump motors.

e. Record entering and leaving water temperatures and flow through all equipment and devices.

f. Check and record all flow rates at all locations in the piping system with flow meters.

G. Upon completion of air and hydronic systems testing, patch insulation, ductwork and housings, using materials identical to those removed (refer to 2.01).

H. Final testing, adjusting and balancing shall be performed during summer season for air conditioning systems and during winter season for heating systems, including operation when outside conditions are within 5 degrees F wet bulb temperature of maximum summer design condition, and within 10 degrees F dry bulb temperature of minimum winter design condition.

I. Retest, adjust, and balance systems subsequent to system modifications. Resubmit test results.

END OF SECTION

SECTION 15992

TESTING, ADJUSTING, AND BALANCING OF AIR AND HYDRONIC SYSTEMS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Qualifications / Construction and Installation Procedures

1. Proof of Compliance and Sample Blank Report

   a. Certification that the testing, adjusting and balancing entity meets the requirements of 1.04 and all other specified requirements.

   b. Prior to performing the work, submit sample blank forms of the test reports that will be used, indicating all data and parameters to be included.

B. Site Inspection Reports

1. Draft Reports: Submit certified test reports, signed by the authorized representative of the testing and balancing specialist. The reports shall be certified proof that the systems have been tested, adjusted and balanced in accordance with 1.02 A (NEBB or AABC); are an accurate representation of how the systems have been installed; are a true representation of how the systems are operating at completion of the testing, adjusting and balancing procedures; and are an accurate record of all final quantities measured, to establish normal operating values of the systems. Upon completion of testing, adjusting and balancing procedures, prepare draft reports on the approved forms. Draft report may be handwritten, but must be complete, factual, accurate and legible. Organize and format draft reports as described herein below. Submit two complete sets of draft reports. Only one complete set of draft reports will be returned.

   Report Format: Report forms shall be the standard forms as specified in 1.02 A for each respective item and system to be tested, adjusted and balanced. Include schematic systems diagrams. Enclose the report contents in a 3-ring binder. Divide the contents into the below listed divisions, separating them by divider tabs with titles descriptive of the contents:

   a. General Information and Summary

   b. Air Systems

   c. Hydronic Systems

2. Final Reports: Submit certified test reports, signed by the authorized representative of the testing and balancing specialist. The reports shall be certified proof that the systems have been tested, adjusted and balanced in accordance with 1.02 A (NEBB or AABC); are an accurate representation of how the systems have been installed; are a true representation of how the systems are operating at completion of the testing, adjusting and balancing procedures; and are an accurate record of all final quantities measured, to establish normal operating values of the systems.
Upon verification and approval of draft reports, prepare final reports, typewritten, organized and formatted as described herein below. Submit two complete sets of final reports.

Report Format: Report forms shall be the standard forms as specified in 1.02 A for each respective item and system to be tested, adjusted and balanced. Include schematic systems diagrams. Enclose the report contents in a 3-ring binder. Divide the contents into the below listed divisions, separating them by divider tabs with titles descriptive of the contents:

a. General Information and Summary

b. Air Systems

c. Hydronic Systems

Report Contents: Provide the following minimum information, forms and data:

a. General Information and Summary: The inside cover sheet shall identify the testing, adjusting and balancing agency, Contractor, owner, Engineer and contract. Include addresses, contact names and telephone numbers. Include a certification sheet containing the seal and name, address, telephone number and signature of the agency's responsible certified test and balance engineer. Include in this division a listing of the instrumentation used for the procedures, along with the proof of calibrations.

b. The remainder of the reports shall contain the appropriate forms containing, as a minimum, the information indicated on the standard report forms in accordance with 1.02 A (AABC and NEBB), for each item of equipment and system. Prepare a schematic diagram for each item of equipment and system, to accompany each respective report form.

Calibration Reports: Submit proof that all required instrumentation has been calibrated to tolerances specified in 1.02 A within a period not exceeding six months prior to conducting the test procedures.

END OF APPENDIX "A"

SECTION 15992

TESTING, ADJUSTING, AND BALANCING OF AIR AND HYDRONIC SYSTEMS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(1.02 B)	Air inlet and outlet flow rates in cfm.
(2.01)	Special patching materials.

B. Other Items

Modify Appendix "A" - Submittals per project specific requirements.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16000

ELECTRICAL GENERAL REQUIREMENTS

PART 1. GENERAL

1.01 SUMMARY

Unless otherwise shown on the Contract Drawings, or unless otherwise specified in other Sections of these Specifications, the general requirements specified in this Section are applicable to all electrical work of this Contract. Additional requirements applicable to individual Sections of these Specifications are specified in those Sections, or are shown on the Contract Drawings.

1.02 REFERENCES

The following is a listing of publications referenced in this Section:

	American National Standards Institute (ANSI)
ANSI C 2	National Electrical Safety Code.
	American Society of Testing and Materials (ASTM)
ASTM D 178	Standard Specification for Rubber Insulation Matting.
	National Fire Protection Association (NFPA)
NFPA 70	National Electrical Code.
	Occupational Safety and Health Administration (OSHA)

1.03 QUALITY ASSURANCE

A. Any entity performing Work shall have had experience on at least two projects involving quantities and complexities at least equal to those required under this Division or the applicable Section thereof.

B. All workmen performing under this Division shall be skilled workers of the trade involved. Where specialty work, such as splicing or welding are required, submit proof of training, experience and work history for each workman, for review by the Engineer. Only approved workmen shall perform specialty work.

C. All electrical work shall be performed under the supervision of an electrical contractor, licensed in the state (and the city as required) in which the work is to be performed. Submit a copy of the qualifying license for review by the Engineer.

D. All calculations required by this and other various Sections of these Specifications, or as shown on the Contract Drawings, shall be certified and sealed by a Professional Engineer licensed in the state in which the Work is to be performed, and shall be submitted to the Engineer for review.

E. Various Sections of these Specifications contain the requirement for the specific material or equipment to be furnished with an experience statement "satisfactorily used for purposes similar to those intended herein" or words of similar intent and a statement that specifies the required experience time. These statements shall mean that the manufacturer of the material or equipment being furnished for the Work specified in this Contract shall have manufactured similar material or equipment to that specified, for at least the time specified.

F. In various Sections of this Division there is a statement that refers to the length of required experience that must be satisfied.

G. Polyvinyl Chloride (PVC): PVC conduits, PVC-insulated power wiring, or items containing PVC, except PVC-insulated wiring for communications systems, remote control, signaling, and power limited circuits, shall not be installed in any indoor area. PVC-insulated wiring for communications systems, remote control, signaling, and power-limited circuits shall be furnished and installed in accordance with NFPA 70.

H. Asbestos

Asbestos or items containing asbestos shall not be furnished or installed.

I. Conformance Labels

All electrical materials and equipment for which there is a nationally recognized standard shall bear the conformance labeling of the third party inspection authority, such as Underwriters Laboratories Inc., Factory Mutual, ETL, or approved equal. Where the phrase "where there are established UL standards, shall bear the UL label", or words of similar intent appear in other Sections, the instructions for the conformance label above shall apply.

1.04 CODES AND STANDARDS

A. The electrical installation shall conform to all requirements of ANSI C2, NFPA 70, and the codes and standards specified in other Sections, all local codes and the requirements of OSHA, which would be applicable if the Authority were a private corporation.

B. Standards publications of technical organizations and regulatory agencies are referenced in other Sections, and unless stricter requirements are indicated, materials and equipment so specified shall be manufactured, tested and installed to conform, as a minimum, to the requirements of such reference standards and publications.

C. Installations for aeronautical markers, lighting, guidance signs, and other work as shown on the Contract Drawings, shall comply with the standards of the Federal Aviation Administration (FAA), where applicable.

D. In case of conflict between provisions of codes, laws and ordinances, the more stringent requirement shall apply.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver material in manufacturers' original unopened protective packaging.

B. Store materials in original packaging in a manner to prevent soiling, physical damage, wetting or corrosion prior to installation.

C. Handle in a manner to prevent damage to finished surfaces.

D. Where possible maintain protective coverings until installation is complete and remove such covers as part of final cleanup.

E. Touch up any damage to finishes to match adjacent surfaces to the satisfaction of the Engineer.

1.06 SUBMITTALS

See Appendix "A" for submittal requirements.

1.07 SPECIAL TERMS

Throughout this and other Sections of this Division the term "Authority" is used. In PATH contracts, substitute the term "PATH" is deemed substituted for the term "Authority".

PART 2. PRODUCTS

2.01 MATERIAL AND EQUIPMENT TO BE FURNISHED

Equipment and materials furnished shall be new and unused, prior to this installation, first grade commercial quality and shall be essentially the standard cataloged products of a manufacturer regularly engaged in the manufacture of the products. Only those items specifically shown on the Contract Drawings as existing, relocated or Authority furnished shall be reused in this installation. Rebuilt or remanufactured equipment will not be permitted.

2.02 IDENTIFICATION

A. All parts of equipment, such as switchboards, panel boards, safety switches, motor starters, circuit breakers, time clocks, contactors and similar items shall be identified by name, function or control with laminated plastic nameplates consisting of two black sheets with one white sheet bonded to and between the two outer sheets and having letters machine engraved in the face sheet to the depth of the white plastic. Nameplates shall not be smaller than 1 inch by 3 inches with characters not less than one-quarter inch. Where letter sizes are not specified, use one-inch high letters for panel boards, switchboards and motor control centers and one quarter inch high elsewhere. Nomenclature shall be according to a schedule approved by the Engineer.

B. All device plates other than lighting switch plates, telephone and 120 volt, single phase, 15 or 20 ampere receptacles, shall have black or white (as directed) silk-screened lettering Helvetica Medium type face (or other type face as directed by the Engineer) designating:

1. System.
2. Voltage (where applicable).
3. Number of phases (where applicable).
4. Current rating (where applicable).
5. Frequency (where applicable).

C. Before placing orders for nameplates or silk-screened device plates, submit a typewritten list to the Engineer for review.

D. The outside of the covers of all junction or pull boxes located above hung ceilings and the inside of the covers of all junction or pull boxes exposed shall be labeled with an indelible marker indicating the operating voltage and the system contained therein.

E. All device plates of receptacles connected to a standby or emergency power distribution system shall be labeled with an orange plastic nameplate, engraved with the panel board and circuit number to which the receptacle is connected. Nameplate character engraved shall be not less than one-quarter inch in height.

F. Unless otherwise shown on the Contract Drawings, all panel boards, switchboards, switchgear, circuit breakers, switches and transformers connected to a standby or emergency power distribution system shall be finished Federal Safety Orange in color.

2.03 RUBBER MATTING

A. Provide continuous insulated rubber matting not less than 36 inches wide and not less than one quarter inch thick in one piece in front of:

1. Substation transformers.
2. Switchgear.
3. Switchboards.
4. Motor control centers.
5. Panel boards.
6. On each side and end of a standby or emergency generator set.
7. Other locations as shown on the Contract Drawings.

B. Matting shall conform to ASTM D 178, Type 2.

PART 3. EXECUTION

3.01 GENERAL

A. Work of this Division shall include all labor, material and apparatus necessary for the completion of all electrical work as shown on the Contract Drawings and as hereinafter specified, left ready for satisfactory operation.

B. Coordinate with Authority operations and construction by other trades.

1. Coordinate with the Work of all trades as necessary to facilitate timely completion, avoid unnecessary cutting and patching and to ensure proper installation and operation of all equipment.
2. Coordinate all components and aspects of the Work, in order to minimize power shutdowns to the power distribution systems. Should any part of the Work require an "off-hours" shutdown in excess of 8 hours, supply temporary services or feeders as required to maintain operation of the existing systems and equipment.

3. Furnish to appropriate trades, shop drawings, catalog cuts and instructions necessary for construction of concrete bases, concrete encasement, anchor bolts, and other construction required to accommodate installations under other Sections.

4. Obtain all wiring diagrams and other instructions required for proper electrical connection of equipment installed or furnished under other Divisions of these Specifications and coordinate the installation, wiring and connections for equipment furnished under this Division, or other various Divisions.

C. The arrangement of electrical equipment and conduit runs as shown on the Contract Drawings and described in the Specifications is schematic. Locate and install electrical work in coordination with other trades so that all electrical equipment and material is installed with working clearances in accordance with NFPA 70. Route conduit to avoid interference with existing installation and with work to be performed by other trades.

D. The location of equipment and motors shown on the Contract Drawings shall be subject to minor revisions due to field conditions or coordination with other trades without any increase in Contractor's compensation. Prior to roughing-in, verify the exact location of all electrical connections to equipment and motors from reviewed shop drawings and field verification.

E. Maintain records of all inspections, testing, overload and overcurrent settings throughout the construction and any corrective actions taken, and submit records to the Engineer for review.

F. All electrical work shall be subject to inspection by the Engineer. Correct any deficient work, as required for the approval of the Engineer.

G. Any equipment, materials, wiring or labor that are a necessary part of the electrical work and to its proper performance, although not specifically mentioned herein or shown on the Contract Drawings, shall be furnished and installed as if called for in detail, without additional cost to the Authority.

3.02 REMOVALS, RELOCATIONS, RECONNECTIONS, RESTORATIONS

A. Relocate existing equipment and materials as shown on the Contract Drawings.

B. Unless otherwise shown on the Contract Drawings, existing equipment and materials that are to be removed and not required to be relocated under this Contract, will become the property of the Contractor and shall be removed from the property of the Authority, and shall be properly disposed of. Disposal of equipment and materials shall comply with all local, state and Federal laws and regulations as if the Authority was a private corporation.

C. Unless specifically shown on the Contract Drawings, salvaged equipment and materials shall not be reused in the installation.

D. If existing electrical feeders, wiring, conduit, lighting fixtures or equipment interfere with the installation of new construction of any trade, the existing electrical feeder, wiring and conduit shall be rerouted or the equipment relocated in a manner approved by the Engineer to permit installation of the new construction. Where existing circuits or devices, or portions of the existing wiring system are to remain in service, but are interrupted by the construction, continue the existing wiring to maintain the remainder of the wiring system in operation.

E. Notify the Engineer immediately of any damage caused by the Contractor to existing wiring, services or feeders that are to remain in service. Repair the damage in a workmanlike manner to restore to service, at no cost to the Authority.

F. Before shutdown or discontinuation of service on any circuit, system or feeder, coordinate such activities with the Engineer in order to minimize shutdown periods. Provide a minimum of two weeks notice in writing to the Engineer before performing any shutdowns. The minimum period may be reduced with the express written permission of the Engineer.

3.03 LOCATION OF EQUIPMENT

A. Unless otherwise shown on the Contract Drawings, the location of outlets or devices, from finished floor to center of plate or device, shall be as follows:

1. Lighting switches: 48 inches.
2. Thermal switches: 48 inches.
3. Receptacles: 16 inches.
4. Telephone outlets: 16 inches.
5. Fire alarm stations: 48 inches.
6. Fire alarm horn/light signals: 7 feet 6 inches.
7. Clocks: 7 feet 8 inches.

B. Unless otherwise shown on the Contract Drawings, the location of equipment, from finished floor to top of enclosures shall not exceed 6 feet, 6 inches, and shall not protrude more than 4 inches if higher than 27 inches.

1. In exposed or public locations, panel boards and cabinets shall generally be flush mounted and all covers shall be identical in layout and size, and shall be installed to maintain a level and straight top and bottom alignment.
2. In concealed locations, or in closets or electrical or mechanical rooms, or non-public locations, panel boards and cabinets shall generally be surface mounted and shall be installed to maintain a level and straight top alignment.

3.04 DISSIMILAR METALS

A. Dissimilar metals shall mean those metals that are incompatible with one another in the presence of moisture, as determined from their relative positions in the Electrochemical Series, or from test data. Where dissimilar metals come in contact, paint the joint both inside and out with approved coating so as to exclude moisture from the joint, or provide a suitable insulating barrier separating the metals.

B. Transitions in raceways, from one metal to a dissimilar metal shall only be made at boxes or other enclosures, except where shown on the Contract Drawings.

3.05 NAMEPLATES

Secure nameplates on equipment or walls with stainless steel or brass screws.

3.06 RUBBER MATS

A. Install rubber mats in front of each panelboard, switchboard, motor control center, switchgear and substation transformers, and along each side and the end or each generator set, or as shown on the Contract Drawings.

B. Rubber mats, when installed, shall lay flat without curling.

3.07 CUTTING AND PATCHING

A. Perform all cutting and patching of existing construction required for installation of all materials and equipment as specified in this Division.

B. Perform all patching to match existing adjacent construction to the satisfaction of the Engineer and using the best possible workmanship of the various trades involved.

3.08 FINAL FIELD TESTS

A. The entire electrical installation shall be inspected prior to final acceptance testing, thoroughly cleaned, and damaged finishes touched up after final completion and prior to final acceptance testing being performed. Not less than 30 days prior to the testing, furnish a test plan, to the Engineer for review, outlining all aspects of the testing, including tests to be performed and the expected results.

B. Perform the following field test in the presence of the Engineer to demonstrate the reliability of the electrical installation. Give the Engineer a minimum of one-week advance notice of such tests.

1. Operate all electrical systems and equipment for a period of 24 hours, unless in the opinion of the Engineer, a different test period is required, to prove the operation and performance of a system and its equipment.

2. Should the foregoing test reveal any defects, promptly correct such defects and re-run the tests until the entire installation conforms to the requirements of these Specifications and the Contract Drawings.

C. Tests requiring certified reports and those requiring factory or field inspection shall be conducted and reported to the Engineer in conformance with standards herein specified.

D. In addition to the tests outlined above, after completion of the electrical system and prior to occupancy:

1. The following equipment and devices, as a minimum, shall be thermographically inspected utilizing a Hughes Aircraft Probeye infrared detector, or approved equal, with videotaping attachment.

a. High voltage cable splices and connections.

b. Switchboard.

c. Transformer.

d. Switchgear.

e. Panelboards.

f. Motor control centers.

g. Automatic transfer switch and emergency power system connections.

h. Chiller motor and starter connections.

i. All 600 volt (nominal) cable connections rated 100 amperes (#3 AWG) or greater.

j. Other equipment as shown on the Contract Drawings.

2. The inspection shall be made by an independent inspection company such as Infrared Services, Inc, Montville, N.J., General Electric Apparatus Service Division, or approved equal. The inspection shall be made with all equipment, motors, lighting fixtures, and miscellaneous loads operating and with all equipment covers removed. Inspection reports complete with color photographs of the infrared scan and control photographs indicating the ambient temperature and any hot spots of each item inspected shall be submitted to the Engineer for approval. Any equipment, connections or devices indicated to be operating improperly performing equipment shall be replaced or repaired by the Contractor at no cost to the Authority. The cost of the inspections and necessary repairs shall be included in the Contract.

E. Demonstrate to the Engineer equipment or systems installed or modified in this Contract.

1. After completion of all testing, and prior to placing equipment or systems in operation, demonstrate the features and operation of the equipment or systems to the Engineer, and all other staff or interested parties, as designed by the Engineer, so that operational and maintenance personnel are familiarized with the equipment and systems, as follows:

a. Switchboards and panelboards.

b. Transformer.

c. Switchgear.

d. Motor control centers.

e. Fire alarm and smoke detection systems.

f. Automatic transfer switches.

g. Standby/Emergency generator sets.

h. Other equipment as shown on the Contract Drawings.

2. Provide the necessary accessories, test equipment, and personnel, for each demonstration.

3. Complete all arrangements for the demonstrations through the Engineer.

4. Upon the completion of each demonstration or instructional session, obtain "sign-off" from the Engineer. The "sign-off" shall state that the demonstration or instructions for use were provided, that they were complete and were given to the designated personnel.

END OF SECTION

SECTION 16000

ELECTRICAL GENERAL REQUIREMENTS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Substation and high-voltage transformers.
2. Switchgear.
3. Switchboards.
4. Motor control centers.
5. Emergency lighting battery systems.
6. Working drawings for the installation sequence of medium voltage cables, and other systems where shown on the Contract Drawings, including the reel designations for each leg of the installation. Drawings shall include the calculations for pulling tensions and sidewall pressure of all cable pulls, including identification of manhole locations with splices and manholes that will be "pulled-through" without splicing. Calculations shall be certified and sealed by a Professional Engineer licensed in the State in which the Work is to be performed.

B. Catalog Cuts

1. Conduit, and fittings.
2. Wire and cable.
3. Wiring devices.
4. Multi-outlet assemblies.
5. "Standard" outlet and junction boxes.
6. Medium voltage cable, splicing and termination kits.
7. Lightning arresters.
8. Capacitors.
9. Panel boards and cabinets.
10. General purpose transformers.
11. Circuit breakers.
12. Lighting fixtures.
13. Pulling devices and end seals.
14. Special pull and junction boxes.

15. Supporting devices.

C. Certifications

Training, experience and work history for certified splicers and welders.

D. Design Calculations

Calculations where required by the Specifications or the Contract Drawings.

E. Maintenance Manuals

Operation and maintenance manuals, where required by the Specifications or the Contract Drawings.

F. Schedules

Nameplate designations.

G. Record Documents

One set of Shop Drawings revised, completed and brought up to date showing the permanent construction as actually made, in accordance with "Shop Drawings, Catalog Cuts and Samples" of Division 1, and showing the exact location of all equipment and conduit runs, as actually installed.

H. Site Inspection Reports

A final copy of the records and certified test reports for all tests, to the Engineer for review, for not less than the following:

1. Primary cable and terminators insulation testing.
2. Insulation testing of 600V (nominal) cables rated 100 amperes (#3 AWG) and above.
3. Ground resistance test of each service ground.
4. Ground fault circuit breaker and receptacle testing.
5. Setting of all adjustable overcurrent devices.
6. Setting or size of all overload elements installed, indicating the following:
   a. Motor designation.
   b. Nameplate horsepower, full load current, voltage and phases.
   c. Operating current and voltage.
   d. Overload element size or setting.
7. Emergency power distribution equipment and system test results.

END OF APPENDIX "A"

SECTION 16000

ELECTRICAL GENERAL REQUIREMENTS

INSTRUCTIONS TO SPECIFIER

A. General

ENSURE THAT THIS SECTION IS INCORPORATED IN ALL CONTRACTS, IN ADDITION TO THE VARIOUS SECTIONS REQUIRED FOR THE SPECIFIC WORK.

B. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(1.03 D)	Changes to, or additional general requirements not in this or other Sections of these Specifications.
(1.03 D)	Calculations required but not shown in this or other Sections of these Specifications.
(1.06 E)	Installation sequence of cables and other systems as required.
(2.01)	Identify all material furnished by the Authority, or existing or relocated items that shall be reused.
(2.02 F)	Panelboards, switchboards, switchgear, circuit breakers, switches, and transformers connected to standby or emergency power that will not be finished Federal Safety Orange in color.
(2.03 A.7)	Rubber matting in front of items other than 2.03 A.1 through 2.03 A.6.
(3.01 B)	Location of equipment and motors.
(3.02 A)	Relocated existing equipment and materials.
(3.02 B)	Identify existing equipment and materials that are to be removed and not relocated that will be kept by the Authority.
(3.02 C)	Identify salvaged equipment and materials to be reused.
(3.03 A, B)	Outlets, devices or equipment not located as per the Specification.

C. Coordinate with other disciplines, and specifically Architectural, for locations of devices, in areas such as:

a. Lavatories, toilets and sink areas.

b. Kitchens.

c. Laboratories.

d. Cabinetry and casework areas.

e. Vehicle garages - generally 4 feet.

f. Control centers, supervisory desks or other "high-tech" installations.

(3.06 A)	Rubber mat locations, other than as noted.
(3.08 D.1.j)	Equipment to be thermographically inspected other than as noted in 3.08 D.1. a through i.
(3.08 E.1.h)	Demonstrate features and operation of equipment and systems other than as noted in 3.08 E.1 a through g.

D. Other Items

Ensure that the Specifications include the various Sections required for the type of work shown on the Contract Drawings.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16110

RACEWAYS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for raceways.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

	American National Standards Institute (ANSI)
ANSI C 80.1	Rigid Steel Conduit - Zinc Coated
ANSI C 80.3	Electrical Metallic Tubing - Zinc Coated
ANSI C 80.5	Rigid Aluminum Conduit
ANSI C 80.6	Intermediate Metal Conduit - Zinc Coated
	National Electrical Manufacturers Association (NEMA)
ANSI/NEMA FB 1	Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies
NEMA RN 1	Polyvinyl – Chloride (PVC) externally coated galvanized rigid steel conduit and intermediate metal conduit
NEMA TC-3	PVC Fittings for use with rigid PVC Conduit and Tubing
NEMA TC-6	PVC and ABS plastic utilities duct for underground installation
NEMA TC-8	Extra-strength PVC plastic utilities duct for underground installation
NEMA TC-14	Filament – Wound Reinforced Thermosetting Resin Conduit and Fittings
	National Fire Protection Association (NFPA)
NFPA 70	National Electric Code
	Underwriters Laboratories Inc. (UL)
ANSI/UL 1	Flexible Metal Conduit
ANSI/UL 5	Surface Metal Raceways and Fittings
ANSI/UL 6	Rigid Metal Conduit
ANSI/UL 209	Cellular Metal Floor Raceways and Fittings
ANSI/UL 360	Electrical Liquid-tight Flexible Steel Conduit

ANSI/UL 514B	Fittings for Conduit and Outlet Boxes
ANSI/UL 651	Schedule 40 and 80 Rigid PVC Conduit
ANSI/UL 651A	Type EB and A Rigid PVC Conduit and HDPE Conduit
ANSI/UL 797	Electrical Metallic Tubing
ANSI/UL 870	Wireways, Auxiliary Gutters, and Associated Fittings
ANSI/UL 884	Underfloor Raceways and Fittings
ANSI/UL 1242	Intermediate Metal Conduit
ANSI/UL 1479	Fire Tests of Through-Penetration Firestops

1.03 DELIVERY, STORAGE, AND HANDLING

A. Deliver material in manufacturer's original, unopened, protective packaging. Protective caps shall be removed only upon installation of conduit.

B. Store materials in a clean, dry space and protect them from weather.

C. Handle in a manner to prevent damage to finished surfaces.

1.04 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MATERIALS

A. General

1. Locations, types and sizes of raceways are shown on the Contract Drawings.
2. Minimum size of conduit shall be 3/4 inch.
3. Conduit shall be supplied in a minimum of 10-foot lengths and accordance with UL 6.

B. Rigid Metal Conduit

1. RGS - Rigid galvanized steel conduit (Heavy-wall) hot dipped galvanized inside and out, with hot dipped galvanized threads, conduit shall conform to UL 6 and ANSI C80.1.
2. RGS/PVC - PVC coated, rigid galvanized steel conduit (Heavy-wall) hot dipped galvanized inside and out with hot dipped galvanized threads. The interior of the conduit shall have a thermoplastic or thermosetting coating of a nominal thickness of .007 (7 mils) and shall conform to NEMA TC-14. All PVC coated conduit shall conform to NEMA RN-1.
3. IMC - Intermediate metal conduit, galvanized steel (medium-wall) conduit, threads shall be galvanized and shall conform to ANSI/UL 1242 and ANSI C80.6.
4. ALC - Aluminum conduit shall conform to UL 6 and ANSI C 80.5.

5. All preformed elbows shall be the same in construction to and of a type designed for use with the appropriate conduit and shall conform to UL 6.

6. All fittings shall be threaded and shall conform to NEMA FB-1.

7. If threads are cut after the zinc coating has been applied, the threads shall be treated with protective coating of zinc equivalent to hot-dipped process and conform to NEMA RN-1.

C. Electrical Metallic Tubing

1. EMT - Electrical metallic tubing (thin-wall) shall be galvanized steel and shall conform to ANSI/UL 797 and ANSI C 80.3.

2. All fittings shall be indenter or compression type made of malleable or pressed steel and shall conform to ANSI/NEMA FB 1.

D. Cellular Metal Floor Raceway

Cellular Metal Floor Raceway and Fittings shall conform to NFPA 70 and ANSI/UL 209.

E. Flexible Metal Conduit

1. FSC - Flexible steel (galvanized) conduit shall conform to ANSI/UL 1.

2. LSC - Liquid-tight flexible metal conduit shall conform to ANSI/UL 360.

3. Fittings shall be of a type designed for use with the respective conduit and shall conform to ANSI/UL 514B.

F. Surface Metal Raceways

1. Surface raceways shall conform to ANSI/UL 5.

2. Surface metal raceways shall come complete with all necessary accessories for installation.

G. Underfloor Raceways

1. Duct, fittings, and accessories shall be suitable for encasement in concrete and shall conform to NFPA 70 and ANSI/UL 884.

2. Underfloor raceways shall come complete with all necessary accessories for installation.

H. Rigid Nonmetallic Conduit

1. PVC Type 40 Standard Wall polyvinyl chloride (PVC) conduit shall conform to ANSI/UL 651 and NEMA TC-3.

2. PVC Type 80 Heavy wall polyvinyl chloride (PVC) conduit shall conform to ANSI/UL 651.

3. PVC Type "A" Light wall polyvinyl chloride (PVC) conduit shall conform to ANSI/UL 651A

4. PVC Type EB Light wall polyvinyl chloride (PVC) conduit shall conform to ANSI/UL 651A and NEMA TC-8.

5. PVC Type DB Light wall polyvinyl chloride (PVC) conduit shall conform to ANSI/UL 651A and NEMA TC-8.

6. HDPE Type 40 Standard wall High-Density Polyethylene (HDPE) Conduit shall conform to ANSI/UL 651A and NEMA TC-6.

7. FRE - Fiberglass Reinforced Epoxy (FRE) conduit shall conform to ANSI/NEMA TC-14.

I. Fire stops, Through Penetrations of Conduits

1. Where raceways penetrate wall or floor, fire stops with a fire rating equal or greater than the rating of the penetrated wall or floor shall be provided.

2. All fire stops shall conform to the UL 1479.

J. Wireways

1. Wireways shall be seamless galvanized steel construction, cover to be locked with captive screws and shall conform to ANSI/UL 870.

2. Wireways shall come complete with all necessary accessories for installation.

K. Fastening Devices

Provide inserts, clamps, bolts and washers, or any other type of fastening devices conforming to the requirements of the Section entitled "SUPPORTING DEVICES", required to secure conduits to walls or above hung ceilings. Unless otherwise shown on the Contract Drawings, all fasteners shall be hot dipped galvanized and of sizes and types recommended by the equipment manufacturer.

PART 3. EXECUTION

3.01 INSTALLATION

A. General

1. All conduit bends shall be accomplished with a trade approved bending tool and in accordance with the manufacturer's recommendations and NFPA 70.

2. Ream conduit ends free from burrs prior to installation, and draw joints up tight.

3. Make transitions in conduit from one metal to a dissimilar metal only at boxes or other enclosures, unless otherwise shown on the Contract Drawings.

4. Install concealed conduits or tubing in as direct a line as possible.

5. Install exposed raceways, located above hung or accessible ceilings, parallel with or at right angles to the lines of buildings and as close to the ceiling as possible, unless otherwise shown on the Contract Drawings.

6. Install expansion fittings in all conduits that cross expansion joints, where conduits attach to independent structures, or where exposed to large temperature changes.

7. Securely fasten threaded conduits entering enclosures, other than threaded cast boxes, by means of two lock-nuts, one on each side of the enclosure. Terminate the conduits in insulated bushings.

8. Cap all free ends of empty conduit to prevent water entrance.

9. Conduit through roofs and external walls of buildings, manholes and other structures shall be watertight. Contractor shall submit detailed shop drawings for the Engineer's approval.

10. Where portions of an interior raceway system are exposed to widely different temperatures, make provisions to prevent circulation of air from a warmer to a colder section through the raceways.

11. Apply zinc rich paint to all exposed threads after joints have been made up clean and tight.

12. Support all conduits as required in these Specifications under Section entitled "SUPPORTING DEVICES".

13. All conduit runs shall leave or enter structures perpendicularly.

14. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or mono-filament plastic line having not less than 200-lb tensile strength. Leave not less than 12 inches of slack at each end of the pull wire.

B. Rigid Metal Conduit

1. RGS shall be used where Fire Alarm Systems are installed.

2. RGS/PVC shall not be used indoors.

3. IMC may not be used in wet locations, or high corrosive area, otherwise NFPA 70 Article 345 fully applies.

C. Electrical Metallic Tubing

EMT used for power feeder or branch circuits, shall not exceed 2-inch trade size. EMT used for control circuits and communications systems shall not exceed 4-inch trade size.

D. Cellular Metal Floor Raceway

Installation limits shall be defined by NFPA 70.

E. Flexible Metal Conduit

1. Install FSC for motor connections and for other equipment connections where subject to movement and vibration. Conduit shall be installed to permit maximum flexibility, without crushing or permanent deformation, and shall not exceed 18 inches in length, without approval of the Engineer.

2. Use LSC for the same installation conditions as FSC above, and where also subjected to one or more of the following conditions:

   a. Exterior locations;

   b. Condensating, moist, wet or humid conditions;

   c. Corrosive atmospheres;

   d. Water spray;

   e. Dripping oil, grease or water.

3. Install FSC and LSC with a separate, insulated copper, code-sized, equipment-grounding conductor, installed inside the flexible conduit.

F. Surface Metal Raceways

1. Only metallic surface metal raceways will be permitted, unless otherwise shown on the Contract Drawings. Installation shall be in accordance with manufacturer's written recommendations and instructions accompanying the raceways.

2. Provide surface raceway system with means for assuring a continuous ground path throughout.

3. Use fittings without sharp edges introduced into any part of the raceway system.

G. Underfloor Raceways

Install underfloor raceways in accordance with the Contract Drawings NFPA 70, ANSI/UL 884 and the recommendations and requirements of the manufacturer.

H. Polyvinyl Chloride (PVC) Conduit

1. PVC Conduit shall not be used indoors.

2. PVC Conduits Types 40 and 80 conform to NFPA 70 Article 347 except it shall not be used indoors.

3. PVC Conduits Types 40, A and EB shall be used for concrete encasement.

4. PVC Conduit Type DB shall be used for direct burial, sand encased.

I. High-Density Polyethylene (HDPE) Conduit

1. HDPE conduit shall not be used indoors.

2. HDPE Type 40 shall be used for direct burial or encased in concrete.

J. Fiberglass Reinforced Epoxy (FRE) Conduit

1. Shall be installed as described in NFPA 70.

2. All sweeps, bends, or changes in direction shall be done with fittings only.

3. Elbows and fittings shall be manufactured from the same resin/hardener/glass system as the conduit.

K. Dissimilar Metals

1. "Dissimilar metals" shall mean those metals which are incompatible with one another in the presence of moisture, as determined from their relative positions in the Electrochemical Series, or from test data.

2. Where dissimilar metals come in contact, paint the joint both inside and out with approved coating to exclude moisture from the joint, or provide a suitable insulating barrier separating the metals.

3.02 FIELD TESTS

A. Conduit Cleaning and Testing

1. After installation of conduits and accessories and completion of all concreting operations, if any, carefully clean and clear all conduit runs of all obstructions and foreign matter to the satisfaction of the Engineer.

2. Test conduits, in the presence of the Engineer, by pulling through each conduit a flexible cylindrical mandrel having an outside diameter not more than 1/4 inch smaller than the inside diameter of the conduit, but nominally 85 percent of the trade diameter, whichever is larger. Only nylon cable of adequate strength shall be used to pull the mandrel through the conduit system. The use of rope will not be permitted.

B. Connections to Existing Conduits

1. Where conduits installed under this Contract are connected to existing conduits, or conduits installed by others, test the entire run to the nearest box, manhole, handhole, or equipment enclosure as specified in 3.02 A.2 above.

2. Report immediately to the Engineer any defect or stoppage found in portions of the conduit system not installed under this Contract. Do not attempt to rectify any defect or stoppage found in conduit not installed under this Contract unless specifically instructed to do so by the Engineer. The Contractor's compensation for the rectifying of such defects or stoppages at the direction of the Engineer will be determined in accordance with the Clause of the Contract providing compensation for Extra Work.

3. The Engineer shall be the sole judge as to whether a defect or stoppage exists. Perform all tests required by the Engineer to enable him to make his decision.

END OF SECTION

SECTION 16110

RACEWAYS

APPENDIX A

SUBMITTAL REQUIREMENTS

A. Submit the following in accordance the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

1. Shop Drawings

   Raceway systems - only when shop drawings are required by the Contract Drawings

2. Catalog Cuts

   a. Conduit and Tubing

   b. Surface Metal Raceway and Accessories

   c. Underfloor Raceway and Accessories

   d. Wireways and Auxiliary Gutters

END OF APPENDIX "A"

SECTION 16110

RACEWAYS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(1.04)	List all raceway systems that require shop drawings. Require shop drawing where installation details must be determined before construction.
(2.01 A.1)	Show locations, types and sizes of raceways
(2.01 K)	Specify fasteners that are not hot dipped galvanized steel, such as hot dipped galvanized PVC coated or stainless steel.
(3.01 A.3)	Show special dissimilar metal transition methods (other than the specified method).
(3.01 A.5)	Show raceways that are not run parallel or at right angles to the line of the building.
(3.01 B.1)	Show or specify areas where RGS shall be used, such as hazardous locations, under a runway in wet locations, where a transition from underground to above ground is taking place.
(3.01 F.1)	Specify all surface raceways that are not metallic.

B. Other Items

Ensure that the Specifications include the following Sections referenced in this Section:

(2.01 K) "SUPPORTING DEVICES"

1. For World Trade Center contracts where floor outlets for power and communications are required, specifier shall call for "Palucell" fire stop packets as shown on the Contract Drawings, No substitutions will be permitted.
2. Specify required submittals by editing Appendix A "Submittal Requirements".

END OF INSTRUCTIONS

DIVISION 16

SECTION 16114

CABLE TRAYS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies the requirements for metallic and non-metallic cable trays and their accessories.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

	American Society for Testing and Materials (ASTM)
ASTM A 153	Standard Specification for Zinc Coatings (Hot Dip) on Iron and Steel Hardware
ASTM A 123	Standard Specification for Zinc Coatings (Hot Dip) on Assembled Steel Products
ASTM A 653	Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process
ASTM A 568	Standard Specification for Steel, Sheet, Carbon, and High-Strength, Low Alloy, Hot-Rolled and Cold-Rolled Sheet, General Requirements for
ASTM D 150	Standard Test Methods for AC Loss Characteristics and Permitivity (Dielectric Constant) of Solid Electrical Insulation
ASTM D 696	Standard Test Methods for Coefficient of Linear Thermal Expansion of Plastics
ASTM D 2583	Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor
ASTM E 84	Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E 162	Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source
ASTM E 662	Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials
ASTM A 924	Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
	Military Specification (MIL)
MIL C 24643	Cable and Cord, Electrical, Low Smoke for Shipboard use, General Specification

National Electrical Manufacturers' Association (NEMA)

NEMA FG 1	Fiberglass Cable Tray Systems
NEMA VE 1	Metallic Cable Tray Systems

National Fire Protection Association (NFPA)

NFPA 70	National Electrical Code
NFPA 258	Standard Research Method for Determining Smoke Generation of Solid Materials

Underwriters Laboratories (UL)

UL 94	Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

The cable trays shall be designed, manufactured, and tested in accordance with the latest revision of the applicable ASTM, NEMA, NFPA, UL and MIL. SPEC. Standards. Where a discrepancy exists between the various standards, the most stringent requirements shall apply.

1.04 QUALITY ASSURANCE

Cable trays of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

1.05 DELIVERY, STORAGE AND HANDLING

A. Deliver material in manufacturer's original, unopened, protective packaging.

B. Store materials in a clean, dry space and protect them from weather.

C. Handle in a manner to prevent damage to finished surfaces.

D. Where possible, maintain protective coverings until installation is complete and remove such coverings as part of final cleanup.

E. Touch up any damage to finishes to match adjacent surfaces.

1.06 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURER

Subject to compliance with requirements of this Section, provide cable tray products of one of the manufacturers listed on the Contract Drawings.

2.02 CONSTRUCTION FEATURES

A. Cable trays shall be furnished as a complete system, including, but not limited to, all necessary fasteners, old-down clips, connectors, support systems, barrier strips, covers, horizontal and vertical fittings including elbows, reducers, tees and crosses. The cable tray system shall be in accordance with the requirements of NFPA 70.

B. Cable tray fittings shall be fully assembled by the manufacturer.

C. As shown on the Contract Drawings, cable tray shall be ventilated or non-ventilated, and of the ladder, trough, solid bottom or channel-type, with or without covers of the ventilated or non-ventilated type.

D. Cable tray size shall be as shown on the Contract Drawings. The minimum size shall be:

1. Width: 12 inches (inside)
2. Depth: 4 inches (outside)
3. Radii of Fitting: 24 inches (inside)

2.03 METALLIC CABLE TRAYS

A. Material

As shown on the Contract Drawings, the material shall be:

1. Galvanized Steel
   a. Ladder, trough and solid bottom cable trays
      (1) Hot dipped after fabrication
      (2) Minimum 16 gauge
      (3) The material and galvanizing process shall be in accordance with the following: ASTM A 123 ASTM A 153 ASTM 568ASTM A 653 ASTM A 924
2. Aluminum
   a. Ladder and trough cable trays
      (1) Aluminum alloy shall be 6063-T6
   b. Solid bottom cable trays
      (1) Aluminum alloy shall be 5052
      (2) Corrugated construction
   c. Cover
      (1) Aluminum alloy shall be 3003
      (2) Solid flanged construction

B. Connectors

Connectors for tray sections shall be universal for use on straight sections and fittings. Connectors shall be of the high pressure, bolted type with the required number of bolts.

2.04 NON-METALLIC CABLE TRAYS

A. Splice plate fasteners shall be fiberglass encapsulated stainless steel. Fasteners must be capable of withstanding torque of 10 foot-pounds, without damage to threads or encapsulated coating.

B. Material

1. Cable trays shall be of pultruded glass reinforced polyester, meeting the following standards:

   ASTM D 2583, ASTM D 696, ASTM D 150ASTM E 162, ASTM E 84

2. The completed assembly shall pass the smoke generation test for both flaming and non-flaming when tested in accordance with ASTM E 662 and NFPA 258.Smoke density shall be measured by using the Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials in NFPA 258.

3. Halogen content not to exceed 0.2 percent when tested in accordance with MIL C 24643.

4. Flammability classification in accordance with UL 94.

C. Physical Properties

The manufacturer shall provide values for Mechanical, Electrical, Fire Retardant, Thermal Bending and Other Properties of the cable tray products in reference to related ASTM, NEMA, NFPA, UL, MIL SPEC Standards for the Purchaser's review

D. Veil

Glass reinforced polyester components shall have a dacronnexus veil applied to exterior surfaces to improve weatherability and inhibit ultraviolet degradation. An ultraviolet stabilizer shall be incorporated into the resin formulation in order to further inhibit ultraviolet degradation.

2.05 STRUCTURAL DESIGN

A. Cable tray shall be of ladder type design having "C" or "I" shaped side rails for metallic tray and "C" or "E" shaped side rails for non-metallic tray, as shown on the Contract Drawings.

B. Rungs shall be of the same material as the side rail and securely bonded in place. Rungs shall be mechanically locked into place by means of an intermediate side rail flange to prevent rollover when cables are pulled into the tray.

C. Unless otherwise shown on the Contract Drawings, cable tray sections shall be 20 feet in length (+/- 1/8 inch) excluding splice plates. Each straight section shall be furnished with pre-punched holes for splice plate attachment.

D. Tray system design shall meet or exceed loading capabilities in accordance with NEMA VE 1 and NEMA FG 1for Metallic and Non-metallic trays, respectively.

E. The fully loaded tray shall also be capable of supporting a 200 lb. concentrated static load at mid-span without failure or permanent deflection.

F. Manufacturer shall provide certified test data to verify compliance with above loading and deflection data.

2.06 WARNING SIGNS

Furnish and install warning signs, wording and layout as shown on the Contract Drawings.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install cable tray in conformance with NEMA VE 1, NEMA FG 1 and NFPA 70 requirements, in accordance with the manufacturer's instructions and the following minimum requirements:

1. Cable tray shall be installed as a complete and continuous system, using the manufacturers standard fittings, from source to termination.
2. Drop-offs, take-offs, or extensions from cable tray system shall be via raceways approved by the Engineer. Raceways shall be fastened to the cable tray system using fittings approved or listed by a qualified electrical testing laboratory. Open or exposed cable leaving a cable tray system without a raceway is not permitted.

B. Support cable tray at each connection point, at the end of each run, and at other points to maintain spacing between supports of 10 feet, maximum.

C. Use expansion connectors where indicated in NEMA VE 1 and NEMA FG 1.

D. Cut standard straight sections to length in field.

E. Install warning signs, not to exceed 50 foot on center, on each side of the cable tray, along the route of the cable tray, located to be visible from the floor level.

F. Provide bonding continuity between metallic cable tray sections and fittings in accordance with the manufacturer's instructions.

END OF SECTION

SECTION 16114

CABLE TRAYS

APPENDIX "A"

A. Submittal Requirements

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

1. Shop Drawings

   a. Outline drawings showing straight sections, horizontal and vertical fittings, connectors, covers and supports.

   b. Outline drawings showing dimensions, support points and weights of the sections and fittings.

   c. Bill of material for all equipment including description and part number

   d. Installation instruction including list of special tools required for field installation.

B. Test Reports

Submit data on the physical properties of the cable tray system as specified in 2.04 of this Section.

END OF APPENDIX "A"

SECTION 16114

CABLE TRAYS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.01) List of manufacturers of the cable tray system. List a minimum of (2) two manufacturers and include "approved equal". If an item is unique of "sole source" then a "sole source" letter will be required.

B. Suggested List of Manufacturers

Square D Company
T. J. Cope
MP Husky
Chalfont Mfg. Co.
George Ingraham
Robroy Industries
B-Lineh. Enduro Composite Systems

(2.02 A) Type of cable tray - ventilated or non-ventilated, the ladder, trough, solid bottom or channel type with or without covers.

(2.02 B) The size of cable tray.

(2.03 A) Material for metallic cable tray - galvanized steel or aluminum.

(2.04 A) Fasteners for Non-metallic cable tray – Stainless steel with fiberglass encapsulation or high strength non-metallic fastener.

(2.05 A) Side rails, shape - "C", "E" or "I" for the ladder type cable tray.

(2.05 C) Length of cable tray sections other than 20 feet long.

(2.06) Wording and layout for warning signs.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16115

UNDERGROUND CONDUIT SYSTEMS

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies requirements for underground conduits, manholes, handholes, vaults and accessories.

B. Definitions

1. Conduit: A single enclosed raceway for wires or cables; duct.
2. Ductbank: A structure containing one or more ducts or conduits.
3. Conduit System: A combination of conduit, conduits, manholes, handholes and vaults joined to form an integrated whole.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

	American National Standards Institute (ANSI)
ANSI C 2	National Electrical Safety Code
ANSI C 80.1	Rigid Steel Conduit - Zinc Coated
	American Society for Testing and Materials (ASTM)
ASTM A 185	Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
	Institute of Electrical and Electronics Engineers, Inc. (IEEE)
IEEE 837	Standard for Qualifying Permanent Connections Used in Substation Grounding
	National Electrical Manufacturers Association (NEMA)
NEMA RN 1	Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 2	Electric Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80)
NEMA TC 14	Filament-Wound Reinforced Thermosetting Resin Conduit and Fittings
	National Fire Protection Association (NFPA)
NFPA 70	National Electrical Code
OSHA	Occupation Safety and Health Administration
	Underwriters Laboratories Inc. (UL)
UL 6	Rigid Metal Conduit
UL 514B	Fittings for Conduits and Outlet Boxes

UL 467	Electrical Grounding and Bonding Equipment
UL 651	Schedule 40 and 80 Rigid PVC Conduit
UL 651A	Type EB and A Rigid PVC Conduit and HDPE Conduit

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

The underground conduit system shall be furnished and installed in accordance with this Section and as specified on the Contract Drawings.

A. Components of the underground conduit system manufactured, supplied, and installed shall comply with the requirements of NFPA 70, all local codes, and the requirements of OSHA.

1.04 QUALITY ASSURANCE

A. The manufacturer shall have had a minimum of three years experience within the last five years in manufacturing the products of the type(s) and size(s) described in this Section. Those products shall have been satisfactorily used for purposes similar to those intended herein. The Contractor shall provide a list of installations and contracts for which the manufacturer has produced such materials.

B. All electrical materials and equipment for which there is a nationally recognized standard, shall bear the conformance label of the nationally recognized third party inspection authority, such as Underwriters Laboratories Inc. (UL), Factory Mutual (FM) or ETL.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in manufacturer's original, unopened, protective packaging. Protective caps shall be removed immediately prior to installation of conduit.

B. Store materials in a clean, dry space and protect them from weather.

C. Handle in a manner to prevent damage to finished surfaces.

1.06 SUBMITTALS

For submittal requirements, see Appendix "A".

PART 2. PRODUCTS

2.01 MATERIALS

A. General

1. Location, types and sizes of conduits and conduit systems are shown on the Contract Drawings.

2. Conduits shall be supplied in standard lengths in accordance with applicable UL standards.

3. Unless otherwise shown on the Contract Drawings, conduit or duct shall be type RGS as specified in this Section.

B. Rigid Metal Conduit

1. RGS - Galvanized steel conduit (heavy-wall) shall be hot dipped galvanized after cutting and threading and shall conform to UL 6 and ANSI C 80.1.

2. RGS-PV - PVC coated, galvanized steel conduit (heavy-wall) shall be hot dipped galvanized after cutting and threading, shall be coated with 40 mils of PVC and shall conform to NEMA RN 1, Type A 40.

3. All preformed elbows shall be similar in construction to and of a type designed for use with the appropriate conduit and shall conform to UL 6.

4. All fittings shall be threaded.

C. Rigid Nonmetallic Conduit

1. PVC-T - Schedule 20 (thin-wall) polyvinyl chloride (PVC) conduit shall conform to UL 651A.

2. PVC-H - Schedule 40 (standard-wall) polyvinyl chloride (PVC) conduit shall conform to UL 651.

3. PVC-80 - Schedule 80 (extra heavy-wall) polyvinyl chloride (PVC) conduit and elbows shall conform to NEMA TC 2 and UL 651.

4. Fiberglass reinforced epoxy conduit shall be glass filament wound, embedded in ultra-violet resistant epoxy. Conduit fittings and elbows shall conform to NEMA TC 14 and the following:

   a. FGS-T - Standard-wall conduit, wall thickness shall be not less than 70 mils for all sizes. Type FGS-T conduit shall be used only where encased in concrete.

   b. FGS-S - Heavy wall conduit, UL listed, with a wall thickness not less than 70 mils for conduits less than 4 inch trade size, not less than 90 mils for conduits 4 inch trade size and not less than 110 mils for conduits larger than 4 inch trade size. Type FGS-H shall be used where direct buried, encased in concrete, or where conduit risers extend to above grade, in accordance with the requirements of the UL listing.

   c. FGS-E - Extra-heavy wall conduit, with a wall thickness not less than one-quarter inch. Type FGS-E conduit shall be used for exposed exterior conduit runs on bridges and elevated structures.

5. Elbows, fittings, offsets, etc. shall be preformed and similar in materials and construction to the conduit.

6. Couplings shall be of a type to provide a watertight installation of the conduit system.

D. Manholes, Handholes, and Vaults

1. Precast manholes, handholes and vaults shall be as shown on the Contract Drawings. Concrete shall be in accordance with the requirements of Division 3 Section on concrete.

2. Cast-in-place manholes, handholes and vaults conforming in size and strength to the precast manholes, handholes and vaults shown on the Contract Drawings may be substituted, subject to the approval of the Engineer.

3. Continuous inserts shown on the Contract Drawings shall be hot-dipped galvanized steel, and shall be supplied complete with end caps and waxed cardboard closure strips. All metallic parts shall have a hot-dipped galvanized finish.

4. Racking assemblies shall be capable of being mounted on the continuous inserts supplied in manhole, handhole and vault walls, without modification, utilizing hot-dipped galvanized spring nuts and bolts.

   a. The racking assemblies shall, at a minimum, include supports on each wall of the manhole, handhole or vault, with arms on each support for each cable or arc-proofed cable group. Each arm shall have insulators to support each cable or cable group. Provide additional arms and insulators as shown on the Contract Drawings.

   b. Racking assembly arms and insulators, for installation on existing supports, shall match the existing supports without modification.

5. Manhole, handhole and vault frames and covers shall be as shown on the Contract Drawings.

6. Provide pulling hooks shall be Hubbard Co. No. 9119, or approved equal.

E. Grounding Assemblies

1. Grounding bushings shall be plated malleable iron body, insulated type, rated 150 degrees C.

2. Ground rods shall be minimum 3/4-inch diameter, copper-clad steel. Unless otherwise shown on the Contract Drawings, ground rods shall be 10 feet long.

3. Unless otherwise shown on the Contract Drawings, conductors for grounding assemblies within manholes, handholes, or vaults shall be copper, minimum #4 AWG.

4. Ground rod connections shall be either exothermic welds, or high-strength compression-crimp system conforming to the requirements of IEEE 837 and UL 467, or approved equal.

5. Ground cable clamps shall be split-bolt, high strength, copper alloy connectors.

PART 3. EXECUTION

3.01 EXAMINATION

A. Inspect all conduit, equipment and accessories prior to installation. Replace any damaged items.

3.02 PREPARATION

A. The Contractor shall be responsible for field verification of dimensions and existing underground utilities.

3.03 INSTALLATION

A. General

Underground conduit systems shall be installed in accordance with the requirements of ANSI C 2, NFPA 70 and as shown on the Contract Drawings.

B. Excavation and Backfill

Excavation and backfill for underground conduits, handholes, manholes and shall be in accordance with the applicable requirements of the Section entitled "EXCAVATION, BACKFILLING AND FILLING" of these Specifications.

C. Concrete Encased Conduit

1. Concrete encasement of conduit shall conform to the details shown on the Contract Drawings and the requirements of Division 3 Section on concrete.
2. The dead-ending of conduit shall be accomplished as shown on the Contract Drawings.
3. No variation from a straight line of greater than 1/2 inch in fifty feet will be permitted when installing a concrete encased conduit.
4. Reinforce junctions with existing concrete encased conduit, or existing systems, with W8 x W4 - 10 x 10 welded wire fabric, conforming to ASTM A 185, encased in four inches additional thickness of concrete around each set of conduits. The additional encasement shall extend at least four feet in each direction from the junction.
5. Where the placing of concrete is interrupted for one hour or more, reinforce the concrete encasement at the point of interruption with W4 x W4 - 10 x 10 welded wire fabric, conforming to ASTM A 185.
6. Preformed or precast conduit may be substituted for the field-encased type, subject to the approval of the Engineer. All precast conduit shall meet the same requirements specified herein or shown on the Contract Drawings.
7. All conduits shall leave or enter structures perpendicularly.
8. Changes in direction of conduits shall be made by bends having a minimum radius of 15 feet. Elbows or sweeps to equipment or foundations shall have a radius not less than 10 times the trade diameter of the conduit.
9. Conduits shall be installed in true alignment and shall be sloped for drainage toward manholes or handholes. All free ends of empty conduits shall be sealed to prevent water entrance.
10. Openings for conduits in manhole construction shall be sealed and made watertight in an approved manner.
11. Transitions between conduits of different materials shall be made using the manufacturer's standard adapters.
12. Terminations of rigid nonmetallic conduits in manholes, handholes, and other concrete structures, shall be made with end bells, set flush with the inside face of the concrete.

13. Terminations of rigid metal conduits in manholes, handholes, vaults and other concrete structures, shall be made with insulated grounding bushings, projecting 2 inches beyond the inside face of the concrete.

D. Direct-Buried, Rigid Nonmetallic Conduit (PVC-H or FRE)

1. Direct-buried conduits shall be laid on firmly tamped and graded stone-free sand not less than 2 inches deep. Backfill in contact with the conduits shall be sand to a minimum of 3 inches above the conduits and the remainder of the backfill shall be unfrozen, stone-free earth. Buried depth shall be as shown on the Contract Drawings.

2. Conduit entering or exiting manholes, handholes, vaults and other concrete structures shall be a 10-foot length of rigid metal conduit protected with two coats of asphaltic paint.

3. Terminations of conduits in manholes, handholes, vaults and other concrete structures shall be made with insulated grounding bushings projecting 2 inches beyond the inside face of the concrete.

E. Manholes, Handholes, and Vaults

1. Set precast manholes, handholes and vaults so that they are firmly and fully bedded at required grades.

2. Set frames and covers using mortar and masonry as required. Radially laid concrete brick shall have 1/4-inch thick vertical joints at inside perimeter. Lay all concrete brick in a full bed of mortar and completely fill all joints. Where more than one course of concrete brick is required, stagger vertical joints.

3. Set racking assemblies as required so that the unsupported length of wires or cables shall not exceed 30 inches.

F. Vertical Adjustment of Existing Manholes, Handholes, and Vaults

1. Adjust the top elevation of existing structures to suit new finished grades in accordance with the details shown on the Contract Drawings.

2. Existing frames and covers shall be carefully removed, cleaned of all mortar fragments to the satisfaction of the Engineer and reset at the required elevation in accordance with the requirements shown on the Contract Drawings.

G. Grounding

1. Install a complete grounding system in each manhole or vault, and in selected handholes shown on the Contract Drawings. Electrically bond all arm supports, insulated grounding bushings, and ground rods together.

2. After installation, coat all bare surfaces or connections in the grounding system with asphaltic paint.

H. Testing

1. Test conduits, in the presence of the Engineer, by pulling through each conduit a flexible cylindrical mandrel having an outside diameter not more than 1/4 inch smaller than the inside diameter of the conduit, but nominally 85 percent of the trade diameter, whichever is larger. Only nylon cable of adequate strength shall be used to pull the mandrel through the conduit system. The use of rope will not be permitted.

I. Connections to Existing Conduits

1. Where conduits installed under this Contract are connected to existing conduits, test the entire run to the nearest box, manhole, handhole, vault or equipment enclosure, including all existing conduits installed by others, that will be used under this Contract.

2. Where any work shall be performed in conduits emanating from a manhole, handhole, vault or equipment enclosure, all existing spare conduits (conduits containing no electric wire or cable) shall be tested to the nearest manhole, handhole, vault or equipment and a pull line shall be left in place in each such conduit.

3. Report immediately to the Engineer any defect or stoppage found in portions of the conduit system not installed under this Contract. Do not attempt to rectify any defect or stoppage found in conduit not installed under this Contract unless specifically instructed to do so by the Engineer. The Contractor's compensation for the rectifying of such defects or stoppages at the direction of the Engineer will be determined in accordance with the clause of the Contract providing compensation for Extra Work.

4. The Engineer shall be the sole judge as to whether a defect or stoppage exists. Perform all tests required by the Engineer to enable him to make his decision.

3.04 ADJUSTMENTS

A. Conduit Cleaning

After installation of conduits, manholes, handholes, vaults, accessories and completion of all concreting operations, if any, carefully clean and clear all conduits of all obstructions and foreign matter to the satisfaction of the Engineer.

END OF SECTION

SECTION 16115

UNDERGROUND CONDUIT SYSTEMS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Handholes
2. Vaults
3. Frames and covers
4. Manholes, including "exploded" views with complete details as to the location of all existing and new conduits, wires and cables identified by permanent feeder numbers, racking assemblies and grounding assemblies. Manhole drawing blanks will be furnished by the Engineer.

B. Catalog Cuts

1. Conduit
2. Racking assemblies
3. Grounding assemblies
4. Continuous inserts

END OF APPENDIX "A"

SECTION 16115

UNDERGROUND CONDUIT SYSTEMS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.01 A.1)	Locations, types and sizes of conduits and conduit systems
(2.01 D.1)	Precast manholes, handholes, and vaults
(2.01 D.2)	Cast-in-place manholes, handholes and vaults
(2.01 D.3)	Continuous inserts
(2.01 D.4.a)	Additional racking assembly arms and insulators other than specified
(2.01 D.5)	Manhole, handhole, and vault frames and covers
(2.01 E.2)	Ground rod size, other than specified
(2.01 E.3)	Ground conductor size, other than specified
(3.03 A)	Underground conduit system requirements
(3.03 C.1)	Details of concrete encased conduit
(3.03 C.2)	"Dead-ending" of conduit
(3.03 C.6)	Special requirements of preformed or precast conduits
(3.03 D.1)	Required depth of direct-buried conduit
(3.03 F.1)	Details of vertical adjustment of existing manholes, handholes and vaults
(3.03 F.1)	Required top elevation(s) of vertically adjusted structures
(3.03 G.1)	Selected handholes requiring complete grounding system
(3.03 I.1)	Conduit installed by others

B. Other Items

Ensure that the Specifications include the following Sections referenced in this Section:

(2.01 D.1)	"CONCRETE"
(3.03 B)	"EXCAVATION, BACKFILLING AND FILLING"

C. Recommended Manufacturers

(2.01 B.1) Rigid galvanized steel conduit; shall be as manufactured by OCAL, Occidental Coating Company or approved equal.

(2.01 B.2) PVC coated rigid galvanized steel conduit; shall be as manufactured by Robroy Industries or approved equal.

(2.01 C) Polyvinyl Chloride conduit; shall be as manufactured by Carlon Company or approved equal.

(2.01 C.4) Fiberglass reinforced epoxy conduit; shall be as manufactured by Smith Fiberglass Products, Inc., or approved equal.

(2.01 D.2) Manholes, handholes and vaults; shall be as manufactured by Berri-Roche or approved equal.

(2.01 D.5) Manhole and handhole frames and covers; shall be as manufactured by Campbell Foundry or approved equal.

(2.01 D.3) Continuous Inserts; shall be as manufactured by Unistrut Corporation or approved equal.

(2.01 D.4) Manhole and Handhole Racking assemblies; shall be as manufactured by A.B. Chance or approved equal.

(2.01 E.4) Grounding clamps and connections; shall be as manufactured by Burndy Corporation, Cadweld, or approved equal.

(2.01 E.2) Ground Rods; shall be as manufactured by Cadweld, or approved equal.

(2.01 E.1) Grounding bushings; shall be as manufactured by O-Z/Gedney. or approved equal.

D. Coordination With Other Sections

1. This Section applies specifically to exterior Underground Conduit Systems. For installation of a complete Underground Conduit System ensure that the following Sections, at a minimum, are incorporated in the Specifications:

   RACEWAYS
   WIRES, CABLES, SPLICES, TERMINATIONS (MEDIUM VOLTAGE)
   WIRES, CABLES, SPLICES, TERMINATIONS (MEDIUM VOLTAGE)
   ARCPROOFING

E. This Section applies specifically to exterior Underground Conduit Systems. Those continuations or extensions of the Conduit System that are in or under buildings or other structures are incorporated into the Section entitled "RACEWAYS".

END OF INSTRUCTIONS

DIVISION 16

SECTION 16120

WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS)

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for wires, cables, splices, terminations, and appurtenances for electrical systems of 600 volts or less.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

American Society for Testing and Materials (ASTM)

ASTM B 1	Hard-Drawn Copper Wire
ASTM B 2	Medium-Hard-Drawn Copper Wire
ASTM B 3	Soft or Annealed Copper Wire
ASTM B 8	Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B 33	Tinned Soft or Annealed Copper Wire for Electrical Purposes
ASTM B 174	Bunch-Stranded Copper Conductors for Electrical Conductors
ASTM B 189	Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes
ASTM D 2802	Ozone-Resistant Ethylene-Propylene-Rubber Insulation for Wire and Cable
ASTM D 3005	Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape
ASTM E 662	Standard Test Method for specific Optical Density of Smoke Generated by Solid Materials

Federal Specifications (FS)

HH-I-553	Insulation Tape, Electrical (Rubber, Natural and Synthetic)

Insulated Cable Engineers Association (ICEA)

ICEA S-19-81	Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC 3)

ICEA S-61-402	Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC 5)
ICEA S-66-524	Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC 7)
ICEA S-68-516	Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC 8)
ICEA T-33-655	Guide for Low Smoke, Halogen-Free (LSHF) Polymeric Cable Jackets

Institute of Electrical and Electronics Engineers (IEEE)

IEEE 383	Type Test of Class 1E Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations
IEEE 837	Standard for Qualifying Permanent Connections Used in Substation Grounding

Military Specifications

MIL C-24643	Electrical Cable and Cord for Shipboard Use, Testing for Low Smoke and Halogens

National Fire Protection Association (NFPA)

NFPA 70	National Electrical Code

Naval Engineering Standards

NES 713	Determination of Toxicity Index of Products of Combustion From Small Specimens of Materials

Underwriters Laboratories Inc. (UL)

UL 44	Rubber-Insulated Wires and Cables
UL 62	Flexible Cord and Fixture Wire
UL 83	Thermoplastic-Insulated Wires and Cables
UL 467	Grounding and Bonding Equipment
UL 510	Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 854	Service-Entrance Cables
UL 1581	Reference Standard for Electrical Wires, Cables, and Flexible Cords
UL 1685	Standards for Safety Vertical Tray Fire Propagation and Smoke Release Test for Electrical and Optical Fiber Cables

1.03 QUALITY ASSURANCE

A. Wires and cables which have been manufactured more than two years prior to installation shall not be used in the Work of this Section.

B. Tapes for splices or terminations shall be dated by the tape manufacturer to indicate that they have been manufactured no longer than six months prior to use in the Work of this Section.

C. Polyvinyl Chloride (PVC): PVC-insulated power wiring and items containing PVC, except PVC-insulated wiring for communications systems, remote control, signaling, and power-limited circuits, shall not be installed in indoor area. PVC-insulated wiring for communications systems, remote control, signaling, and power-limited circuits shall be furnished and installed in accordance with NFPA 70.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Single conductor wire or cable sizes #4/0 AWG and larger that are to be installed in the same raceway shall be paralleled by the cable manufacturer prior to shipment. Cable assembly overall diameter shall be kept to a minimum.

B. Wire and cable sizes #4/0 AWG and larger shall be provided with fctory-applied caps unless otherwise shown on the Contract Drawings. End seals shall be heat-shrink, irradiated, modified polyolefin, and shall be sized for individual wires and cables.

C. Store material in a clean, dry space and protect it from the weather.

1.05 SUBMITTALS

See Appendix "A" for submittals requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide wires, cables, wire and cable splicing, terminating and arcproofing materials of manufacturers as shown on the Contract Drawings.

2.02 WIRES AND CABLES

A. General

1. Definitions

a. Wire shall be defined as a solid or stranded conductor smaller than No. 6 AWG with or without insulation.

b. Cable shall be defined as a single conductor No. 6 AWG or larger, or two or more conductors of any size wire under a common covering.

2. Locations, types, sizes and numbers of wires and cables are shown on the Contract Drawings. Where not indicated, provide proper wire and cable selection to comply with this section and NFPA 70 Standards.

3. Unless otherwise shown on the Contract Drawings, solid conductors shall be soft or annealed copper, conforming to ASTM B 33 (tinned), ASTM B 189 (lead-coated or lead-alloy coated), or ASTM B 3 (uncoated). Unless otherwise specified in this Section or unless otherwise shown on the Contract Drawings, stranded copper conductors shall be concentric stranding conforming to ASTM B 8.

4. Unless otherwise shown on the Contract Drawings, cable jackets for interior use shall be low smoke, low toxicity, non-halogen, flame retardant type and shall meet the following performance characteristics:

   a. Cables shall pass the flame propagatory and smoke release criteria according to the test method of UL 1685.

   b. The halogen content of cable jackets shall not exceed 0.2 percent according to the test method of MIL-C-24643. The Authority classifies 0.2 percent or less halogen content as "non-halogen".

   c. The toxicity index of cable jackets shall not exceed 4.0 according to the test method of NES 713.

   d. The cable jackets shall comply with ICEA T-33-655 for smoke generation.

   e. The acid gas content of cable jackets shall not exceed a maximum of 3.0 percent according to the test method of MIL-C-24643.

5. Use the additional performance characteristics for wires and cables which will be installed in subway areas, substations, tunnels, etc. where stringent flame retardency, low smoke, low toxicity, zero halogen and good circuit integrity during a fire are required.

   a. Wires shall pass the flame propagatory criteria according to the test method of VW-1.

   b. The halogen content of both the wire and cable insulation and cable jacket(s) shall not exceed 0.2 percent according to the test method of MIL-C-24643. The Authority classifies 0.2 percent or less halogen content as "non-halogen".

   c. The toxicity index of both the wire and cable insulation and cable jacket(s) shall not exceed 2.0 according to the test method of NES 713.

   d. The acid gas content of both wire and cable insulation and cable jacket(s) shall not exceed a maximum of 2.0 percent according to the test method of MIL-C-24643.

e. The wire and cable insulation materials shall pass the smoke generation test in accordance with ASTM E 662. Wire and cable insulation when tested on a specimen of 80 mils thick slab shall not exceed the following values:

Flaming Avg. Ds (4 minutes)	100
Flaming Avg. Dm (20 Minutes)	200
Non-Flaming Avg. Ds (4 minutes)	100
Non-Flaming Avg. Dm (20 minutes)	350

f. The cable jacket materials shall pass the smoke generation test in accordance with ASTM E 662. Wire and cable jacket when tested on a specimen of 80 mils thick slab shall not exceed the following values:

Flaming Avg. Ds (4 minutes)	50
Flaming Avg. Dm (20 minutes)	150
Non-Flaming Avg. Ds (4 minutes)	50
Non-Flaming Avg. Dm (20 minutes)	250

6. Color-Coding for Power and Lighting Conductors

a. Insulation or covering of wires and cables shall be factory color-coded by the use of colored compounds or coatings. The color-code shall be followed cnsistently throughout the performance of the Work.

b. Upon written request of the Contractor, the Engineer may permit the use of the following methods in lieu of the wire or cable manufacturer's color-coding, when limited quantities of wire and cable are involved, for sizes #8 AWG and larger.

(1) For dry locations only, spiral application of 3/4 inch wide, colored pressure sensitive plastic tape, half lapped for a distance of not less than six inches may be used. To prevent unwinding, the last two wraps of tape shall be applied with no tension.

(2) For wet or dry locations, application of three, 3/16 inch wide, colored, fungus-inert, self-extinguishing, self-locking, nylon cable ties spaced 3 inches apart may be used. The ties shall be snugly applied with a special tool or pliers, and any excess removed.

(3) Each wire and cable shall be color-coded at all terminal points, in all manholes, boxes, or other similar enclosures.

(4) Color markings shall be applied so as not to obliterate the manufacturer's identification markings.

c. Color code chart shall be as follows:

	System Voltage	
Conductor	208Y/120V	480Y/277V
Phase A	Black	Brown
Phase B	Red	Orange
Phase C	Blue	Yellow
Neutral	White	Gray
Ground	Green	Green

7. All wires, cables, splices and terminations, for which there are established UL standards, shall bear the UL label.

B. General-Purpose Wires and Cables

Unless otherwise shown on the Contract Drawings, general purpose wires and cables shall be as follows:

1. General-purpose wires and cables shall be single conductor, ASTMB8, Class B stranded for sizes #8 AWG and larger, and solid for sizes #10 AWG and smaller.

2. Select from the following list of UL wire and cable types:

a. Type XHHW: Flame retarding, Cross-linked-polyolifin insulation, conforming to UL 44, for dry locations only.

b. Type XHHW-2: Flame retardant, Cross-linked-polyolifin insulation, conforming to UL 44.

c. Type THWN: Flame retardant, moisture and heat resistant thermoplastic insulation with a nylon jacket or equivalent; Double rated THHN-THWN gasoline-oil resistant II; conforming to UL 83.

The use of this cable shall be in accordance with the requirements of paragraph 1.03C of this Section.

d. Type USE: Heat and moisture resistant ethylene- propylene-rubber insulation with heavy duty thermosetting chlrosulphanated polyethylene or heavy- duty neoprene jacket; multiple rated "USE-RHH-RHW"; conforming to ASTM D 2802, ICEA S-68-516, UL 44 and UL 854. Unless otherwise indicated, Type USE shall be the only wire and cable used for underground installations.

C. Overhead Service Cables

Unless otherwise shown on the Contract Drawings, overhead service cables shall be two or more type SE, ASTM B 8, Class B or Class C stranded, hard-drawn copper conductors, ethylene-propylene-rubber insulation, with heavy duty neoprene or heavy duty thermosetting chloro-sulphonated polyethylene jacketed, marked "sunlight resistant", conforming to ASTM D 2802, UL 44 and UL 854. Cable shall be factory assembled with copper-clad messenger conforming to ICEA S-68-516.

D. Portable Cords

Unless otherwise shown on the Contract Drawings, portable cords shall be as follows:

1. Type S shall be 60 degrees C rated, with heavy-duty thermosetting insulation and jacket, conforming to UL 62, 600-volt rated.
2. Type SO shall be oil resistant, 60 degrees C rated, with heavy-duty thermosetting insulation and jacket, conforming to UL 62, 600-volt rated.
3. Type G or Type W shall be 90 degrees C rated, with ethylene-propylene-rubber insulation and Hypalon jacket, 600-volt rated.
4. Special types shall be used only where shown on the Contract Drawings.

E. Lighting Fixture Wires

Unless otherwise shown on the Contract Drawings, lighting fixture wires shall be stranded only, and shall be Type SF-2, silicone rubber insulated conforming to UL 62.

F. Grounding Wires and Cables

Unless otherwise shown on the Contract Drawings, grounding wires and Cables shall be as follows:

1. Insulated
   a. Solid for sizes #8 AWG and smaller; ASTM B 8, Class B stranded for sizes #6 AWG and larger; and of the same insulation type as the power conductors.
   b. Covering shall be a continuous green color and conform to ASTM B 33 and UL 44.
2. Uninsulated
   a. General

      Solid for sizes #8 AWG and smaller; ASTM B8, Class B stranded for sizes #6 AWG and larger.

   a. In raceways

      Soft-drawn and conforming to ASTM B 3.

   b. Direct buried or encased in concrete

      Soft-drawn, medium-hard-drawn, or hard-drawn and conforming to ASTM B 1, B 2 or B 3, respectively.

G. Control Wires and Cables

Unless otherwise shown on the Contract Drawings, control wires and cables shall be as follows:

1. Single conductor wires and cables shall be ASTM B 8, Class B stranded, type XHHW or XHHW-2 flame retardent, cross-linked-polyolifin insulation. Both shall conform to UL44 and ICEA S-66-524.

2. Multiconductor cables shall be ASTM B 8, Class B or Class C stranded, Control Cable Type B, conforming to ICEA S-61-402. Color-coded as per ICEA S-61-402, Method No. 1 for NFPA 70 applications (with white and green) or ICEA S-19-81, for paired conductor cables. Select from the following list of cable types.

   a. Individual ethylene-propylene rubberinsulation with overall flame retardent, cross-linked-polyolifin jacket; conforming to ICEA S-68-516, UL 44, and UL 1581.

   b. Individual ethylene-propylene-rubber insulation with individual and overall flame-retardent, cross-linked polyolifin jackets; conforming to ICEA S-68-516 and UL 44.

   c. Individual flame retardent, cross-linked-polyolifin insulation with and overall flame retardent, cross-linked-polyolifin jacket; conforming to ICEA S-66-524.

   d. Individual cross-linked-polyolifin insulation with overall polyvinyl chloride jacket conforming to ICEA S-66-524.

   e. Individual polyolifin insulation with individual and overall polyvinyl chloride jackets conforming to ICEA S-61-402.

H. Switchboard Wires and Cables

Unless otherwise shown on the Contract Drawings, switchboard wires and and cables shall be as follows:

1. Switchboard wires and cables shall be single conductor, ASTM B 8, Class B stranded, except that for wires and cables crossing hinged joints and swinging panels, and where "Extra Flexible" wire or cable is shown on the Contract Drawings, conductors shall be ASTM B 174, Class K stranded.

2. Wires and cables shall be Type SIS, cross-linked-thermosetting-polyethylene insulation, conforming to ICEA S-61-402, IEEE383 and UL 44.

I. Cable Tags

1. Dry Locations

   a. Fiberglass tags, 1/16 inch thick and 3/4 inch wide, indented with letters and numbers 5/16 inch high, with #14 AWG copper or nylon, weather-resistant cable ties.

   b. Lighting branch circuit wiring and single conductor signal and control wiring may be identified with "Quiklables" manufactured by W. H. Brady Company, or approved equal.

2. Wet Locations

   Stainless steel metal tags, No. 28 gauge and 3/4 inch wide, embossed with letters and numbers 5/16 inch high, with #14 AWG copper or nylon, weather-resistant cable ties, or stainless steel cable ties.

2.03 SPLICING, TERMINATING AND ARCPROOFING MATERIALS

A. General

1. All splicing, terminating and arcproofing materials shall be compatible so that no one material will adversely affect the physical or electrical properties of any other, or of the wire or cable itself.

2. All materials for making splices and terminations shall be specifically designed for use with the type of wire or cable, insulation and installation and operating conditions of the specific application.

B. Connectors

Subject to compliance with requirements of this Section, provide connectors of the following types:

1. Solderless, uninsulated, high conductivity, corrosion resistant, compression connectors conforming to UL 467 and IEEE 837;

2. Insulated, indenter type compression butt connectors;

3. Insulated, integral self-locking flexible shell, expandable spring connectors;

4. Uninsulated, indenter type compression pigtail connectors;

5. Welded type connectors.

C. Terminals

Subject to compliance with requirements of this Section, provide terminals of the following types:

1. Solderless, uninsulated, high conductivity, corrosion resistant, compression terminals conforming to UL 467 and IEEE 837;

2. Insulated, compression terminals;

3. Solderless, high conductivity, corrosion resistant, hex screw type, bolted terminals;

4. Welded type terminals.

D. Shrinkable Tubing

Subject to compliance with requirements of this Section, provide shrinkable tubing of the following types:

1. Either irradiated modified polyvinyl chloride or irradiated modified polyolefin heat shrinkable tubing;

2. Cold shrinkable tubing.

E. Tapes and Sealers

1. Vinyl Tapes

Flame-retardent, cold and weather-resistant, 3/4 inch or 11/2 inches wide, as required, and conforming to UL 510 and ASTM D 3005.

a. For interior, dry locations, provide 7 mils, conforming to ASTM D 3005 (Type I); Scotch (3M) No. 33, or approved equal.

b. For exterior or damp and wet locations, provide 8.5 mils, conforming to ASTM D 3005 (Type II); Scotch (3M) No. 88, or approved equal.

2. Rubber Tapes

Ethylene-propylene, rubber-based, 30-mil splicing tape, rated for 130 degrees C operation; 3/4inch and wider (1, 1 1/2, 2 inches) as shown on the Contract Drawings or approved by the Engineer, conforming to Federal Specification HH-I-553 (Grade A); Scotch (3M) No. 130C, or approved equal.

3. Insulating Putty

Rubber-based, 125-mil elastic filler putty; 1 1/2 inches wide; Scotch (3M) Scotchfil, or approved equal.

4. Silicone Rubber Tapes

Inorganic silicone rubber, 12-mil, 130 degrees C rated, anti-tracking, self-fusing tape; 1 inch wide; Scotch (3M) No. 70, or approved equal.

5. Sealer

Liquid applied, fast-drying sealant; Scotch (3M) Scotchkote, or approved equal.

F. Resin Filled Splices

1. Epoxy Molded Type

Two-piece, snap-together molded bodies, sized for wire or cable, with two-part low viscosity polyurethane insulating and sealing compound, rated for 600 volts, using crimp-type wire connector; Scotch (3M) No. 82-A1, 82-A2 or 82-A3 compound, or approved equal.

2. Re-Enterable Type

Transparent, molded bodies clamped with stainless steel strain-relief bar and shield continuity connectors, sized for wire or cable, with loosely woven polyester spacer web and jelly-like urethane formulation for permanent re-entry capability; Scotch (3M) No. 78-R1 thru 78-R5, with No. 2114 compound, or approved equal.

G. Arcproofing Materials

1. Fire resistant tapes shall be Scotch (3M) No. 77, or approved equal.

2. Glass cloth binding tapes shall be Scotch (3M) No. 69, or approved equal.

H. Special splicing materials and methods shall be as shown on the Contract Drawings.

2.04 SHOP TESTS

A. For quantities as shown on the Contract Drawings, regular dielectric-withstand and insulation-resistance in water tests for wires and cables shall be performed in accordance with UL44.

B. Flame tests for wires and cables shall be performed in accordance with IEEE 383.

C. The test results shall be certified for each reel/coil/box of wire or cable.

D. Factory inspection and witnessing of tests by the Engineer shall be required for all wires and cables furnished under this Contract. The Engineer reserves the right to require additional testing, or to waive factory inspection or witnessing of tests. The Contractor shall notify the Engineer 14 days in advance of the scheduling of such factory tests.

PART 3. EXECUTION

3.01 PREPARATION

A. Prior to pulling wires and cables, clean raceway systems of all foreign matter and perform all operations necessary so as not to cause damage to wires and cables while pulling.

B. Prior to pulling wires and cables into underground conduit systems, place a feeding tube approved by the Engineer at the entrance end of such systems.

3.02 INSTALLATION

A. Wire and Cable Installation

1. General

   a. Keep wires and cables dry at all times.

   b. Seal wire and cable ends with watertight end seals if splicing or terminating does not follow at once.

   c. Before splicing or terminating wires and cables, make a thorough inspection to determine that water has not entered the wires and cables or that the wires and cables have not been damaged.

   d. Use adequate lubrication when installing cables in conduits or raceways. Any pulling compounds shall be compatible with the finish of the wires and cables furnished.

2. General Purpose Wires and Cables

   a. Minimum wire or cable size shall be #12 AWG for light and power service.

b. Wires or cables shall be at least #10 AWG for the entire length of branch circuits, where distances to first outlets are as follows:

(1) 100 feet or more on 480Y/277 Volt systems.

(2) 70 feet or more on 208Y/120 Volt systems.

3. Lighting Fixture Wires

a. For wiring within lighting fixtures only, where sizes #14 AWG or smaller are required, use Type SF-2 fixture hookup wire. Type SF-2 wire shall not be used for wiring end-to-end connected fluorescent fixtures.

b. For connecting lighting fixtures to branch circuit conductors, use either Type RHH-VW-1, XHHW or USE, up to 90 degrees C, in dry locations.

4. Grounding Wires and Cables

a. Use bare, uninsulated wire and cable only where shown on the Contract Drawings or where approved by the Engineer.

b. Insulated grounding cable shall be of the type specified in this Section or as shown on the Contract Drawings.

5. Control Wires and Cables

Control wires and cables shall not be smaller than #14 AWG unless otherwise shown on the Contract Drawings.

B. Splicing and Terminating

1. General

Splicing and terminating shall be as specified in this Section. Details of special splicing and terminating shall be as shown on the Contract Drawings. Any splicing or terminating methods other than those specified below, for which the components are in accordance with the requirements of this Section, shall be submitted to the Engineer for approval.

2. General Purpose Wires and Cables

a. Splices in dry locations for sizes #10 AWG and smaller

Splicing shall be completed using one of the following:

(1) Insulated, integral, self-locking flexible shell, expandable spring connectors shall be applied to the twisted conductors. Two, half-lapped layers of vinyl tape, extending to a distance of not less than one inch from the connector, shall be applied.

(2) Compression type, insulated butt connectors shall be applied to the butted conductors by means of an appropriate crimping tool, providing controlled indentation. Two, half-lapped layers of vinyl tape, extending to a distance of not less than one inch from the connector, shall be applied.

(3) Compression type, pigtail connectors shall be applied to the conductors by means of an appropriate crimping tool, providing controlled indentation. The connector shall be covered with a polyamide cap and two, half-lapped layers of vinyl tape, extending to a distance of not less than one inch from the connector, shall be applied.

b. Splices in dry locations for sizes #8 AWG and larger

Splicing shall be completed using all of the following:

(1) Connectors shall be split sleeve solderless type or solderless compression type.

(2) Fill indents of connectors with Scotchfil insulation putty.

(3) Apply rubber splicing tape equal to the original insulation rating.

(4) Apply two, half-lapped layers of vinyl tape, or a shrinkable tubing.

c. Splices in wet locations

(1) Same as dry locations specified in 3.02B.2.a and 2.b, except that after vinyl tape is applied, cover with two coats of sealer or shrinkable tubing.

(2) Resin-filled splice shall be covered with two, half-lapped layers of vinyl tape and two coats of sealer or shrinkable tubing.

d. Terminations in dry locations for sizes #10 AWG and smaller

Terminations shall be compression terminals, insulated or uninsulated.

e. Terminations in dry locations for sizes #8 AWG through #3/0 AWG

(1) Ring tongue terminals shall be solderless, uninsulated compression crimp type.

(2) Ring tongue lugs shall be bolted hex screw type.

f. Terminations in dry locations for sizes #4/0 AWG and larger.

Ring tongue terminals shall be solderless, uninsulated compression crimp type.

g. Terminations in wet locations

In addition to the dry location terminations specified in 3.02 B.2.d, 2.e and 2.f, cover the entire termination area with two, half-lapped layers of vinyl tape and apply two coats of sealer over the tape.

3. Overhead Service Cables

Splices and terminations in overhead service cables shall be the same as specified in 3.02 B.2.c and 2.g, respectively, appropriate for overhead service.

4. Portable Cords

   a. Splices shall not be made in portable cords.

   b. Terminations shall be made only at apparatus to be served or at branch circuit connection by means of any of the following:

      (1) Insulated, integral, self-locking flexible shell, expandable spring, or crimp type connectors;

      (2) Insulated, crimp type, compression connectors;

      (3) Uninsulated, ring tongue terminals for connection to wire terminal strip block.

5. Lighting Fixture Wires

   Connections to branch circuit and to fixture wiring shall be made by either insulated, integral, self-locking flexible shell, expandable spring, or crimp type connectors.

6. Grounding Wires and Cables

   a. Splices and terminations shall be installed in accordance with the manufacturer's recommendations.

   b. In hazardous or classified locations, splices and terminations shall be solderless high conductivity, corrosion resistant, compression type connectors and terminations shall be clamp type pressure connectors, suitable for such use.

   c. All underground connections shall be covered with two coats of asphalt base paint.

7. Control Wires and Cables

   a. Splices shall be made in accordance with the requirements specified in 3.02 B.2.c and shall be enclosed in a re-enterable splicing case. Where shielded cable is shown on the Contract Drawings, the shielding shall be continued through the splice. Shields shall be grounded at one location only unless otherwise shown on the Contract Drawings.

   b. Terminations shall be insulated, indenter type ring tongue terminals.

8. Switchboard Wires

   a. No splices are permitted.

   b. Terminations shall be insulated, indenter type ring tongue terminals.

C. Arcproofing

1. Arcproofing shall be applied where shown on the Contract Drawings.

2. Arcproofing, which has been disturbed for any reason, shall be reinstalled as soon as possible after the disturbance.

3. Arcproofing shall be installed as follows:

a. Wires and cables shall be grouped by circuit and arcproofing applied over the group of wires and cables comprising one circuit. Splices shall be arcproofed individually and the taping shall join with and be overlapped by the group taping.

b. Arcproofing shall be applied in two wrappings of half-lapped tape, bound with glass cloth tape applied at the ends of the fire resistant tape, and at intervals not to exceed 24 inches along the entire length of the cables. The two wrappings shall be applied with opposing-lays.

c. Arcproofing shall be extended into the conduit opening or end bell of the raceway entering a handhole, manhole or box.

d. Arcproofing tape shall be 1 1/2 inches wide where the diameter of the individual cable, or of the circumscribed circle for the circuit group, is less than 1 3/4 inches. For larger diameters, the tape shall be 3 inches wide.

D. Identification of Wires and Cables

1. Each wire and cable shall be identified by its circuit in all cabinets, boxes, manholes, handholes, wireways and other enclosures and access locations, and at all terminal points.

2. The circuit designations shall be as shown on the Contract Drawings. Tags shall be attached to wires and cables in such a manner as to be readily visible.

3. The tag ties shall be wrapped around all conductors comprising the circuit or feeder to be identified.

4. Wires and cables which are arcproofed shall also be identified outside the applied arcproofing.

3.03 FIELD TESTS

Test all wires and cables up to equipment installed under this Contract with a 1000-volt Megohmmeter. Furnish the Engineer with a copy of the "Megger" readings together with an outline of the method used. If, in the opinion of the Engineer, any reading is lower than that required by applicable codes, promptly replace the materials involved, at the Contractor's expense, and retest.

END OF SECTION

SECTION 16120

WIRE, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS)

APPENDIX "A"

SUBMITTALS

A. Submit Catalog Cuts for the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

1. Wires and cables for each type and size;
2. Splice kit materials and installation procedures.

B. Submit certified shop test reports for wires and cables.

C. Submit field test results for wires and cables, including "Megger" readings with the test method used.

END OF APPENDIX "A"

SECTION 16120

WIRES, CABLES, SPLICES, TERMINATIONS

(600 VOLTS OR LESS)

INSTRUCTIONS TO SPECIFIER

1.01 Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(1.04 B)	List cables to be furnished without factory-applied caps.
(2.01)	Show manufacturers of wires, cable wires, and cable splicing, terminating and arcproofing materials on contract drawing. List a minimum of 2 manufacturers and include "a approved equal". If an item is unique or sole source, then a sole source letter will be required.
(2.02 A.1)	Show locations, types, sizes and numbers of and cables.
(2.02 A.2)	Specify special type of conductors that are not soft or annealed copper.
(2.02 A.5)	The wires and cables specified in this paragraph are not easily available. Large quantities and/or a prepurchase may be required.
(2.02 B.2)	Specify any general-purpose wires and cables not listed in this paragraph.
(2.02 D)	Specify special types of portable cords not listed in this paragraph.
(2.02 E)	Specify any special type lighting fixture wires that is not Type SF-2.
(2.02 F)	Specify any special type grounding wires and cables not covered by the specification of this paragraph.
(2.02 G)	Specify any special control wire and cable not covered by the specification of this paragraph.
(2.02 H)	Specify any special switchboard wire and cable not covered by the specifications of this paragraph.
(2.03 E.2)	Show size of rubber tape as specified.
(2.03 H)	Show any special splicing materials and methods not specified in this section.
(3.02 A.4.a)	Show any bare grounding wire to be installed.
(3.02 A.4.b)	Show any special grounding wire to be installed.

(3.02 A.5)	Show any control wire other than #14 AWG to be installed.
(3.02 B)	Shown any special splicing and terminating details not specified in this section.
(3.02 B.7.a)	Show control cable shields that are to be grounded in more than one location.
(3.02 C.1)	Show locations where arcproofing is to be applied.
(3.02 D.2)	Show all circuit designations.

1.02 Other Items

Specify required submittals by editing Appendix A "Submittal Requirements"

END OF INSTRUCTIONS

DIVISION 16

SECTION 16121

WIRES, CABLES, SPLICES, TERMINATIONS (MEDIUM VOLTAGE: 601 VOLTS TO 34,500 VOLTS, INCLUSIVE)

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for wires, cables, splices, terminations and appurtenances for electrical systems of medium voltage: 601 volt to 34,500 volts, inclusive.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

	American Society for Testing and Materials (ASTM)
ASTM B 1	Hard-Drawn Copper Wire
ASTM B 2	Medium-Hard-Drawn Copper Wire
ASTM B 3	Soft or Annealed Copper Wire
ASTM B 8	Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B 29	Pig Lead
ASTM B 33	Tinned Soft or Annealed Copper Wire for Electrical Purposes
ASTM B 189	Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes
ASTM D 1373	Medium-Voltage Rubber Insulating Tape
ASTM D 2802	Ozone-Resistant Ethylene-Propylene-Rubber Insulation for Wire and Cable
	Association of Edison Illuminating Companies (AEIC)
AEIC CS-6	Ethylene-Propylene-Rubber Insulated Shielded Power Cable Rated 5 through 69 KV
	Federal Specifications (FS)
HH-I-553	Insulation Tape, Electrical (Rubber, Natural and Synthetic)
	Insulated Cable Engineers Association (ICEA)
ICEA S-68-516	Ethylene-Propylene-Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
	Institute of Electrical and Electronics Engineers (IEEE)
IEEE 48	High Voltage AC Cable Terminators, Test Procedure and Requirements
IEEE 383	Type Test of Class 1E Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations

IEEE 404	Standard for Type Test of Cable Joints for Use with Extruded Dielectric Cable Rated 5,000 through 46,000 Volts, and Cable Joints for Use with Laminated Dielectric Cable Rated 2,500 through 500,000 Volts
IEEE 837	Standard for Qualifying Permanent Connections Used in Substation Grounding
	National Fire Protection Association (NFPA)
NFPA 70	National Electrical Code
NFPA 258	Standard Research Method for Determining Smoke Generation of Solid Materials
OSHA	Occupation Safety and Health Administration
	Underwriters Laboratories Inc. (UL)
UL 44	Rubber-Insulated Wires and Cables
UL 467	Grounding and Bonding Equipment
UL 510	Insulating Tape
UL 1581	Reference Standard for Electrical Wires, Cables, and Flexible Cords.

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. Wires, cables, splices and terminations for medium voltage: 601 Volts to 34,500 Volts, inclusive, shall be furnished and installed in accordance with this Section and as specified on the Contract Drawings.

B. Components of the medium voltage system, manufactured, supplied and installed, shall comply with the requirements of NFPA 70, all local codes, and the requirements of OSHA.

1.04 QUALITY ASSURANCE

A. Wires and cables that have been manufactured more than two years prior to installation shall not be used in the Work of this Section.

B. Tapes for splices or terminations shall be dated by the tape manufacturer to indicate that they have been manufactured no longer than six months prior to use in the Work of this Section.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Where multiple single conductor cables are to be installed as one cable, single conductor cables shall be paralleled by cable manufacturer prior to shipment. Cable assembly overall diameter shall be kept to a minimum.

B. Store material in a clean, dry space and protect it from the weather.

1.06 SUBMITTALS

See Appendix "A".

PART 2. PRODUCTS

2.01 MANUFACTURERS

Provide wires, cables, splices and terminations, and ancillary equipment, in compliance with the requirements of this section, and as shown on the Contract Drawings.

2.02 MATERIALS

A. Wires and Cables

1. Locations, types, sizes and numbers of wires and cables are shown on the Contract Drawings.

2. Unless otherwise shown on the Contract Drawings, solid conductors shall be soft or annealed copper, conforming to ASTM B 33 (tinned), ASTM B 189 (lead-coated or lead alloy coated), or ASTM B 3 (uncoated).

3. Pulling Devices and End Seals

   a. Wires and cables shall be provided with factory fitted pulling devices and end caps unless otherwise shown on the Contract Drawings. Shop drawings showing the pulling devices and end caps to be used shall be submitted to the Engineer for approval.

   b. For pulling tensions up to 1000 pounds per grip, basket grips may be utilized.

   c. All wires and cables shall be end-sealed, at both ends of each length. Lead cable shall be solder-wiped sealed with a heat-shrinkable cap, to prevent the entrance of moisture.

   d. Lead-sheathed cables shall be provided with either compression type or solder-wiped style pulling bolts or eyes on the leading end of each conductor, or on the overall assembly. The pulling device shall be installed and fitted with either solder-wipe or heat-shrinkable sleeve to prevent the entrance of moisture.

4. Wires and cables shall be identified in accordance with AEIC CS 6. Outer jacket shall be printed with manufacturer's identification, type of insulation, size of conductor, rated voltage, year of manufacture, insulation thickness and UL listing. Each reel shall carry a tag identifying manufacturer, cable type, size, voltage and length of cable on reel.

   In addition, on each single conductor cable when shipped triplexed or paralleled, there shall be a unique series of "111" or "222" or "333" respectively per phase or leg to identify the phase connection.

5. Grounding Wires and Cables

   Unless otherwise shown on the Contract Drawings, grounding conductors shall be as follows:

   a. Insulated

      (1) Solid for sizes #8 AWG and smaller, Class B stranded for sizes #6 AWG and larger, 600 volt rated, XHHW or RHW.

(2) Covering shall be a continuous green color and conform to ASTM B 33 and UL 44.

b. Uninsulated

(1) Solid for sizes #8 AWG and smaller, Class B stranded for sizes #6 AWG and larger.

(2) In raceways

Soft-drawn and conforming to ASTM B 3.

(3) Direct buried or encased in concrete

Soft-drawn, medium-hard-drawn or hard-drawn and conforming to ASTM B 1, B 2 or B 3, respectively.

6. Medium Voltage Flat Strap Cable, (FSC)

a. Flat Strap Cable shall be used for all underground and outdoor locations unless otherwise shown on the Contract Drawings.

b. Jacketed, single conductor cable.

(1) Voltage rating shall be as shown on the Contract Drawings.

(2) Insulation

Insulation shall be Ethylene-Propylene-Rubber (EPR). Cables shall conform to AEIC CS-6, ASTMD-2802 and ICEA S-68-516.

(3) General Construction

In cross section from center to circumference, jacketed, single conductor cable shall consist of the following:

(a.) Copper conductor shall be annealed, uncoated, compressed round strand or compact round strand when shown on the Contract Drawings.

(b.) Extruded conductor shielding;

(c.) Insulation shall be EPR, 133 percent insulation level;

(d.) Extruded semiconducting insulation shielding;

(e.) Flat strap neutral shall consist of tin coated, annealed flat copper wires per ASTM B272, helicaly applied over the insulation shield. The edges of the straps shall be rounded. The equivalent conductor size shall be #2 AWG unless otherwise shown. It shall cover not less than 80% of the insulation-shielding surface;

(f.) Jacket of linear low-density polyethylene (LLDPE) in accordance with ASTM D1248. The jacket thickness shall be 50 mils and shall conform to IPCEA and UL standards. For cable used for indoor locations, jacketing material shall be selected to receive the UL label for tray use;

(g.) Maximum outside diameter shall be as shown on the Contract Drawings;

c. Assembly

Unless otherwise shown on the Contract Drawings, cables shall be triplexed at the factory prior to shipping.

7. Medium Voltage Lead-sheathed Cables (For Exterior and Underground Use)

a. Lead-Sheathed Cable shall only be used where specifically shown on the Contract Drawings.

b. Jacketed, Single Conductor Cable

(1) Voltage ratings shall be as shown on the Contract Drawings.

(2) Insulation

Insulation shall be ethylene-propylene-rubber (EPR). Cables shall conform to AEIC CS-6, ASTM D 2802 and ICEA S-68-516.

(3) General Construction

In cross section from center to circumference, jacketed, single conductor cable shall consist of the following:

(a.) Copper conductor, annealed, uncoated, Class B stranded or compact strand or sector, as shown on the Contract Drawings;

(b.) Extruded conductor shielding;

(c.) Insulation shall be EPR, 133 percent insulation level;

(d.) Extruded EPR, semi-conducting, insulation shielding;

(e.) Lead sheath overall;

(f.) Jacket of black polyethylene, polyvinyl chloride, or as shown on the Contract Drawings.

(g.) Maximum outside diameter shall be as shown on the Contract Drawings.

c. Jacketed, Three Conductor Cable

(1) Voltage ratings shall be as shown on the Contract Drawings.

(2) Insulation

EPR insulated cables shall conform to AEIC CS-6 and ASTM D 2802, ICEA S-68-516.

(3) General Construction

In cross section from center to circumference, jacketed, single conductor cable shall consist of the following:

(a.) Three insulated, shielded conductors, each with:

i. Copper conductor, uncoated, Class B stranded or compact strand or sector;

ii. Extruded conductor shielding;

iii. Insulation shall be EPR, 133 percent insulation level;

iv. Extruded, semi-conducting, insulation shielding;

v. Copper shielding tape, 5-mil, spirally wrapped with 12.5 percent overlap.

(b.) Ground conductors and fillers as necessary to provide an overall round cross section;

(c.) Tape binder over the three insulated, shielded conductors;

(d.) Lead sheath overall;

(e.) Jacket of black polyethylene, polyvinyl chloride, or as shown on the Contract Drawings.

(f.) Maximum outside diameter shall be as shown on the Contract Drawings.

8. Medium Voltage Cables (For Interior Use)

a. Jacketed, Single Conductor Cable

(1) Voltage ratings shall be as shown on the Contract Drawings.

(2) Insulation

Insulation shall be Ethylene-propylene-rubber (EPR). Insulated cables shall conform to AEIC CS-6, ASTM D 2802 and ICEA S-68-516.

(3) General Construction

In cross section from center to circumference, jacketed, single conductor cable shall consist of the following:

(a.) Copper conductor, uncoated, Class B stranded or compact strand or sector, as shown on the Contract Drawings;

(b.) Extruded conductor shielding;

(c.) Insulation shall be EPR, 133 percent insulation level;

(d.) Extruded EPR, semi-conducting, insulation shielding;

(e.) Tinned copper braided shield, 85% minimum coverage, or copper shielding tape, 5-mil, spirally wrapped with 12.5 percent overlap;

(f.) Jacket of flame retardant, low smoke chemically cross-linked polyolefin (XLPO), or chlorosulfonated polyethylene (CSP), or as shown on the Contract Drawings.

(g.) Maximum outside diameter shall be as shown on the Contract Drawings.

b. Jacketed, Three Conductor Cable

(1) Voltage ratings shall be as shown on the Contract Drawings.

(2) Insulation

EPR insulated cables shall conform to AEIC CS 6 and ASTM D 2802, ICEA S-68-516.

(3) General Construction

In cross section from center to circumference, jacketed, three conductor cable shall consist of the following:

(a.) Three insulated, shielded conductors, each with:

i. Copper conductor, uncoated, Class B stranded or compact strand or sector;

ii. Extruded conductor shielding;

iii. Insulation shall be EPR, 133 percent insulation level;

iv. Extruded, semi-conducting, insulation shielding;

v. Tinned copper braided shield, 85% minimum coverage, or copper shielding tape, 5-mil, spirally wrapped with 12.5 percent overlap.

(b.) Ground conductors and fillers as necessary to provide an overall round cross section;

(c.) Tape binder over the three insulated, shielded conductors;

(d.) Jacket of flame retardant, low smoke chemically cross-linked polyolefin (XLPO), or chlorosulfonated polyethylene (CSP) or as shown on the Contract Drawings.

(e.) Maximum outside diameter shall be as shown on the Contract Drawings.

9. Cable Tags

Stainless steel metal tags, No. 28 gauge and 3/4-inch wide, embossed with letters and numbers 5/16-inch high, fastened to the cable at both ends of tags with nominal 1/16-inch diameter monel metal wire or stainless steel cable ties.

10. Splicing, Terminating and Arcproofing Materials

a. General

(1) All splicing, terminating and arcproofing materials shall be compatible so that no one material will adversely affect the physical or electrical properties of any other, or of the wire or cable itself.

(2) All materials for making splices and terminations shall be specifically designed for use with the type of wire or cable, insulation and installation and operating conditions of the specific application.

(3) Splices and terminations shall be supplied as complete kit assemblies with all components and detailed installation instructions. Unless otherwise shown on the Contract Drawings, splices and terminations for medium voltage cables shall be heat-shrink polymeric type as manufactured by Raychem.

b. Connectors

Subject to compliance with requirements of this Section, provide Split-sleeve, solder, high conductivity, corrosion resistant connectors.

c. Terminals

Subject to compliance with requirements of this Section, provide Solder type, high conductivity, corrosion resistant terminals.

d. Shrinkable Tubing

Subject to compliance with requirements of this Section provide shrinkable tubing of the following types:

(1) Either irradiated modified polyvinyl chloride or irradiated modified polyolefin heat shrinkable tubing.

(2) Cold, shrinkable tubing.

e. Tapes and Sealers

(1) Vinyl Tapes

Flame-retardant, cold and weather-resistant, 3/4 inch and 1 1/2 inches wide, as required, and conforming to UL 510 and ASTM D 3005.

(a.) For interior, dry locations, provide Tape 7 mils thick, conforming to ASTM D 3005 (Type I).

(b.) For exterior or damp and wet locations, provide tape 8.5 thick, mils conforming to ASTM D 3005 (Type II).

(2) Rubber Tapes

Ethylene-propylene, rubber-based, 30-mil splicing tape, rated for 130 degrees C operation; 3/4 inch and wider (1, 1 1/2, 2 inches) or as shown on the Contract Drawings, or as approved by the Engineer, conforming to ASTM D 1373 and Federal Specification HH-I-553 (Grade A).

(3) Insulating Putty

Rubber-based, 125-mil elastic filler putty; 1-1/2 inches wide; Scotch (3M) Scotchfil, or approved equal.

(4) Silicone Rubber Tapes

Inorganic silicone rubber, 12-mil 130 degrees C rated, anti-tracking, self-fusing tape; 1 inch wide.

(5) Sealer

Liquid applied, fast-drying sealant; Scotch (3M) Scotchkote, or approved equal.

f. Binding wire shall be uninsulated, tinned copper.

g. Lead sleeve shall be 5/32 inches thick, commercially and chemically pure, and shall conform to ICEA S-68-516 and ASTM B 29.

h. Solder

(1) Solder used on the shielding braids of any cable shall be 50% Tin / 50% Lead.

(2) Solder used for wiping the lead splice sleeve to the lead sheath of any cable shall be 40 Tin/60 Lead, Class A.

(3) Flux used when soldering conductor connectors or shielding tapes and shielding braids shall be of a non-corrosive and non-acid type.

i. Insulating compound shall be installed in all lead-covered splices and all potheads.

j. Arcproofing Material

For arcproofing materials, refer to Section 16128 of the Specification.

k. Ground Straps

Flexible, tinned copper braid, equivalent to #6 AWG.

l. Special splicing materials and methods shall be as shown on the Contract Drawings.

PART 3. EXECUTION

3.01 EXAMINATION

A. Inspect all wire, cables, equipment and accessories prior to installation. Replace any damaged items.

3.02 PREPARATION

A. Prior to pulling wires and cables, clean raceway systems of all foreign matter and perform all operations necessary so as not to cause damage to wires and cables while pulling.

B. Prior to pulling wires and cables into underground conduit systems, place a feeding tube approved by the Engineer at the entrance end of such systems.

3.03 INSTALLATION

A. Wire and Cable Installation

1. General

a. Keep wires and cables dry at all times.

b. Seal wire and cable ends with watertight end seals if splicing or terminating does not follow at once.

c. Before splicing or terminating wires and cables, make a thorough inspection to determine that water has not entered the wires and cables or that the wires and cables have not been damaged.

d. Use adequate lubrication when installing cables in conduits or raceways. Any pulling compounds shall be compatible with the finish of the wires and cables furnished.

B. Splices and Terminations

1. General

a. All medium voltage wires and cables shall be spliced in each manhole through which they pass.

b. Any splicing or terminating methods other than those required by this Section, for which the components are in accordance with the requirements of this Section, shall be submitted to the Engineer for approval.

c. All cables shall be checked for phase identification before and after terminations have been made. All phase discrepancies shall be corrected.

2. Insulated Wires and Cables

a. Splices and terminations shall be completed by workmen trained and experienced in the type of cable and the voltage class specified in this Section, with not less than 3 years experience in this specialty type of work, and who perform similar splices and terminations on a regular basis.

b. Where required by the Engineer, sample splices shall be demonstrated to the Engineer by each splicer performing the Work of this Section. The sample shall be provided to the Engineer after completion of the demonstration.

c. Terminations using stress-relief cones, which conform to Class 1, IEEE 48 shall be made in accordance with the cable manufacturer's recommendations.

d. Splices shall conform to IEEE 404 and shall:

(1) meet the full electrical and physical integrity of the wire and cable construction, including voltage rating, ampacity, BIL, and type of waterproofing;

(2) conform to the wire and cable manufacturer's requirements and recommendations.

e. For cable where moisture is present, each such cable shall be nitrogen-purged to remove all moisture. The purging procedure shall be submitted to the Engineer for approval.

f. Where splices or terminations are on the Electrical Utility Company (Utility) side of incoming service equipment, the splices or terminations shall be of the type and style approved by the Utility and shall be submitted to the Utility for approval.

3. Grounding Wires and Cables

a. Splices and terminations shall be installed in accordance with the manufacturer's written recommendations.

b. In hazardous or classified locations, splices and terminations shall be solderless, high conductivity, corrosion-resistant, compression type connectors.

c. All underground connections shall be covered with two coats of asphalt base paint.

d. Each splice shall be bonded to ground, using a flexible ground strap, 2 feet long, not less than #6 AWG or equivalent size.

C. Arcproofing

For arcproofing of cables, see Section 16128, of the Specification.

D. Identification of Wires and Cables

1. Each wire and cable shall be identified by its circuit in all cabinets, boxes, manholes, handholes, wire ways, and other enclosures, and at all terminal points.

2. The circuit designations shall be as shown on the Contract Drawings. Tags shall be attached to wires and cables in such a manner as to be readily visible.

3. The tag ties shall be wrapped around all conductors comprising the circuit or feeder to be identified.

4. Wires and cables that are arcproofed shall be identified outside the applied arcproofing.

E. Field Tests

1. Medium Voltage Shielded Cables

   a. After installation and before they are placed in service, run direct current voltage tests in accordance with AEIC CS 6, paragraphs K.2 and K.3, on all shielded cables.

   b. A copy of all test reports, together with an outline of the test method used, shall be submitted to the Engineer for review.

2. Ground Wires and Cables

   a. Ground wires and cables shall be tested to prove continuity and proper connections to equipment and ground rods.

   b. The Contractor shall certify all field testing and shall submit the test results to the Engineer for approval.

F. Factory Tests

1. For quantities as shown on the Contract Drawings, regular dielectric-withstand and insulation-resistance in water tests for wires and cables shall be performed in accordance with UL 44.

2. The following tests for wires and cables shall be performed and certified reports of these tests shall be submitted to the Engineer:

   a. Flame tests in accordance with IEEE 383 (were appllicable).

   b. Jacket tests in accordance with ICEA 5-68-516.

   c. Cable tests in accordance with AEIC CS-6.

3. The test results shall be certified for each shipping reel of wire or cable.

4. Factory inspection and witnessing of tests by the Engineer shall be required for all wires and cables furnished under this Contract. The Engineer reserves the right to require additional testing, or to waive factory inspection or witnessing of tests. The Contractor shall notify the Engineer 14 days in advance of the scheduling of such factory tests.

G. Independent Laboratory Test

1. Unless otherwise shown on the Contract Drawings, submit a 2'-0" sample from 25% of the shipping reels to an independent laboratory for the following tests which shall be performed in accordance with AEIC and ICEA standards.

   a. A.C. Voltage Breakdown Tests

   b. Adhesion of Insulation Shield to Insulation

   c. Volume Resistivity of Conductor Shield to Insulation Shield

   d. Dissection and Dimensional Analysis

   e. Microscopic examination for voids, contaminants, and protrusions

   f. Hot Creep Test to determine state of cure of insulation

   g. Partial Discharge (DC) measurements

h. Dissipation factor of cable insulation

i. Impulse breakdown tests.

3.04 ADJUSTMENTS

A. Should the test results reveal any defects, promptly correct such defects and rerun the tests until the entire installation is satisfactory to the Engineer in all aspects.

END OF SECTION

SECTION 16121

WIRES, CABLES, SPLICES, TERMINATIONS (MEDIUM VOLTAGE: 601 VOLTS TO 34,500 VOLTS, INCLUSIVE)

APPENDIX "A"

SUBMITTALS

A. Submit the following in accordance with the requirements of "Shop Drawings", Catalog Cuts, and Samples", of Division 1 - General Provisions:

1. Shop Drawings

   Submit Shop Drawings for the installation sequence, pulling tensions and sidewall pressure of all wire and cable pulls, including identification of manhole or pullbox locations with splices.

2. Catalog Cuts

   a. Medium Voltage Cable(s)

   b. Ground Wire(s)

   c. Terminators

   d. Splices

   e. Pulling Devices and End Seals

B. Submit certified shop test reports for wires and cables.

C. Submit field test results for wires and cables, including all test data and methodology.

D. Submit nitrogen purge procedure for moisture laden wires and cables.

END OF APPENDIX "A"

SECTION 16121

WIRES, CABLES, SPLICES, TERMINATIONS (MEDIUM VOLTAGE: 601 VOLTS TO 34,500 VOLTS, INCLUSIVE)

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.01 A)	List manufacturers of all equipment. List a minimum of two manufacturers and include the phrase "or approved equal". If an item is unique, or sole source, then a sole source letter will be required.
(2.02 A.1)	Show locations, types, sizes, and numbers of wires and cables.
(2.02 A.2)	Specify special types of conductors.
(2.02 A.3.A)	Show wires and Cables to be furnished without factory fitted pulling devices.
(2.02 A.5)	Show special types of ground conductors.
(2.02 A.6.b)	Show maximum, outside diameter of lead-sheathed cable.
(2.02 A.6.a)	Specify jacket material if not of black polyethylene, polyvinyl-chloride, or as shown on the Contract Drawings.
(2.02 A.7.d)	Show maximum, outside diameter of jacketed, three-conductor cable.
(2.02 B)	Specify special splicing materials and methods.
(3.03 F.1)	Specify regular dielectric-withstand and insulation-resistance in water tests for wires and cables for quantities as shown on the Contract Drawings.
(3.03 B.1)	Specify wires and cables not to be spliced in each manhole through which they pass.
(3.03 D)	Show circuit designations.

B. Other Items

Ensure that the Specifications include the following Sections referenced in this Section.

(3.02 B)	RACEWAYS
(3.02 B)	UNDERGROUND CONDUIT SYSTEMS
(2.02 A.10)	ARC-PROOFING

C. Recommended Manufacturers

(2.02 A) Wires and Cables shall be as manufactured by:

1. Kerite
2. Pirelli Cable Corporation

3. The Okonite Company
4. General Cable

(2.02 B) Splicing and Terminations shall be as manufactured by Raychem.

Add where appropriate:

1. Minnesota Mining and Manufacturing Company (3M)
2. MAC Products Inc.

(2.02 B.5a) Vinyl Tapes:

1. Interior Vinyl Tapes shall be 3M, Scotch No. 33, or approved equal.
2. Exterior Vinyl Tapes shall be 3M, Scotch No. 88, or approved equal.

(2.02 B.5.b) Rubber Tapes:

1. Etylene-Propylene Tapes shall be 3M, Scotch No. 130C, or approved equal.

(2.02 B.5.c) Insulating Putty:

1. Rubber based putty shall be 3M, Scotchfil, or approved equal.

(2.02 B.5.d) Silicone Rubber Tapes:

1. Inorganic Silicone rubber tape shall be 3M, Scotch No. 70, or approved equal.

(2.02 B.5.e) Sealer:

1. Liquid applied, fast drying sealant shall be 3M, Scotchkote or approved equal.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16122

CABLES, SPLICES, TERMINATIONS (D.C. TRACTION POWER CABLE)

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for cables, splices, terminations and appurtenances for D.C. traction cables.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

	American Society for Testing and Materials (ASTM)
ASTM E 662	Test Method for Specific Optical Density of Smoke Generated by Solid Materials
ASTM B 1	Hard-Drawn Copper Wire
ASTM B 2	Medium-Hard-Drawn Copper Wire
ASTM B 3	Soft or Annealed Copper Wire
ASTM B 8	Concentric-Lay-Stranded Copper Conductors Hard, Medium-Hard, or Soft
ASTM B 33	Tinned Soft or Annealed Copper Wire for Electrical Purposes
ASTM B 189	Lead-Coated and Lead-Alloy Coated Soft Copper Wire for Electrical Purposes
ASTM D 1373	Medium-Voltage Rubber Insulating Tape
ASTM D 2802	Ozone-Resistant Ethylene-Propylene-Rubber Insulation for Wire and Cable
ASTM D 3005	Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape
	Federal Specifications (FS)
FS HH I 553	Insulation Tape, Electrical (Rubber, Natural and Synthetic)
	Insulated Cable Engineers Association (ICEA)
ICEA S 68 516	Ethylene-Propylene-Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
	Institute of Electrical and Electronics Engineers (IEEE)
IEEE 48	High Voltage AC Cable Terminators, Test Procedure and Requirements
IEEE 383	Type Test of Class 1E Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations.
IEEE 404	Standard for type Test of Cable Joints for Use with Extruded Dielectic

	Cable Rated 5,000 through 46,000 Volts, and Cable Joints for Use with Laminated Dielectic Cable Rated 2,500 through 500,000 Volts
IEEE 837	Standard for Qualifying Permanent Connections Used in Substation Grounding
	Military Specifications (MIL)
MIL C 24643	Cable and Cord, Electrical Low Smoke for Shipboard Use.
	National Fire Protection Association (NFPA)
NFPA 70	National Electrical Code
NFPA 130	Standard for Fixed Guideway Transit Systems
NFPA 258	Standard Research Method for Determining Smoke Generation of Solid Materials
	Naval Engineer Standards (NES)
NES 713	Determination of the Toxicity Index of the Products of Combustion for Small Specimens of Material
	Underwriters Laboratories Inc. (UL)
UL 44	Rubber-Insulated Wires and Cables
UL 467	Grounding and Bonding Equipment
UL 510	Insulating Tape
UL 1685	Standards for Safety Vertical Tray Fire Propagation and Smoke Release Test for Electrical and Optical Fiber Cables
UL 1581	Reference Standard for Electrical Wires, Cables, and Flexible Cords.

1.03 QUALITY ASSURANCE

A. The manufacturer shall have a minimum of three (3) years experience in manufacturing cable of the type and size described herein and the Contractor shall have the manufacturer provide a list of installations and contracts for which he has produced such materials.

B. Tests requiring certified reports and those requiring factory or field inspection shall be conducted and reported to the Engineer in conformance with standards herein specified.

C. Cables that have been manufactured more than two years prior to installation shall not be used in the Work of this Section.

D. Tapes for splices or terminations shall be dated by the tape manufacturer to indicate that they have been manufactured no longer than six months prior to use in this Work of this Section.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Store material in a clean, dry space and protect from weather.

B. Unless otherwise shown on the Contract Drawings, cables shall be provided with factory fitted pulling devices and end caps to prevent the entrance of moisture into the cable.

C. Cable real sizes shall be limited to the maximum dimensions shown on the Contract Drawings.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURER

List of acceptable manufacturers is shown on Contract Drawings.

2.02 CABLES

A. General

1. Locations, types, sizes and numbers of cables are shown on the Contract Drawings.
2. Unless otherwise shown on the Contract Drawings, solid conductors shall be soft or annealed copper, conforming to ASTM B 33 (tinned), ASTM B 189 (lead or lead alloy coated or lead alloy coated), or ASTM B 3 (uncoated).
3. Unless otherwise shown on the Contract Drawings, cable jackets shall be low smoke, low toxicity, non-halogen, flame retardant type and shall meet the following performance characteristics:
   a. Cables shall pass the flame propagatory criteria according to the test method of UL 1685.
   b. The halogen content of the cable jackets shall not exceed 0.2 percent according to the test method of Mil-C-24643. The Authority classifies 0.2 percent or less halogen content as "non-halogen".
   c. The toxicity index of cable jackets shall not exceed 2.0 according to the test method of NES 713.
   d. The cable jackets shall comply with ICEA T-33-665 for smoke generation.
   e. The acid gas content of cable jackets shall not exceed a maximum of 2.0 percent according to the test method of MIL-C-24643.
   f. The cable insulation materials shall pass the smoke generation test in accordance with ASTM E 662. Cable insulation when tested on a specimen of 80 mils thick slab shall not exceed the following values.

Flaming Avg. Ds (4 minutes)	100
Flaming Avg. Dm (20 minutes)	200
Non Non-Flaming Avg. Ds (4 minutes)	100
Non Flaming Avg. Dm (20 minutes)	350

g. The cable jacket materials shall pass the smoke generation test in accordance with ASTM E 662. Wire and cable jacket when tested on a specimen of 80 mils thick slab shall not exceed the following values:

Flaming Avg. Ds (4 minutes)	50
Flaming Avg. Dm (20 minutes)	150
Non Non-Flaming Avg. Ds (4 minutes)	50
Non Flaming Avg. Dm (20 minutes)	250

4. Pulling Devices and End Seals

a. Unless otherwise shown on the Contract Drawings, cables shall be provided with factory fitted pulling devices and end caps to be used shall be submitted to the Engineer for approval.

b. For pulling tensions up to 1000 pounds per grip, basket grips may be utilized.

c. All cables shall be end-sealed, at both ends of each length, with a heat-shrinkable cap to prevent the entrance of moisture.

5. Identification

a. The following information shall be durably printed on the jacket surface and repeated at intervals not exceeding 24 inches:

Manufacturer's Name
Manufacturing Plant No.
No. of Conductors
Size of Conductors
Insulation Material and thickness
Jacket Material LS-Non-Hal/No acid
2000 volts (rated voltage)
DC Traction Power Cable
Sequential Footage
Date of Manufacture
UL Listing (where applicable)

b. Each reel shall carry a tag identifying the manufacturer, cable type, size, voltage, and length of cable on reel.

B. Jacketed, Single Conductor D.C. Traction Power Cable

1. Voltage ratings shall be for 2,000 volts D.C. continuously, rated for 90 degree C operations, and capable of withstanding frequent spikes of 3,000 volts as is typical to occur in an electrical railroad system.

2. General Construction

a. Copper conductor, (bare, lead or tin coated,) Class B or Class C stranded as shown on the Contract Drawings in accordance with ASTM B 8 and ASTM B 33.

b. An opaque separating tape shall be applied over the conductor that shall prevent migration of the insulation into the conductors, so as to aid in stripping for terminating.

c. The insulation shall be ethylene propylene rubber concentricity extruded over the screen. The insulation thickness shall be 0.140 inches and the thickness at any point shall not be less than 90 percent of that value. The insulation shall otherwise conform to ICEA S 68-516. The insulation shall conform to Type II of these standards. The cable shall conform to the requirements of ASTM D 2802.

d. A cross-linked polyolifin jacket of 95 mils average thickness, with a minimum at any point of not less than 90 percent of that value, shall be extruded over the insulated conductor.

3. Maximum outer diameter shall be as shown on the Contract Drawings.

C. Cable Splicing, Terminating and Arcproofing Materials

1. Tapes for splices or terminations shall be dated by the tape manufacturer to indicate that they have been manufactured no longer than six months prior to use in the Work of this Section.

2. All splicing, terminating and arcproofing materials shall be compatible, so that no one material will adversely affect the physical or electrical properties of any other, or of the cable itself.

3. Splicing materials shall conform to the following:

a. Connectors shall be as follows:

(1) Uninsulated split sleeve solder connectors shall be high conductivity, corrosion-resistant type.

(2) Uninsulated solderless, comparison connectors shall be conductivity cooper or bronze, corrosion resistant type.

(3) Uninsulated solderless bolted connectors shall be high conductivity cooper or bronze, corrosion-resistant type.

(4) Welded type connectors.

b. Terminals

(1) Uninsulated solder terminals shall be high conductivity, corrosion resistant type.

(2) Uninsulated solderless compression terminals shall be high conductivity, corrosion-resistant type.

(3) Uninsulated solderless, bolted terminals shall be high conductivity cooper or bronze, corrosion-resistant type.

c. Shrinkable Tubing

(1) Heat shrinkable tubing shall be irradiated modified polyolifin.

(2) Cold shrinkable tubing.

d. Tapes and Sealers

(1) Vinyl Tape - Flame-retardant, cold and weather-resistant, 3/4 inch and 1 1/2 inch wide, as required, and conforming to UL 510 and ASTM D 3005.

(a.) For interior, dry locations provide 7 mils conforming to ASTM D 3005 (Type I); Scotch (3M) No. 33, or approved equal.

(b.) For exterior or damp and wet locations provide 8.5 mils conforming to ASTM D 3005 (Type II); Scotch (3M) No. 88, or approved equal.

(2) Rubber Tapes - Ethylene-propylene, rubber-based, 30 mil splicing tape, rated for 130 degrees C operation; 3/4 inch and wider (1, 1 1/2, 2 inches) as shown on the Contract Drawings or approved by the Engineer, conforming to ASTM D 1373 and Federal Specification HH-I 553 (Grade A); Scotch (3M) No. 130C, or approved equal.

(3) Insulating Putty - Rubber-based, 125 mil elastic filler putty; 1-1/2 inches wide; Scotch (3M) Scotchfil, or approved equal.

(4) Silicone Rubber Tapes - Inorganic silicone rubber, 12 mil 130 degrees C rated, anti-tracking, self-fusing tape; 1 inch wide; Scotch (3M) No 70, or approved equal.

(5) Sealer - Liquid applied, fast-drying sealant; Scotch (3M) Scotchkote, or approved equal.

e. Solder

(1) Solder used on solder type connectors or terminals shall be 50 Tin/50 Lead.

(2) Flux used when soldering conductor connectors shall be of a non-corrosive and non-acid type.

f. Arcproofing Material

(1) Fire resistant tape shall be Scotch (3M) No. 77, or approved equal.

(2) Glass, cloth binding tape shall be Scotch (3M) No. 69, or approved equal.

g. Special splicing materials and methods shall be as shown on the Contract Drawings.

h. Cable Tags - Stainless steel metal tags, No. 28 gauge and 3/4-inch wide, embossed with letters and numbers 5/16-inch high, fastened to the cable at both ends of tags with 1/16-inch diameter monel wire or stainless steel cable tags.

2.03 TESTS

A. Shop Tests

1. Unless otherwise shown on the Contract Drawings, regular AC and DC dielectri-withstand and insulation-resistance tests shall be performed for all cable in accordance with ICEA S68 516. Both tests shall be performed with cable submerged in a tank of water.

2. Flame tests for cables shall be performed in accordance with IEEE 383.

3. Smoke generation tests for cables shall be performed in accordance with ASTM E662.

4. Halogen content test shall be performed in accordance with MIL C 24643.

5. Toxicity index test shall be performed in accordance with NES 713.

6. The flame, smoke generation, halogen content and toxicity index tests shall be performed per cable production run as long as the same batch of compound is being used. A minimum of two (2) tests shall be performed for each. Test samples as chosen by the Engineer.

7. The test results shall be certified and submitted to the Engineer for each reel of cable.

8. Factory inspection and witnessing of tests by the Engineer shall be required for all cables furnished under this Contract. The Engineer reserves the right to revise the shop test schedule, to waive factory inspection or witnessing of tests. The Contractor shall notify the Engineer 14 days in advance of the scheduling of such factory tests.

9. The cost of the shop tests shall be borne by the Contractor.

B. Independent Laboratory Tests

1. If required by contract drawing the following tests shall be performed in conformance with AEIC or ICEA standards:

   a. Regular AC and DC dielectric-withstand and insulation resistance.

   b. Dissection and dimensional analysis.

   c. Microscopic examination for voids, contaminants and protrusions.

   d. Hot creep test to determine sate of cure of insulation.

   e. Any other additional test that the Authority may require in order to assure the quality of the cable.

2. In the event that the cable does not conform and is rejected by the Authority, the cost of the independent lab test shall borne by the Contractor.

3. The independent laboratory, selected by the Authority, will provide the Authority and manufacturer with all test results in writing within 14 days after receiving test cable specimens.

PART 3. EXECUTION

3.01 PREPARATION

A. Prior to pulling cables, clean raceway systems of all foreign matter and perform all operations necessary so as not to cause damage to cables while pulling.

B. Prior to pulling cables into underground conduit systems, place a feeding tube approved by the Engineer at the entrance end of such systems.

3.02 INSTALLATION

A. Cable Installation

1. General

   a. Keep cables dry at all times.

   b. Seal cable ends with watertight end seals if splicing or terminating does not follow at once.

c. Before splicing or terminating cables, make a thorough inspection to determine that water has not entered the cables or that the cables have not been damaged.

d. Use adequate lubrication when installing cables in conduits or raceways. Any pulling compounds shall be compatible with the finish of the wires and cables furnished.

B. Splices and Terminations

1. General

a. Unless otherwise noted herein or on the Contract Drawings, or where the Contractor submits pulling tension and sidewall pressure calculations and they are approved by the Engineer, all D.C. traction power cable shall be spliced in each chamber or manhole through which they pass. Sufficient slack shall be provided for several resplicings.

b. Any splicing or terminating methods other than those required by this Section, for which the components are in accordance with the requirements of this Section, shall be submitted to the Engineer for approval.

2. Insulated Wires and Cables

a. Splices and terminations shall be completed by workmen trained and experienced in the type of cable and the voltage class specified in this Section, with not less than 3 years experience in this type of work.

b. Where required by the Engineer, sample splices shall be demonstrated to the Engineer by each splicer performing the Work of this Section. The sample shall be provided to the Engineer after completion of the demonstration.

c. Splices shall conform to IEEE 404 and shall:

(1) meet the full electrical and physical integrity of the cable construction, including voltage rating, ampacity, and type of waterproofing;

(2) conform to the cable manufacturer's requirements and recommendations.

C. Arcproofing

1. All D.C. traction power cables in splice chambers or manholes or other points of access including equipment shall be arcproofed.

2. Arcproofing that has been disturbed for any reason, shall be reinstalled as soon as possible after the disturbance.

3. Arcproofing shall be installed as follows:

a. Cables shall be grouped by circuit and arcproofing applied over the group of cables comprising one circuit. Splices shall be arcproofed individually and the taping shall join with and be overlapped by the group taping.

b. Arcproofing shall be applied in two wrappings of half-lapped tape, bound with glass cloth tape applied at the ends of the fire resistant tape and at intervals not to exceed 24 inches along the entire length of the cables. The two wrappings shall be wrapped with opposing-lays.

c. Arcproofing shall be extended into the conduit opening or end bell of the raceway entering a splice chamber, manhole, junction box or other points of access.

d. Arcproofing tape shall be 1-1/2 inches wide where the diameter of the individual cable, or the circumscribed circle for the circuit group, is less than 1-3/4 inches. For larger diameters, the tape shall be 3 inches wide.

e. Arcproofing shall be performed by trained workers with 3 years of experience in this type of work.

D. Identification of Cables

1. Each cable shall be identified by its circuit in all junction boxes, manholes, splice chambers or other points of access, and at all termination points.

2. The circuit designations shall be as shown on the Contract Drawings. Tags shall be attached to cables in such a manner as to be readily visible.

3. The tag ties shall be wrapped around all conductors comprising the circuit or feeder to be identified.

4. Cables that are arcproofed shall be identified outside the applied arcproofing.

5. Cable tags shall be stainless steel metal tags, gauge and 3/4-inch wide, embossed with letters and numbers 5/16-inch high, fastened to the cable at both ends of tags with 1/16-inch diameter monel metal wire or stainless cables ties.

3.03 FIELD TESTS

A. A copy of all test reports, together with an outline of the test method used, shall be given to the Engineer. If, in the opinion of the Engineer, and tests do not meet the requirements of good practice or codes, the Contractor shall promptly replaced, at his own expense, the material or equipment involved or by other approved means review his work so that subsequent tests will indicate acceptable standards.

B. Should the foregoing tests reveal any defects, Contractor shall promptly correct such defects and rerun the tests until the entire installation is satisfactory to the Engineer in all aspects.

END OF SECTION

SECTION 16122

CABLES, SPLICES, TERMINATIONS
D.C. TRACTION POWER CABLE

APPENDIX A

SUBMITTAL REQUIREMENTS

A. Submit the following in accordance with the requirements of Shop Drawings, Catalog Cuts, and Samples of Division I - "GENERAL PROVISIONS"

B. Catalog Cuts shall be provided for the following but not limited to:

1. D.C. traction power cable(s)
2. Connectors and terminators
3. Splices
4. Pulling devices and end seals

C. Working drawings shall be submitted for the calculations installation sequence. Drawings shall include pulling tensions and sidewall pressure calculations of all cable pulls, including identification of manhole locations with splices and manholes which will be "pulled through" without splicing.

1. Submit certified shop tests reports of cable.
2. Submit field test results of cables, including "Megger" readings with the method used.

END OF APPENDIX "A"

SECTION 16122

CABLES, SPLICES, TERMINATIONS (D.C. TRACTION POWER CABLE)

INSTRUCTIONS TO SPECIFIERS

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(1.04 B.)	Requirement for factory-fitted pulling devices and end caps.
(1.04 C.)	Cable reel size maximum dimensions.
(2.01)	List of a minimum of three manufacturers concluded with the statement "or approved equal". Suggested Manufacturers are: <u>Cables</u>: Pirelli Cable Corporation The Okonite Company BIW Cable Systems, Inc. Rome Cable Corporation <u>Splices and Terminations</u>: Bishop Electric Corporation Burndy Corporation Cadweld (Erico Products Inc.) MAC Products Inc. Minnesota Mining and Manufacturing Company (3M) The Okonite Company Plymouth Rubber Company, Inc. Raychem Corporation Square D Company Thomas and Betts Corporation
(2.02 A.1)	Locations, types, sizes, and number of cables.
(2.02 A.2)	Requirement for solid conductors.
(2.02 A.3)	Requirement for cables jackets.
(2.02 A.4)	Requirement for factory-fitted pulling devices.
(2.02 B.3)	Maximum outer cable diameter.
(2.03 C.3.g)	Special splicing materials and methods.
(2.03 A.1)	Requirement for AC and DC dielectric withstand insulation resistance tests.
(2.03 B.1)	Requirements for independent laboratory tests.
(3.02 B.1)	Requirement for pulling tension and side wall pressure calculations.
(3.02 B.1)	Whenever cables are to be pulled through without splicing in a manhole.
(3.02 D.2)	Circuit designations.

B. Other Items

Ensure that the Specifications include the following Sections:

RACEWAYS
UNDERGROUND CONDUIT SYSTEMS

END OF INSTRUCTIONS

DIVISION 16

SECTION 16125

TRAFFIC SIGNAL CABLES

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for traffic signal cables.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

	American Society for Testing and Materials (ASTM)
ASTM B 3	Standard Specification for Soft or Annealed Copper Wire.
ASTM B 8	Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
ASTM B 33	Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes.
	Electrical Testing Laboratories, Inc. (ETL)
	International Municipal Signal Association (IMSA)
IMSA	Official Wire And Cable Specifications (Series 19/20-600 Volts).
	National Electrical Manufacturers Association (NEMA)
NEMA TS 2	Traffic Controller Assemblies with NTCIP requirements.
	National Fire Protection Association (NFPA)
NFPA 70	National Electrical Code (NEC).
	Underwriters Laboratories, Inc. (UL)

1.03 QUALITY ASSURANCE

Wires and cables that have been manufactured more than two years prior to installation shall not be used in the Work of this Section.

1.04 DELIVERY, STORAGE, AND HANDLING

Store material in a clean, dry space and protect from weather.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MATERIALS

A. Traffic signal cable wires shall be soft annealed copper wire in accordance with ASTM B 33 for tinned coated conductors or ASTM B 3 for bare copper conductors and shall be stranded copper conductors with concentric stranding conforming to ASTM B 8.

B. Color-Coding for Conductors

1. Insulation or covering of wires and cables shall be factory color-coded by the use of colored compounds or coatings. Consistently follow the color-code throughout the performance of the Work.
2. Color-code for conductors shall meet the IMSA standards.

C. All wires, cables, splice and terminations for which there are established UL standards shall bear the UL label.

D. Traffic Signal Cable

1. Shall meet the requirements specified herein, shall be Underwriters Laboratories (UL) and Electrical Testing Laboratories (ETL) approved and shall bear such approval labels.
2. Conductors shall be stranded copper of the gauge and number shown on the Contract Drawings. Standard conductor size for traffic signal cable applications shall be #14 AWG. Where voltage drop exceeds 5 percent, the conductor size for the traffic signal cable shall be #12 AWG.
3. Each conductor shall be factory tested for insulation resistance and for continuity of conductors.
4. Cables shall have a 600-volt rating, shall be factory tested for each conductor insulation resistance and for continuity of conductors and shall conform to the following International Municipal Signal Association (IMSA) Specifications:
   a. Cable in conduit and raceways: IMSA Specification 19-1 for polyethylene insulated polyvinyl chloride jacketed signal cable, with individual color-coded conductors and black outer jacket.
   b. Aerial Cable: IMSA Specification 19-3 for polyethylene insulated polyvinyl chloride jacketed signal cable with integral messenger, with individual color-coded conductors and black outer jacket.

2.02 CONSTRUCTION FEATURES

A. Cable Tags

1. Dry and Wet Locations
   a. Polyethylene tags, 0.025-inches thick and 1-1/2-inches wide, with letters and numbers 7/8-inch wide, with 2-14 AWG nylon, weather-resistant cable ties.
   b. PVC tags, 0.025-inches thick and 9/16-inch wide, with letters and numbers 5/16-inch wide, with 2-14 AWG nylon, weather-resistant cable ties.

B. Splicing and Terminating

1. All splicing and terminating materials shall be compatible so that no one material will adversely affect the physical or electrical properties of any other, or of the wire or cable itself.

2. All materials for making splices and terminations shall be specifically designed for use with the type of wire or cable, insulation and installation and operating conditions of the specific application.

3. All cable terminations shall meet the requirements of NEMA TS 2.

PART 3. EXECUTION

3.01 PREPARATION

A. Prior to pulling wires and cables, clean raceway systems of foreign matter and perform all operations necessary so as not to cause damage to wires and cables while pulling.

B. Prior to pulling wires and cables into underground conduit systems, place a feeding tube approved by the Engineer at the entrance end of such systems.

3.02 INSTALLATION

A. Locations, types, sizes and numbers of wires and cables are shown on the Contract Drawings. Where not indicated, provide traffic signal cable selection to comply with this Section and NFPA 70 standards.

B. Keep wires and cables dry at all times.

C. Use adequate lubrication when installing cables in conduits or raceways. Any pulling compounds shall be compatible with the finish of the wires and cables furnished.

D. Pull wires and cables through conduits in such a manner as not to overstress or stretch any wire. Do not score out, twist or damage the protective covering or insulation. In the pulling of wire or cable into conduits, where the strain on the wire or cable may prove excessive, use wire lubricant. Without exception, provide all cables and wires in junction or pull boxes with an adequate amount of slack formed around the interior of the box.

E. After cables have been installed and pending permanent splicing, make a thorough inspection to determine that water has not entered the wires and cables and that the wires and cables have not been damaged. Carefully seal the end of each section of cable in hand holes and service panels or cabinets, using rubber tape, and paint with a sealing type of waterproof compound. All cables in hand holes shall be placed on cable racks while waiting to be permanently spliced.

F. Cables and wires installed in a conduit system shall be properly trained through the hand holes to permit racking and connection to traffic signal poles and controller cabinets.

G. For wiring trained through existing hand holes, if any, which are not equipped with cable racks, furnish and install a cable rack assembly. Provide ground bushing and bonding wire on all metallic conduit ends within such hand holes. Cable rack assemblies for installation in existing hand holes, if any, shall consist of four cable racks, including inserts and fasteners.

H. Install cable terminations and terminate cables with insulated spade terminals conforming to NEMA TS 2.

I. Provide one coil of slack wire, three feet minimum, in all pole bases and six feet minimum in rectangular hand holes to allow for proper connection of all wiring. The allowable slack specified shall be the minimum amount of slack required. At certain locations or under certain conditions additional slack may be necessary, as shown on the Contract Drawings.

J. Secure conductors to the cable racks using nylon cable ties. In circular hand holes, provide one coil of slack wire, eight feet minimum, secured in a loop with nylon cable ties and placed in the bottom.

K. Cable/Wiring Joints and Splices

1. Cable shall be run between units of equipment without splices except in pole bases or unless otherwise shown on the Contract Drawings.

2. Where joints or splices are specified:

a. Make them with compression solderless connector and secured mechanically and electrically. Thoroughly clean conductors with a minimum of insulation removed.

b. Insulate joints and splices with insulating tape and provide one and one half times the insulation equivalent to that of the original conductor. Insulate the taped joints and splices with resin splicing kits.

L. Identification of Wires and Cables

1. Identify each wire and cable by its signal number in all cabinets, boxes, manholes, hand holes, wire ways and other enclosures and access locations, and at all terminal points.

2. The signal number designations shall be as shown on the Contract Drawings. Attach tags to wires and cables in such a manner as to be readily visible.

3. Wrap tag ties around all conductors comprising the signal number to be identified.

3.03 FIELD TESTS

A. Test all wires and cables up to equipment installed under the Contract with a Megohmmeter. Furnish the Engineer with a copy of the "Megger" readings together with an outline of the method used. If, in the opinion of the Engineer, any reading is lower than that required by codes that would apply if the Authority were a private corporation, promptly replace the materials involved, at the Contractor's expense, and retest.

B. When each wiring system is completed and before any connection is made to operating equipment, perform the following tests on each circuit in the presence of the Engineer to determine whether the installations are in acceptable working order:

1. Tests for continuity.

2. Tests for ground.

3. Tests for insulation resistance performed between circuit wires and from circuit wires to ground. Upon completion of the electrical system with fuses removed, or devices removed from the circuit, and before energizing, the insulation resistance shall not be less than 150 megohms between conductors or between conductor and ground on those circuits with a total single conductor length of 1,500 feet and over, and no less than 175 megohms for those circuits with a single conductor length of less than 1,500 feet.

C. Perform tests on the system as a whole. Circuits shall be complete, including all splicing from the control cabinet to all the devices it services.

END OF SECTION

SECTION 16125

TRAFFIC SIGNAL CABLES

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

A. Wires and cables for each type and size.

B. Termination and splice kit materials and installation procedures.

C. Furnish four copies of wire and wiring test results identifying the observed readings with their respective circuits. Identify test results with the Contract title, the date of the test and the atmospheric conditions. The Contractor is responsible for recording data and preparing the report with test results.

1. Submit certified shop test reports for wires and cables.
2. Submit field test results for wires and cables, including "Megger" readings with the test method used.

END OF APPENDIX "A"

SECTION 16125

TRAFFIC SIGNAL CABLES

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

2.01 D.2	Show the gauge and number of wires.
3.02 A	Provide locations, types, sizes and numbers of wires and cables.
3.02 I	Provide locations of additional cable slack.
3.02 K.1	Provide locations of splice points.
3.02 H.4.b	Provide circuit designations.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16127

CONTROL/SIGNAL TRANSMISSION MEDIA

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for the following types of control and signal transmission media:

A. Coaxial Cable

B. Twisted Pair Cable

C. Video - Pair Cable

D. Optical Fiber Cable

E. Optical Fiber Connectors and Couplers

1.02 REFERENCES

The following is a listing of the publications referenced in this section:

	American Society for Testing and Materials (ASTM)
ASTM B 3	Soft or Annealed Copper Wire
ASTM B 8	Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B 33	Tinned Soft or Annealed Copper Wire for Electrical Purposes
ASTM E 662	Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials
	Electronics Institute of America (EIA)
EIA FOTP-25	Fiber Optic Test Procedures for Impact Resistance
EIA FOTP-33	Fiber Optic Test Procedures for Maximum Pulling Load
EIA FOTP-41	Fiber Optic Test Procedures for Crush Resistance
EIA FOTP-104	Fiber Optic Test Procedures for Flexibility
EIA TIA-598	Optical Fiber Cable Color Coding Standards
	Insulated Cable Engineering Association (ICEA)
ICEA T-33-655	Guide for Low Smoke, Halogen-Free (LSHF) Polymeric Cable Jackets
	Military Standards
MIL-C-17	Standards for Radio Frequency Coaxial Cables
MIL-C-24643	Electrical Cable and Cord for Shipboard Use, Testing for Low Smoke and Halogens

National Fire Protection Association (NFPA)

NFPA 70	National Electrical Code

Naval Engineering Standards

NES 713	Determination of Toxicity Index of Products of Combustion From Small Specimens of Materials

Underwriters Laboratories Inc.

UL 910	Test for Flame - Propagation and Smoke - Density Values for Electrical and Optical-Fiber Cables Used in Spaces Transporting Environmental Air
UL 1666	Test for Flame Propagation Height of Electrical and Optical - Fiber Cables Installed Vertically in Shafts
UL 1685	Standards for Safety Vertical Tray Fire Propagation and Smoke Release Test for Electrical and Optical Fiber Cables

1.03 QUALITY ASSURANCE

A. Wires and cables that have been manufactured more than two (2) years prior to installation shall not be used in the Work of this Contract.

B. Where cables specified in this Section are used to provide signal paths for systems specified in other Sections of these specifications, or for systems shown on Contract Drawings, the Contractor shall obtain review of the cable characteristics and certification for use with the connected system equipment by the connected equipment manufacturer.

C. All optical fiber cable installations, splices and terminations shall be performed by qualified workers with prior experience in installing optical fiber cable and working on optical fiber systems. Work experience shall include the successful installation of at least 3 other optical fiber systems of similar complexity to the Work of this Contract. Qualifications shall include successful completion of training classes covering optical fiber cable installation, termination, splicing and connectorizing.

D. Cable manufacturers shall be regularly engaged in manufacturing control/signal transmission media products of the types, sizes, and characteristics specified in this section and on the Contract Drawings. Cable manufacturers' products shall have been in satisfactory use in similar service for not less than 3 years.

E. The Contractor shall comply with NFPA 70 "National Electric Code" for components and installation.

F. All cable of each kind shall be the product of a single manufacturer.

1.04 DELIVERY, STORAGE, AND HANDLING

A. The Contractor shall deliver to the worksite cable properly packaged in factory-fabricated type or wound on NEMA specified type cable reels.

B. The Contractor shall store cable in clean dry space in original containers, protected from weather, theft, vandalism, damaging fumes, construction debris and traffic.

C. The Contractor shall handle cable carefully to avoid braising, puncturing and tearing cable insulation and sheathing. Ensure that dielectric resistance and characteristic impedance integrity of transmission media are maintained.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, the Contractor shall provide wires and cables and wire and cable splicing and terminating products of manufacturers as shown on the Contract Drawings.

2.02 Control/ Signal Transmission Media

A. General

1. Locations, types, sizes and numbers of wires and cables are shown on the Contract Drawings.

   Where not indicated, the Contractor shall provide proper wire and cable selection to comply with this section, contract requirements and NFPA 70 Standards, or approved by the Engineer.

2. Unless otherwise shown on the Contract Drawings, solid conductors shall be soft, or annealed copper, conforming to ASTM B 33 (tinned), or ASTM B 3 (uncoated). Unless otherwise specified in this Section or unless otherwise shown on the Contract Drawings, stranded copper conductors shall be concentric stranding conforming to ASTM B 8.

3. Unless otherwise shown on the Contract Drawings, wires and cables that will be installed in riser areas shall pass the flame propagatory and smoke release criteria according to the test method of UL 1666.

4. Unless otherwise shown on the Contract Drawings, wires and cables that will be installed in plenum areas shall pass the flame propagatory and smoke release criteria according to the test method of UL 910.

5. Unless otherwise shown on the Contract Drawings, use the following performance characteristics for wires and cables which will be installed in subway areas, substations, tunnels, etc. where flame retardency, low smoke, low toxicity, zero halogen and good circuit integrity during a fire are required.

   a. Wires shall pass the flame propagatory criteria according to the test method of VW-1.

   b. Cables shall pass the flame propagatory and smoke release criteria according to the test method of UL 1685.

   c. The halogen content of the cable shall not exceed 0.2 percent according to the test method of MIL-C-24643. The Authority classifies 0.2 percent or less halogen content as "non-halogen".

   d. The cable shall comply with ICEA T-33-655 for smoke generation.

e. The toxicity index of the cable shall not exceed 2.0 according to the test method of NES 713.

f. The acid gas content of the cable shall not exceed a maximum of 2.0 percent according to the test method of Mil-C-24643.

6. All wires, cables, splices and terminations, for which there are established UL standards shall bear the UL label.

7. Cable Jacket Labeling

a. The cable jackets shall be labeled using environmental resistant printing in the range of 2 to 4 foot intervals.

b. The label shall indicate:

(1) The length to the end of the cable in feet

(2) The number of wires or optical fibers in the cable

(3) The date of manufacture

(4) The manufacture's name and part number

B. Electronic Cable

1. Single Conductor Coaxial

75-ohm characteristic impedance, solid polyethylene core 97 percent coverage, copper-braid shield, polyethylene jacket; conforming to MIL-C-17.

2. Single Conductor Plenum Coaxial

75-ohm characteristic impedance, solid base copper, central conductor, foamed Teflon dielectric, 100 percent coverage tinned-copper, double-braid shield, Teflon jacket, suitable for installation in air-handling spaces; conforming to MIL-C-17.

3. Direct Burial Coaxial

Single conductor, 75-ohm characteristic impedance, 18 AWG copper clad, steel-center conductor, solid polyethylene dielectric, 34 AWG bare copper-braid outer conductor shield with 95 percent coverage, polyvinyl chloride (PVC) jacket.

4. Aerial Coaxial

Single conductor, 75-ohm characteristic impedance, 18 AWG copper-clad, steel-center conductor, cellular expanded polyethylene dielectric, 34 AWG bare, copper-braid outer conductor shield with 95 percent coverage, ultraviolet-resistant polyvinyl chloride (PVC) jacket.

5. Multiconductor Cable

Quantity and size of conductors shall be as indicated on the Contract Drawings; color coded, low-loss polyvinyl chloride (PVC) insulation; aluminum/mylar shield and 22 AWG tinned-copper drain wire; PVC jacket.

6. Single Twisted Pair

Single-twisted pair, tinned-copper conductors , size of conductors shall be as indicated on the Contract Drawings; color-coded, low-loss polyethylene insulation; unshielded.

7. Multiple Twisted Pair

Quantity of twisted pairs and size of conductors shall be as indicated on the Contract Drawings; tinned-copper conductors; color-coded, low-loss polyethylene insulation; unshielded, polyvinyl chloride (PVC) jacket.

8. Multiple Shielded Twisted Pair

Quantity of twisted pairs and size of conductors shall be as indicated on the Contract Drawings; tinned-copper conductors; color-coded, polyvinyl chloride (PVC) insulation; overall aluminum/polyester shield and 22 AWG tinned-copper drain wire; PVC jacket.

9. Twisted Pair Plenum

Quantity of twisted pairs and size of conductors shall be as indicated on the Contract Drawings; 7-strand, tinned-copper conductors; Teflon insulation; overall aluminum/polyester shield and 22 AWG tinned-copper drain wire; Teflon jacket; suitable for use in air-handling spaces.

10. Video Pair

Balanced pair coaxial cable, 125-ohm characteristic impedance, 16 AWG soft-drawn, bare copper conductors twisted to form pairs, expanded polyethylene core insulation, copper shielding tape, expanded polyester film covering.

C. Optical Fiber Cables

1. Optical fiber cables shall be factory-fabricated, single channel, low-loss, glass, graded index type. The number of fibers and optical requirements shall be as shown on the Contract Drawings.

2. Unless otherwise shown on the Contract Drawings, the optical fibers shall have a 62.5-micron core diameter, 125-micron cladding diameter and 250 micron (nominal) coat diameter.

3. The optical fibers shall be incorporated in the cable construction using either the loose buffer tube or tight buffer tube method. The optical fibers shall be individually cladded, jacketed, and identified within the buffer tubes.

4. Each fiber shall be distinguishable by means of a continuous color code, continuous numbering, continuous lettering, or a combination of methods. Color coding of optical fiber cables shall be in compliance with EIA/TIA-598.

5. Unless otherwise shown on the Contract Drawings, the optical fibers shall have an attenuation of no more than 3.75 dB/Km at a wavelength of 850 nm, and 1.0 dB/Km at a wavelength of 1300 nm.

6. Unless otherwise shown on the Contract Drawings, the optical fibers shall have a minimum bandwidth of 200 MHz-Km at a wavelength of 850 nm, and a minimum bandwidth of 600 MHz-Km at a wavelength of 1300 nm.

7. Optical fiber cables shall conform to EIA FOTP-25 standard for impact resistance.

8. Optical fiber cables shall conform to EIA FOTP-33 standard for maximum pulling load.

9. Optical fiber cables shall conform to EIA FOTP-41 standard for crush resistance.

10. Optical fiber cables shall conform to EIA FOTP-104 standard for flexibility.

11. Optical fiber cables with PVC jackets are acceptable in indoor, general purpose and riser areas. Optical fiber cables with PVC jackets are not acceptable in indoor plenum areas.

12. Optical fiber cable for outdoor use shall be able to sustain the traffic-induced vibrations at all sites without damage to the physical and optical characteristics of the optical fiber.

13. Optical fiber cable for outdoor use shall be moisture resistant as per EIA FOTP-892 standard.

14. All materials used in the optical fiber cable shall be suitable for use under the following climatic conditions:

    a. Temperatures of -40 to +70 degrees centigrade

    b. Relative humidity of 5% to 100% condensing

15. Optical fiber cable for outdoor use shall be resistant to the following chemicals:

    a. Petroleum products (gasoline, diesel fuel, lubricants, etc.)

    b. Atmospheric nitric acid

    c. Carbon dioxide

    d. Carbon monoxide

    e. Nitrous oxides

    f. Atmospheric sulfuric acid

D. Optical Fiber Connectors

Where shown on the Contract Drawings, Contractor shall install stainless-steel optical fiber cable connectors, capable of terminating optical fiber glass cables. Optical fiber connectors shall have an insertion loss of not greater than 1.0 dB.

2.03 FACTORY TEST

A. Factory Inspection

The Authority shall have the right to inspect the manufacturer's quality control, manufacturing, and testing facilities at any time during the procurement process. Inspection by the Authority will include visual examination of the cables, and all related documentation to ensure that the cables are being fabricated in accordance with the Specifications.

B. Test Plan

Where required by the Contract Drawings, the Contractor shall submit a test plan for each type of cable shown on the Contract Drawings. The test plan shall be approved prior to the start of the factory test. The test plan shall include test schedule, lists of test to be conducted, test equipment to be used, expected test results and test documents produced, and copies of any certified test data to be used in lieu of testing.

C. Factory Test

1. For those tests that are not conducted during factory tests, the Contractor shall submit certification by a recognized independent testing laboratory, showing the complete test results. The Contractor shall notify the Engineer 14 days in advance of the scheduling of such factory tests. The Engineer reserves the right to require additional testing, or to waive factory inspection or witnessing of tests.
2. If factory tests are required by the Engineer, the cables shall not be shipped until after the factory tests have been satisfactorily completed and the cables are approved by the Authority.
3. Factory tests for optical fiber cable shall include, but not necessarily be limited to, the following:
   a. Attenuation of each fiber
   b. Bandwidth of each fiber
   c. OTDR (Optical Time Domain Reflectometer) image of each fiber
4. For all cable the following items shall be tested on a sample basis per the applicable test method:
   a. Consistency of color coding
   b. Cable length
   c. Dimensional tolerances

PART 3. EXECUTION

3.01 PREPARATION

Examine raceways and other elements to receive cable for compliance with installation tolerances and other adverse conditions. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install cable as indicated in accordance with NFPA 70 requirements and manufacturer's written instructions. Cable shall be installed in locations as shown on the Contract Drawings by experienced workers in a careful professional manner.
   1. Install transmission media without damaging conductors, shield, or jacket.
   2. Do not bend cable, in handling or installation, to smaller radii than minimum recommended by manufacturer.

B. Pull cables without exceeding cable manufacturer's recommended pulling tensions.
   1. Pull cables simultaneously where more than one is being installed in same raceway.
   2. Use pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation.
   3. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage media or raceway.

C. Splicing Of Cable

1. Splicing of optical fiber cable shall be permitted only when the length of the cable run exceeds those of the cable manufacturers pulling distance restrictions.

2. The number of splices per cable shall be kept to a minimum. Splicing shall be permitted only in electrical closets. Splicing of cable runs in roadway or ramp areas shall not be permitted.

3. Splicing of optical fiber cable shall be performed by means of fusion splicing. The Contractor shall submit, for approval, a detailed written procedure, prior to start of work, which shall include:

   a. The number of splices per fiber, and location of each splice, for all optical fiber cables.

   b. The proposed means to support the splice.

   c. Covering or sheathing of splice

4. Splicing shall be performed in a professional manner by experienced workers.

5. Splices shall not have losses exceeding 0.5 dB per splice.

6. All splices shall be enclosed in a splice organizer and then placed in a splice enclosure box to be mounted in the electrical closet. The Contractor shall submit catalog cuts for splice organizers and enclosures to the Engineer for approval.

D. Use splice and tap connectors that are compatible with cable material. All splice locations shall be approved by the Engineer.

E. Bond shields and drain conductors to ground at only one point in each circuit.

F. Connect components to wiring system and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL Standard 486A.

3.03 FIELD TESTS

After installation of cable and before energizing, the Contractor shall perform the following field tests:

A. Copper cable procedures

Inspect for physical damage and test cable for continuity and shorts. Use time domain reflectometer with strip chart recording capability and anomaly resolution to within 12 inches (300 mm) in runs up to 1000 feet (300 m) in length. Test cable segments for faulty connectors, splices, terminations, and the integrity of the cable and its component parts.

B. Optical fiber cable procedures

Perform each visual and mechanical inspection and electrical test, including optional procedures, stated in NETA Standard ATS, section 7.25. Certify compliance with test parameters and manufacturer's recommendations. The attenuation of each fiber of each cable shall be tested after the cable has been installed. The Authority reserves the right to require:

1. OTDR (Optical Time Domain Reflectometer) tests to be repeated in the field on any fibers that show evidence of physical damage or out-of-specification attenuation. If the field test results indicate that one or more fibers in any segment do not meet the attenuation requirements of this specification, the segment shall be replaced at no cost to the Authority.

C. Operate control/signal systems to demonstrate proper functioning. Replace malfunctioning cable with new materials, and then retest and recommission until satisfactory performance is achieved.

D. All equipment, and personnel, and supervision necessary to conduct the field test shall be provided by the Contractor.

END OF SECTION

SECTION 16127

CONTROL/ SIGNAL TRANSMISSION MEDIA

APPENDIX "A"

SUBMITTAL REQUIREMENTS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

A. Catalog cuts for control/ signal transmission media.

B. Cable certificates, acknowledged by the Communication System Manufacturers, certifying that the cables are suitable for the connected equipment as described in Section 1.03 "Quality Assurance".

C. One (1) foot sample of each type of control/signal transmission media for approval.

D. Sample splice kit materials and installation procedures.

E. Certified shop test reports for control/signal transmission media.

F. Field test reports indicating and interpreting test results.

G. Qualification data for manufacturers as per Section 1.03 "Quality Assurance" stating their capabilities and experience. Include list of completed projects and other information specified.

H. Maintenance requirements for cables.

END OF APPENDIX "A"

SECTION 16127

CONTROL/ SIGNAL TRANSMISSION MEDIA

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.01)	Show manufacturers of Electronic wires, cables and Optical Fiber cables and connectors on the Contract Drawings. List a minimum of 2 manufacturers and include "approved equal". If an item is unique or sole source, then a sole source letter will be required.
(2.01 A.1)	Show locations, types, sizes and numbers of all electronic wires and cables.
(2.01 A.2)	Specify special type of conductors that are not soft or annealed copper.
(2.02 A.5)	The wires and cables specified in this paragraph are not easily available. Large quantities and/or a pre-purchase may be required.
(2.02 B.1)	Specify type of single conductor coaxial cable. Also specify impedance, shield and jacket if different from this paragraph.
(2.02 B.2)	Specify type of single conductor, plenum coaxial cable. Also specify impedance, shield and jacket if different from this paragraph.
(2.02 B.3)	Specify type of direct burial coaxial cable. Also specify impedance, conductor, shield and jacket if different from this paragraph.
(2.02 B.4)	Specify type of aerial coaxial cable. Also specify impedance, conductor, shield and jacket if different from this paragraph.
(2.02 B.5)	Specify type of multi-conductor cable including quantity and size of conductors. Also specify cable insulation, shield and jacket if different from this paragraph.
(2.02 B.6)	Specify type of single twisted pair cable including quantity and size of conductors. Also specify cable insulation if different from this paragraph.
(2.02 B.7)	Specify type of multiple twisted pair cable including quantity and size of conductors. Also specify cable insulation and jacket if different from this paragraph.
(2.02 B.8)	Specify type of multiple shielded twisted pair cable including quantity and size of conductors. Also specify cable insulation, jacket and shield if different from this paragraph.
(2.02 B.9)	Specify type of twisted pair plenum cable including quantity and size of conductors. Also specify cable insulation, jacket and shield if different from this paragraph.
(2.02 C.1)	Show locations, types, sizes and numbers of all optical fiber cables.
(2.02 C.2)	Specify optical fiber diameters if different from this paragraph.
(2.02 C.3)	Specify either loose tube or tight tube method of cable construction.

(2.02 C.5)	Specify optical fiber attenuation if different from this paragraph.
(2.02 C.6)	Specify optical fiber bandwidth if different from this paragraph.
(2.02 D)	Specify type and diameter of optical fiber connectors.
(2.03 B)	Specify test plan for cable if required.

B. Design Criteria

Where applicable use the following criteria to design the Contract Drawings. This is only a partial list and should be used as a guide, additional criteria may be needed.

C. Show control/signal transmission media routing, including links between computers, microprocessors, control systems, distribution terminals, and other major connection points.

D. Indicate wiring method, such as raceway, exposed cable, or messenger for optical fiber cable.

E. Indicate types of control/signal transmission media interconnecting equipment and components.

F. Detail wall and floor penetrations and building entrance penetrations, including any underground work.

G. Detail grounding connections if not covered by proprietary product details.

H. Indicate point of service and type of service entrance.

I. Indicate sources of electrical power for optical fiber equipment.

J. Detail optical fiber cable routing, including interface links between computers, microprocessors, control systems, other components, and other control/signal media.

K. Indicate locations, mounting, types, sizes, and ratings of equipment and components being linked by optical fiber cable.

L. Show types of optical fiber cable interconnecting equipment and components (e.g., transmitters, receivers, drivers and LED's).

1. Submittals
2. Specify required submittals by editing Appendix A "Submittal Requirements"
3. Inspection Coordination
4. Ensure that the Construction Division is advised in writing as to which testing in 3.03 is to be witnessed and approved by a representative of the Engineering Department Design Division Staff.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16128

ARCPROOFING

PART 1. GENERAL

1.01 SUMMARY

This Section specifies arcproofing of low and medium voltage cables for new installations as well as existing installations from which asbestos fireproofing has been removed.

1.02 REFERENCES

American Society for Testing and Materials (ASTM)

ASTM D 1000	Test method for Pressure Sensitive Adhesive Coated Tapes used for Electrical and Electronic Applications
ASTM D 1518	Test methods for Thermal Transmittance of Textile Material
ASTM D 2843	Test method for the Density of Smoke from the Burning or Decomposition of Plastics
ASTM D 2863	Test method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastic (Oxygen Index)
OSHA	Occupation Safety and Health Administration

Underwriters Laboratories (UL)

UL 94V 0	Tests for Flammability of Plastic Materials for Part in Devices and Appliances

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

Acrproofing shall be furnished, and installed, and reinstalled if required in accordance with this Section and as specified on the Contract Documents.

1.04 QUALITY ASSURANCE

All work shall be performed and completed in a thorough, workmanlike manner and shall follow the best modern practice. All work shall be performed by mechanics skilled in their respective trades.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in manufacturer's original, unopened, protective packaging.

B. Store material in original packaging in a manner to prevent soiling and physical damage prior to installation.

C. Handle in a manner to prevent physical damage.

1.06 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 ARCPROOFING MATERIALS

A. Fire Resistant Tape shall be Scotch (3M) No. 77 or approved equal.

B. Glass Cloth Tape shall be Scotch (3M) No. 69 or approved equal.

C. Cable Tags

Stainless steel metal tags, No. 28 gauge and 3/4 inch wide, embossed with letters and numbers 5/16 inch high, fastened to the cable at both ends of tags with nominal 1/16 inch diameter monel metal wire or stainless steel cable ties.

PART 3. EXECUTION

3.01 EXAMINATION

A. Inspect tape prior to installation. Defective tape shall be discarded.

3.02 INSTALLATION

A. Arcproofing shall be installed as follows:

1. Arcproof all wire and cables operating at greater than 600 volts (line to line).
2. Wires and cables shall be grouped by circuit and arcproofing applied over the group of cables comprising one circuit. Splices shall be arcproofed individually and the taping shall join with and be overlapped by the group taping.
3. Arcproofing shall be applied in two wrappings of half-lapped tape, bound with glass cloth tape applied at the ends of the fire resistant tape and at intervals not to exceed 24 inches along the entire length of the cables. The two wrappings shall be wrapped with opposing-lays.
4. Arcproofing shall be extended into the conduit opening or end bell of the raceway entering a handhole, manhole or box.
5. Arcproofing tape shall be 1 1/2 inch wide where the diameter of the individual cable, or the circumscribed circle for the circuit group, is less than 1 3/4 inches. For larger diameters, the tape shall be 3 inches wide.

B. Identification of Wires and Cables

1. Each wire and cable shall be identified by its circuit in all cabinets, boxes, manholes, handholes, and other enclosures, and at all terminal points.
2. The circuit designations shall be as shown on the Contract Drawings. Tags shall be attached to wires and cables in such a manner as to be readily visible.

3. The tag ties shall be wrapped around all conductors comprising the circuit or feeder to be identified.

4. Wires and cables that are arcproofed shall be identified outside of the applied arcproofing.

3.03 ADJUSTMENTS

A. Prior to final inspection, arcproofing that has been disturbed, for any reason, shall be reinstalled as soon as possible.

END OF SECTION

SECTION 16128

ARCPROOFING

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Catalog Cuts

Submit catalog cuts for Fire Resistant Tape, Glass Cloth Tape and Cable Tags.

END OF APPENDIX "A"

SECTION 16128

ARCPROOFING

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(3.02 B.2) Circuit designations.

B. Other Items

This Section applies specifically to Arcproofing. For a complete installation, ensure that the following Sections, at a minimum, are included in the Contract Booklet as required:

Division 16 Section on RACEWAYS.

Division 16 Section on UNDERGROUND CONDUIT SYSTEMS.

Division 16 Section on WIRES, CABLES, SPLICES, TERMINATIONS (MEDIUM VOLTAGE).

END OF INSTRUCTIONS

DIVISION 16

SECTION 16129

TAXIWAY/RUNWAY WIRES AND CABLES

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for wires, cables, splices, terminations and accessories, for airfield construction.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

	American Society for Testing and Materials (ASTM)
ASTM B 1	Specification for Hard-Drawn Copper Wire
ASTM B 2	Specification for Medium-Hard-Drawn Copper Wire
ASTM B 3	Specification for Soft or Annealed Copper Wire
ASTM B 8	Specification for Concentric-Lay Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B 33	Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes
ASTM D 2802	Standard Specification for Ozone-Resistant Ethylene-Propylene-Rubber-Insulation for Wire and Cable
	Federal Aviation Administration, Advisory Circular (FAA-AC)
150/5345-7	Underground Electrical Cables for Airport Lighting Circuits (FAA Specification L-824B)
150/5340-19	Taxiway Centerline Lighting System
150/5345-26	Specification for Plug and Receptacle Cable Connectors (FAA Specification L-823)
	Federal Specifications (FS)
SS-S-1401	Sealing Compound, Hot Applied For Concrete and Asphalt Pavements
	Insulated Cable Engineers Association (ICEA)
S-68-516	Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
	Institute of Electrical and Electronics Engineers (IEEE)
IEEE 383	Type Test of Class 1E Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations

Underwriters Laboratories, Inc. (UL)

UL 44	Rubber Insulated Wires and Cables
UL 83	Thermoplastic-Insulated Wires and Cables

1.03 QUALITY ASSURANCE

A. Tests requiring certified reports and those requiring factory witness or field inspection shall be conducted and reported to the Engineer in conformance with those standards specified in this Section.

B. Installations shall comply with the standards of the Federal Aviation Administration (FAA) where applicable.

C. Wires and cables that have been manufactured more than two years prior to installation shall not be used in the work of this Section.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Where multi-conductors are to be installed as one cable, single conductor cables shall be paralleled by cable manufacturer prior to shipment. Cable assembly overall diameter shall be kept to a minimum.

B. Store material in a clean, dry space and protect from weather.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MATERIALS

A. General

1. Locations, types, sizes and numbers of wires and cables are shown on the Contract Drawings.

2. Unless otherwise shown on the Contract Drawings, solid conductors shall be soft or annealed copper, conforming to ASTM B 33 (tinned), ASTM B 189 (lead-coated or lead-alloy coated), or ASTM B 3 (uncoated).

3. All electrical materials and equipment for which there are established UL standards, shall bear the UL label.

B. 600 volt Insulated Wires and Cables

1. Power Wires and Cables

Type THWN - Secondary Series Lighting wire and cable shall be single conductor, Class C stranded, double rated THHN-THWN, thermoplastic insulated and nylon jacketed, gasoline and resistant and conform to UL 83.

2. Grounding Wires and Cables

Unless otherwise shown on the Contract Drawings, grounding conductors shall be as follows:

a. Insulated

(1) Solid for sizes #8 AWG and smaller, Class B Stranded for sizes #6 AWG and larger, 600 volt rated.

(2) Insulation shall be a continuous green color, double rated THHN-THWN thermoplastic insulated and nylon jacketed, gasoline and oil resistant and conform to UL 83.

b. Uninsulated

(1) Solid for sizes #8 AWG and smaller, Class B stranded for sizes #6 AWG and larger.

(2) In raceways

Soft-drawn and conforming to ASTM B 3

(3) Direct buried or encased in concrete

Soft-drawn, medium-hard-drawn or hard-drawn and conforming to ASTM B 1, B 2, or B 3, respectively.

C. 5000 volt Insulated Wires and Cables

Primary Series Lighting Cable shall be Non-Shielded 5000 Volt Rated, Type 'B', Single Conductor, Coated Copper, Class C, 19 Strands, Ethylene-Propylene-Rubber Insulated (ASTM D-2802 and ICEA S-68-516) and Chlorinated Polyethylene Jacket. The cable shall comply with FAA-AC 150/5345-7 and shall be approved under FAA Specification No. L-824B. Where indicated on the contract drawings, two cables shall be paralleled. (Identify one of the two cables with a yellow stripe.)

2.02 SPLICING AND TERMINATING MATERIALS

A. General

All materials for making splices and terminations shall be specifically designed for use with the type of wire or cable, insulation and installation and operating conditions of the specific application.

B. Power Wire and Cable Splices

1. Connector shall be insulated compression (indenter) type as specified on the contract drawings.

2. Silicone Sealant shall be as specified on the contract drawings.

3. Heat Shrinkable Tubing shall be either irradiated modified polyvinyl-chloride or irradiated polyolifin as specified on the contract drawings.

C. Secondary Series Lighting Cable Connectors

Double Pole plug and receptacle connectors for the secondary series lighting system shall comply with FAA-AC 150/5345-26 and shall be approved under FAA Specification No. L-823 in accordance with Figure No. 15. Plug and receptacles shall be as specified on the contract drawings.

D. Series Lighting Cable Connectors

Single Pole plug and receptacle connectors for the primary series lighting cable system shall comply with FAA-AC 150/5345-26 and shall be approved under FAA Specification No. L-823 in accordance with Figure No. 6. Plug and receptacles shall be as specified on the contract drawings. Coordinate the connector size for use with the cable.

E. Cable Tags

Stainless steel metal tags, No. 25 gauge, and 3/4 inch wide, embossed with letters and numerals 5/16 inch high fastened to the cable at both ends of tags with nominal 1/16-inch diameter monel metal wire or stainless steel cable ties.

F. Hot Rubberized Asphalt Sealer shall be the hot poured type conforming to Federal Specification SS-S-1401 Sealer.

2.03 SHOP TESTS

A. General

1. Factory or in-plant and independent laboratory tests shall be in conformance with the applicable standards and as specified in this Section. All testing, and the results thereof shall be certified, in writing, to the Engineer.

B. Factory or In-Plant Tests

1. Factory inspection and witnessing of tests by the Engineer shall be required for all wires and cables furnished under this contract. The Engineer reserves the right to require additional factory tests as required, or to waive factory inspection or witnessing of tests.
2. The Contractor shall notify the Engineer 14 days in advance of such factory tests.
3. 600 Volt Insulated Wires and Cables
   a. For quantities as shown on the Contract Drawings, regular dielectric-withstand and insulation- resistance in water tests for wires and cables shall be performed in accordance with UL 44.
   b. Flame tests for wires and cables shall be performed in accordance with IEEE 383.
4. 5000 Volt Insulated Wires and Cables
   a. Tests for wires and cables shall be in accordance with FAA-AC 150/5345-7 and ICEA S-68-516.

C. Independent Laboratory Tests

1. The following tests shall be performed by an independent test laboratory:

a. Specific Surface Resistivity

The specific surface resistivity of the cable jacket shall have a value greater than 200,000 Megohms under all of the following conditions:

(1) As manufactured.

(2) After immersion in tap water at 30 Degrees Celsius for 28 days with measurements performed after the first day and then every week.

(3) After immersion in a 50/50 solution of potassium acetate (KAc) deicer and tap water at 30 Degrees Celsius for 28 days with measurements performed after the first day and then every week.

b. The values of specific surface resistivity obtained in 2.03 C.1.a shall be plotted to demonstrate stability over time.

c. Drip Track Resistance

Using apparatus described in ASTM Standard D2303, the cable jacket shall pass the following test;

(1) No. of Samples: 6 - after immersion for 28 days in KAc/H2O solution

(2) Wetting Solution: 50/50 KAc/water

(3) Wetting Rate: 0.2 cm3/minute

(4) Applied Voltage Steps: 100 Volts/30 minutes

(5) Initial Tracking Voltage: >1000 Volts (Median Value)

Airport lighting cables that satisfy the above requirements should bear the following jacket printing;

"Cable Manufacturer" FAA-L-824 Type B MOD A

d. Certification and test required under Section 2.03 C shall be performed by an independent test laboratory. Submit qualifications and the test procedure of the test lab for approval prior to testing.

e. Testing shall not be required for a previously certified cable if successful testing has been performed by the same manufacturer for the identical cable using identical materials. The certified test data shall be submitted for approval.

PART 3. EXECUTION

3.01 PREPARATION

A. Inspect the raceways and conduits prior to installation of wires and cables and notify the Engineer in writing in the event of finding conditions that would prevent the proper installation of materials using the methods specified in this Section.

B. Prior to pulling wires and cables, clean the raceway systems of all foreign matter and perform all operations necessary so as not to cause damage to wires and cables while pulling.

C. Prior to pulling wires and cables into underground conduit systems, place a feeding tube approved by the Engineer at the entrance end of such systems.

3.02 INSTALLATION

A. Wire and Cable

1. General

a. Keep wires and cables dry at all times.

b. Seal wire and cable ends with watertight end seals if splicing or terminating does not follow at once.

c. Before splicing or terminating wires and cables, make a thorough inspection to determine that water has not entered the wires and cables or that the wires and cables have not been damaged.

2. General Purpose Wires and Cables

a. For the connection of taxiway and runway lights to secondaries of isolating transformers.

b. Leave sufficient slack in each cable, but in no case less than:

(1) Three feet in base cans

(2) Six feet in light boxes

3. 5000 Volt Series Lighting Cables

a. For connection of the airport Constant Current Regulator output to the primaries of the isolating transformers.

b. Leave sufficient slack in each cable, but in no case less than:

(1) Fifteen feet in manholes

(2) Ten feet in handholes

(3) Ten feet in lightboxes

(4) Six feet in base cans

B. Connections and Terminations

1. General Purpose Wires and Cables

After the cable has been installed, the connections and terminations shall be installed in accordance with the manufacturer's instructions.

2. 5000 Volt Series Lighting Cables

a. Connections to Transformers

(1) At each isolating transformer for runway and taxiway lights and taxiway signs and as shown on the Contract Drawings, the primary connectors shall consist of an assembly of L-823 Single Pole Plug and Receptacle cable connectors, and heat shrinkable insulation tubing.

(a.) Heat shrinkable insulation tubing shall be 13 inches minimum length and its interior shall be coated with elastic mastic to assure a watertight seal after shrinking.

(b.) Heat shrinkable insulation tubing may be installed in three sections to accommodate a connector that is not uniform in shape. The lengths of the sections shall be two at six inches long and one at eight inches long.

(2) After the cable has been installed, the connectors shall be installed on the ends of the Series Lighting Cable in accordance with the manufacturer's instructions.

(a.) The receptacle shall be installed at one end of the cable and the plug at the other end to establish a continuous plug and receptacle sequence through the wiring system and its associated isolating transformers.

(b.) Precautions shall be taken to release trapped air when inserting the plug in the receptacle. After the joint has been made and wiped clean of excess jelly, a heat shrinkable insulation tube shall be applied over the plug and receptacle in accordance with the manufacturer's recommendations and as approved by the Engineer.

b. Connections

(1) Where the Primary Series Lighting Cables are run through or into taxiway light boxes, handholes, or manholes, without connection to an isolating transformer, a plug and connector type installation as described immediately above, shall be used.

(2) The maximum lengths of uncut wires and cables shall depend on the lengths of the wire and cable that can be installed without damage.

C. Identification of Wires and Cables

1. Each wire and cable shall be identified by its circuit in all cabinet boxes, manholes, handholes, wireways and other enclosures or access locations, and at all terminal points.

2. The circuit designations shall be as shown on the Contract Drawings. Tags shall be attached to wires and cables in such a manner as to be readily visible.

3. Wire and Cable tags shall be fastened to both ends of the series lighting wires and cables.

3.03 FIELD TESTS

In addition to other tests that may be required in other Sections, the Contractor shall perform the following field tests in the presence of the Engineer, to demonstrate the reliability of the electrical installation.

A. Tests on the cables shall be made in accordance with the FAA-AC 150/5340-19.

B. All series lighting cables and circuits shall be tested with a 5000-volt megohm meter. The following test procedure shall be performed on all series lighting circuits:

1. Each single conductor 5000 volt insulated cable from the regulator to the first isolation transformer: Insulation value shall not be below RCI, computed as by the following formula.

$$RCI = \frac{8 \times 106 \text{ (Megohms)}}{Lci}$$

Where Lci is the length of the single conductor cable under test in feet.

2. The remaining portion of circuit from the first isolation transformer to the last isolation transformer shall have an insulation value of not less than Ris, computer by the following formula.

$$\frac{1}{Ris} = \frac{Nit}{2000 \text{ Megohms}} + \frac{Ns}{4000 \text{ Megohms}}$$

Where Nit is the number of isolation transformers, Ns is the number of slices.

3. Each single conductor 5000 volt insulated cable from the last isolation transformer to the regulator: Insulation value shall not be below Rc2, computed as by the following formula:

$$Rc2 = \frac{8 \times 106 \text{ (Megohms)}}{Lc2}$$

Where Lc2 is the length of the single conductor cable under test in feet.

4. The complete circuit after all splices are completed must have an insulation value of not less than Rt, computed by the following formula:

$$\frac{1}{Rt} = \frac{1}{Ris} + \frac{1}{Rci} + \frac{1}{Rc2}$$

Test shall use the step voltage method, using a minimum of 3 voltage levels; 1000 volts, 2500 volts and 5000 volts. Sufficient time shall be allowed for charging currents to subside. Minimum insulation values shall be met at any and all voltage levels. A written record of all tests shall be furnished to the Engineer before acceptance of the insulation. Tests shall be performed by qualified personnel and strict adherence to requirements of the Port Authority and the manufacturer of the equipment. All safety and operating rules shall be strictly observed and enforced.

C. After the installation has been completed, the Contractor shall successfully operate all electrical equipment for a continuous 24-hour period.

D. Unless otherwise shown on the Contract Drawings, all labor, materials and power required for the above tests shall be furnished by the Contractor. Only power for the operating test will be furnished by the Authority.

E. Should the foregoing test results reveal any defects, promptly correct such defects and rerun the tests until the entire installation is satisfactory to the Engineer in all aspects.

F. If any defects in existing equipment or materials are disclosed by the foregoing tests, the Contractor shall so notify the Engineer. After verification by the Engineer, and upon the Engineer's written order, the Contractor shall correct the installation to the extent directed by the Engineer. Any work so ordered by the Engineer and performed by the Contractor in connection with replacing of existing defective equipment or materials shall be compensated for in accordance with the clause of the Form of Contract entitled "Compensation for Extra Work." Damage to existing equipment or materials caused by the Contractor's acts or omissions shall be repaired at the Contractor's cost.

END OF SECTION

SECTION 16129

TAXIWAY/RUNWAY WIRES AND CABLES

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of DIVISION 1 - GENERAL PROVISIONS:

A. Catalog Cuts

1. Primary Series Lighting Cable
2. Primary Series Lighting Cable Connections and Terminations
3. Secondary Series Lighting Cable
4. Secondary Series Lighting Cable Splices
5. Grounding Cable
6. Single Pole Plug Connector
7. Double Pole Plug Connector
8. Flanged Receptacle Connector
9. Cable Tags
10. Sealer

B. Certified factory or in-plant test reports for wires and cables.

C. Certified independent laboratory test report for wires and cables.

D. Field Test reports for wires and cables, including all test data and methodology.

END OF APPENDIX "A"

SECTION 16129

TAXIWAY/RUNWAY WIRES AND CABLES

INSTRUCTIONS TO SPECIFIERS

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.02 A.1)	Locations, types and sizes and numbers of wires and cables.
(2.02 A.2)	Special types of conductors.
(2.02 C)	Indicate two cables paralleled.
(2.03 B.1)	Specify connector as manufactured by Hollings-Worth, or approved equal
(2.03 B.2)	Specify silicone sealant as RTV-106 as manufactured by General Electric Co., or approved equal.
(2.03 B.3)	Specify heat shrinkable tubing as catalog No. Shrink-KON H-912-6, as manufactured by Thomas & Betts Co. or approved equal.
(2.03 C)	Specify secondary series lighting cable connectors as style 90P or 90R, as required, and as manufactured by Amerace-ESNA Corp., or approved equal.
(2.03 D)	Specify series lighting cable connectors as style 54, as manufactured by Amerace-ESNA Corp., or approved equal.
(2.04 d)	Specify independent test laboratory at Cable Technology Laboratories, Inc., located at 690 Jersey Avenue, P.O. Box 707, New Brunswick, N.J. 08903.
(3.02 B.2.a)	Locations of primary connectors at locations other than specified.
(3.02 C.2)	Circuit designations.

B. Other Items

1. Specify required submittals by editing Appendix A "SUBMITTAL REQUIREMENTS".

2. Specify manufacturers for wires, cables, wire and cable splicing and terminating of one the following manufacturers, or approved equal:

   a. Wires and Cables

      American Insulated Wire Corporation
      Pirelli Cable Corporation
      The Okonite Company
      BIW Cable Systems Incorporated
      Rome Cable Corporation
      BICC

   b. Splicing and Terminating

      Wire and cable manufacturer as specified above.

      Crouse Hinds
      Thomas and Betts Corporation
      Burndy Corporation
      Elastimold
      Raychem Corporation
      Minnesota Mining and Manufacturing Company (3M)
      MAC Products Incorporated

END OF INSTRUCTIONS

DIVISION 16

SECTION 16130

CONDUCTOR BARS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for conductor bars and all accessories and appurtenances thereto.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

American Society for Testing and Materials (ASTM)

ASTM F 593 Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs

ASTM F 594 Standard Specification for Stainless Steel Nuts

National Fire Protection Association (NFPA)

NFPA 70 National Electrical Code

1.03 QUALITY ASSURANCE

The Contractor shall arrange that the services of a factory-trained, qualified technical representative be provided to supervise the installation of the conductor bar system; to inspect the completed installation; to make all adjustments necessary to place the system in proper operation; and to instruct the Authority's operating personnel in the proper care and operation of the conductor bar system. The minimum required number of days shall be as shown on the Contract Drawings.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver conductor bar equipment, components and accessories in manufacturers' original, unopened, protective packaging.

B. Store in original packaging in a clean, dry space and protect them from the weather.

C. Handle in a manner to prevent damage to finished surfaces.

D. Where possible, maintain protective coverings until installation is complete and remove such coverings as part of final cleanup.

E. Touch up any damage to finishes to match adjacent surfaces.

1.05 SPARE PARTS

Prior to completion of the Contract, furnish quantities of the required spare parts, as shown on the Contract Drawings, to the Engineer. The spare parts shall be protectively packaged and provided with substantial containers for storage under severe outdoor weather conditions. Each container shall be provided with legibly printed identification of the part designation and number.

1.06 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURER

Subject to compliance with the requirements of this Section, provide conductor bars, components and accessories from one of the manufacturers as shown on the Contract Drawing. No substitutions will be permitted.

2.02 MATERIALS

A. Each component of the conductor bar system shall be manufactured and furnished in accordance with the requirements of this Section, and as shown on the Contract Drawings.

B. The Contract Drawings show the locations of the conductor bars, hanger assemblies, expansion sections, splice assemblies, powerfeed assemblies and end covers required for the conductor bar installation under this Contract.

2.03 ACCESSORIES

All nuts, bolts, washers and other metallic fittings shall be stainless steel, AISI Type 304 and conforming to the applicable requirements of ASTM F 593 and ASTM F 594, unless otherwise shown on the Contract Drawings. Submit shop drawings of all fasteners, fittings and supports for approval by the Engineer.

PART 3. EXECUTION

3.01 INSTALLATION

A. All components of the conductor bar system shall be installed in accordance with the applicable provisions of NFPA 70 and in accordance with the manufacturer's written instructions and with the recommendations of the manufacturer's technical representative(s).

B. Conductor bar locations may, with the prior approval of the Engineer, be varied slightly to overcome any field interferences, providing that the installation is still in compliance with the requirements specified in this Section and with the manufacturer's instructions and recommendations.

The installation procedure used for the conductor bars, accessories and appurtenances shall be in accordance with the approved shop drawings. The Contractor shall not install the conductor bars until after the shop drawings are approved by the Engineer.

C. Any portions of the installation which, at the discretion of the Engineer, are damaged or defective or which are not installed in accordance with the manufacturer's recommendations shall be repaired or replaced to the satisfaction of the Engineer and as required to bring the installation into compliance with the manufacturer's recommendations.

3.02 FIELD TESTS

A. GENERAL

1. A method to reference each expansion joint, splice and connection with respect to the distance from one end of the bridge shall be provided to enable operating personnel to identify the hot spots, subject to approval by the Engineer.

2. One copy of the video tape record, the resistive loads, wiring diagrams for connection of resistive loads, and the results of the hot spot reference method testing shall be submitted to the Engineer upon completion of the test, and shall become the property of the Authority.

B. Infrared Thermographic Survey

Test the entire conductor bar installation by infrared thermographic survey as specified below. The test shall be witnessed by the Engineer and shall be performed in accordance with the specific test methods and equipment submitted by the Contractor and approved by the Engineer. The Contractor will not be permitted to start the conductor bar test until after the specific test methods, including the hot spot reference method, are approved. The test shall be performed in the following manner:

1. Disconnect the conductor bars from their normal 480 volt, 3 phase power source and from ground.

2. Furnish and connect an electric arc welder, or similar power source approved by the Engineer. The four conductor bars shall be temporarily connected to provide the test current simultaneously in all bars.

3. Unless otherwise shown on the Contract Drawings, the Authority power feeders shall be used to supply power for the test. If an engine-driven generator or welder is used for testing purposes, provide noise abatement shields in accordance with the requirements of "Conditions and Precautions" of Division 1 - GENERAL PROVISIONS.

4. Maintain a 60-ampere minimum current flow for a period of at least 24 hours immediately preceding the thermographic survey.

5. Inspect each conductor bar splice, expansion bar power connection and powerfeed connection for the full length of each conductor bar on each span. Check temperature differentials at each location using a thermographic scan, and provide a video tape record and one duplicate copy of the tape, of all thermographic scans. A hand held infrared thermometer shall be used to cross check and verify the absolute temperatures of any hot spots encountered during the scan. Any splice, expansion bar power connection or powerfeed connection, or any other location so directed by the Engineer, which demonstrates a 2.0 degree C temperature differential shall be disassembled, cleaned and reassembled in accordance with the manufacturer's instructions.

6. Retest locations that were disassembled and cleaned as required in 3.02 D of this Section.

C. Operational Test

1. After completion of the thermographic survey, reconnect the normal 480-volt, 3-phase power source to the conductor bars with proper phase connections.

2. Verify the phase relationship of any conductor bar sections through the use of a phase sequence meter. Demonstrate that the phase sequences are the same for adjacent sections.

END OF SECTION

SECTION 16130

CONDUCTOR BARS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Shop drawings, showing all mechancial parts and assemblies including electrical components, complete connection details, as well as a complete list of parts with full identification.
2. Shop drawings for fasteners fittings and supports.

B. Catalog Cuts

1. Components and accessories

C. Submitt the following to the Engineer for approval:

1. Test methods and equipment including connection diagrams.
2. Reference method for identification in accordance with 3.01 A of this Section.

D. Submitt the original and one duplicate copy of the thermographic survey.

END OF APPENDIX "A"

SECTION 16130

CONDUCTOR BARS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items:

(1.03)	The minimum number of days that a factory representative is required on site.
(1.05)	The listing of required spare parts.
(2.01)	A list of the following manufacturers: Insul 8 Corporation Wampler Conclude the List with the statement "No Substitutions will be Permitted."
(2.02)	The required components and their respective locations.
(2.03)	Requirements for other than stainless steel accessories and hardware.
(3.02 B.3)	Requirements for power to be supplied (for testing purposes) from other than the Authority power feeders.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16133

CONTROL PANELS, ENCLOSURES/CABINETS, AND TERMINAL BOXES

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for control panels, electrical enclosures and cabinets.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

	American National Standards Institute (ANSI)
ANSI Z 55.1	Gray Finishes for Industrial Apparatus and Equipment
	National Electrical Manufacturers Association (NEMA)
NEMA ICS 1	Industrial Control and Systems. General Requirements
NEMA ICS 1.1	Industrial Control and Systems. Safety Guidelines for the Application, Installation, and Maintenance of Solid State Control
NEMA ICS 2	Industrial Control and Systems. Controllers, Contractors, and Overload Relays Rated Not More Than 2000 Volts AC or 750 Volts DC
NEMA ICS 3	Industrial Control and Systems. Factory Built Assemblies
NEMA ICS	Industrial Control and Systems. Terminal Blocks
NEMA ICS 6	Industrial Control and Systems. Enclosures.
NEMA ICS 9	Industrial Control and Systems. Power Circuit Accessories
NEMA PB 250	Enclosures for Electrical Equipment (1000 Volts maximum)
NEMA Z 535.4	Product Safety Signs and Labels
	National Fire Protection Association (NFPA)
NFPA 70	National Electric Code
	Underwriters Laboratories Inc. (UL)
ANSI/UL 50	Cabinets and Boxes
ANSI/UL 65	Electric Wired Cabinets
ANSI/ UL 486E	Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors
ANSI/UL 486A	Wire Connectors and Soldering Lugs for Use with Copper Conductors
ANSI/UL 969	Marking and Labeling systems
UL 1059	Electrical Terminal Blocks
ANSI/UL 467	Electrical Grounding and Bonding Equipment
UL 437	Key Locks
ANSI/UL 508	Electric Industrial Control Equipment

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. Control Panels, Enclosures/Cabinets and Terminal boxes shall be designed in accordance with applicable standards of ANSI, NEMA, NFPA, and UL.

B. Unless otherwise shown on the Contract Drawings, enclosures/cabinets shall meet the following environmental requirements:

1. Enclosures/Cabinets located in heated areas shall be NEMA Type 1.
2. Enclosures/Cabinets located in unheated areas or in areas subject to dust or oil, shall be NEMA Type 12.
3. Enclosures/Cabinets located in exterior areas or in areas subject to rain, dripping liquid, or hosing shall be NEMA Type 4X, stainless steel.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Control panels, Enclosures/Cabinets and Terminal boxes shall be delivered to the construction site complete. All electrical devices and accessories shall be in place and wired.

B. Control panels, Enclosures/Cabinets, Terminal boxes and accessories shall be packaged to prevent damage due to vibration, jarring and the like during transportation and handling.

C. If any electrical devices or accessories must be shipped loose they shall be delivered in the manufacturer's original unopened protective packaging and shall be identified with suitable non-corrosive tag.

D. Store components and devices in clean and dry space, protected from weather.

E. Where possible, maintain protective covering until installation is complete and remove such covering as part of final cleanup.

F. Touch up any damage to finishes to match adjacent surfaces.

1.05 SPARE PARTS AND TOOLS

A. One set of all special tools and wrenches required for assembly or disassembly of the panel or cabinet and the installation of devices shall be furnished.

B. Furnish a list of recommended spare parts for each panel or cabinet. This list shall contain the prices and availability of the spare parts recommended.

1.06 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 GENERAL

A. List of acceptable manufacturers is shown on contract drawings.

B. All Enclosures/cabinets and equipment, for which there are established UL standards, shall bear the UL label.

C. Location of control panels and enclosures/cabinets and their approximate dimensions shall be as shown on the Contract Drawings.

D. Each control panels, enclosures and cabinets shall be factory assembled, wired, tested and shipped as a single complete unit, with all devices, terminal blocks and internal wiring installed, unless written permission is given by the Engineer to disassemble any components or parts for shipment. Shipped loose components must fit and be ready for immediate installation in the field.

E. Devices installed shall be grouped according to their function. 15% spare mounting space shall be provided for future alterations.

F. All indicating devices, instruments, control switches and indicating lights shall be mounted on the door or front panel. Protection relays, if used, shall be semi-flush type with built-in test facilities wherever possible.

G. No polyvinyl chloride (PVC) materials, insulation or products shall be used.

2.02 CONSTRUCTION FEATURES

A. Interior

1. Control panel interior shall be designed and assembled so that individual devices, terminal blocks and other removable components and wiring may be easily accessible in order to add, remove or replace them without disturbing or removing adjacent units. All devices shall be located on two surfaces only - front and rear. No intermediate swing panels are allowed unless specified on Contract Drawings.

2. The distance between devices and wiring ducts and between terminal blocks and wiring ducts shall be sufficient to install and make clearly visible full wire designation, but not less than 1 inch.

3. All control cables shall be installed in gutters and wiring ducts with removable covers. Filling of gutters and ducts shall not exceed 50 %. Wireways shall have 0.06 square inch area for each external connection terminal point. This area shall be in addition to wireways required for internal wiring.

4. All internal connections to door mounted devices shall be made with extra-flexible (19 strand) wiring bundled together into the cable tie harness with sufficient slack for opening/closing of the door. The bundle shall be enveloped with a helical plastic lacing to prevent wire abrasion. The wire bundle shall be carried between supporting clamps on the door and fixed portion of the enclosure.

5. Devices and terminal blocks shall be mounted on a mounting panel to space them away from rear wall of the enclosure/cabinet.

6. Enclosures/Cabinets with terminal blocks only shall include terminal straps and brackets sized for the particular enclosure/cabinet and designed to space the terminal blocks away from rear wall of the enclosures/cabinets. Straps and brackets shall be Hoffman Engineering Co., Bulletin A-80 or approves equal.

7. Thermostatically controlled space heaters with mechanical guards shall be provided for all outdoor-located enclosures and for indoor enclosures if requested on the Contract Drawings. Heaters shall be rated 240 volts and operated at 120 volts, each with an individual circuit breaker of suitable rating. Heaters shall be sized to keep the air inside the cabinet above the dew point.

B. Enclosures and Cabinets

1. Enclosures/Cabinets shall be fabricated of code-gauge, sheet-steel, unless hot-dipped galvanized steel or stainless steel is shown on the Contract Drawings.

2. Enclosures and Cabinets shall have a hinged door unless otherwise indicated on the Contract Drawings. Doors shall be fitted with concealed, continuous, flush piano hinges.

3. Enclosures/Cabinets and trims shall be for surface-mounting, recessed installation or free standing (floor mounting) installation as shown on the Contract Drawings.

4. Trim for recessed or flush-mounted enclosures/cabinets shall consist of a one-piece sheet-steel frame with hinged door, catch and lock. Frame shall extend 3/4-inch beyond each side of the cabinets and shall be set with their backs flush with the finished wall. Rolled lip around all sides of the enclosure shall be provided to exclude liquids and contaminants. Door and body stiffeners shall be provided where required to assure rigid construction.

5. Enclosures/Cabinets for surface mounting shall be provided with the door, hinged directly to enclosures/Cabinets. Door shall be made of one piece of sheet-steel, shall have a 3/4-inch flange around all edges shaped to cover the edge of the box, and shall be provided with a catch and lock. Rolled lip around all sides of the enclosure shall be provided to exclude liquids and contaminants. Door and body stiffeners shall be provided where required to assure rigid construction.

6. Floor mounting (freestanding) enclosures/cabinets shall be fabricated of 10-gauge steel with steel channel base to form a rigid, self-supporting structure. Heavy duty lifting eyes anchor into reinforced top shall be provided.

7. On panels or doors weakened by excessive area punched out for device mounting, reinforcing stiffeners shall be provided for extra rigidity.

8. Enclosures/Cabinets with through wiring shall be provided with side gutters 4 inches wide. Enclosures/Cabinets shall be provided with top and bottom gutters not less than 6 inches wide.

9. All doors shall close against a rabbet placed all around the inside edge of the frame, with a close-fitting joint between the door and frame.

10. Each door shall be furnished with a flush cylinder tumbler lock, with catch, and spring loaded type stainless steel door pull. Doors more than 48 inches high shall be provided with a heavy-duty, three-point latching mechanism with rollers on ends of latch rods for easy door closing. Locks shall be fitted to separate keying for each system. Furnish one key for each cabinet installed and a maximum of 20 keys per system.

11. Fastening door screws or door clamps, where required, shall be stainless steel. Door screws shall be of the captive, tamper proof type.

12. Collar studs shall be provided with internal mounting panel.

13. Provide large removable print pockets, mounted inside of each enclosure/cabinet door.

C. Wiring

1. Wiring shall be sized to the duty required. Control wires shall be # 14 AWG minimum

2. Wiring of all relays, instruments, and other devices shall conform to the arrangement shown on approved wiring diagrams.

3. All control wiring, including all spare contacts of all devices, shall be wired to terminal blocks. Terminals shall be arranged for consecutive connections of conductors which compose a given control circuit or connected device. Number of spare contacts in each device shall be as shown on Contract Drawings.

4. All bus wiring such as 125 V DC, 120 V AC, alarm, etc. shall be insulated wire, run from terminal block to terminal block and not rigid buses.

5. Connections made on terminal blocks and devices shall be by means of insulated locking fork, or insulated ring type crimp terminals. All crimps shall be made with a ratchet type compression tool specifically made for this application to produce optimum mechanical and electrical performance.

6. On devices that do not permit locking fork or ring type terminals, control wiring shall be held by tubular screw-type connectors.

7. Internal wiring shall have no splices, nor shall more than two wires be terminated on one terminal point.

8. Seller is solely responsible for correctness of the internal wiring and proper functioning of the equipment being connected.

D. Terminal blocks

1. Terminal blocks shall be as shown on the Contract Drawings, as follows:

   a. Sliding link disconnect terminal blocks shall be rated 600 volt AC and shall be UL recognized, Poweright Products Inc., series SLD-78-S, or approved equal.

   b. Add on type terminal blocks with screw terminals and clamps, rated 600 volts, and sized to accept a wire range of #22 to #8 AWG, UL recognized and CSA certified.

   c. Solderless tubular terminal blocks add-on type shall be rated 600 volts, and sized to accept a wire range of #22 to #8 AWG, with non-rotating clamping surfaces, UL recognized and CSA certified.

   d. Fuse blocks shall be furnished with 600 volt rated fuses and switch-action, blown fuse indicator, pullers.

   e. Provide terminal block accessories, including fanning strips, jumpers, marking strips and terminal covers.

2. Terminal block housings shall be molded from flame-retardant Lexan, Nylon or Polypropylene and terminal block accessories shall be made of flame-retardant materials. All terminal blocks shall be barrier type.

3. Each terminal block assembly shall be supported after every twelve points.

4. Terminal blocks rated 600 volts, 30 Amps shall be provided for all external connections by purchaser, unless otherwise shown on the Contract Drawings.

5. At least 20% uniformly distributed spare terminals shall be provided.

E. Identification

1. All devices shall be indelibly identified with legend plates inscribed in accordance with approved schematic diagrams and layout drawings.

2. Each Enclosure/Cabinet shall be provided with large engraved nameplate on its front. Nameplate nomenclature shall be according to a schedule approved by the Engineer.

3. Unless otherwise shown on the Contract Drawings, fabricate nameplates from an approved type of lamacoid plastic with letters engraved on the plate in white on black background. Where letter sizes are not shown on the Contract Drawings, use 1/2-inch high letters.

4. Secure nameplates on equipment with brass or stainless steel screws.

F. Accessories

1. Front of board test facilities shall be provided for all instrument and relay current and potential circuits that cannot be individually tested by test devices inherently built into relays or meter. Auxiliary contacts and switches shall be provided where necessary to form part of the test blocks.

2. Interior lighting with switches and receptacles, 120 volts AC, shall be provided if called for on Contract Drawings.

3. A color-coded mimic bus shall be provided if called for on Contract Drawings.

4. Internal copper ground bus, size 1/4 x 1 inch and extended throughout the structure, shall be provided in free standing enclosures/cabinets if called for on Contract Drawings. Ground bus shall be bolted, brazed or welded to the framework, side sheets, etc.

2.03 PAINTING

A. Surfaces to be painted shall be prepared by the removal of all grease, oil, rust, scale or other foreign material and chemically treated to provide a bond between the paint and metal surface preventing the entrance of moisture and the formation of rust under the paint film.

B. A prime coat of zinc chromate paint and two (2) finish coats of enamel paint conforming to ANSI Z 55.1 shall be applied. The gray prime and finish paints shall be a compatible finish system. In public areas the cabinets shall be painted as above, unless otherwise shown on Contract Drawings.

C. Furnish a can of touch up paint for use after equipment is positioned.

D. Stainless steel panels shall not be painted. Galvanized panels shall be painted if shown on the Contract Drawings.

2.04 SHOP TEST

A. Shop tests shall be in accordance with NEMA, ANSI and IEEE specifications, including:

1. High potential and operating tests on power equipment to demonstrate that this equipment will function correctly and in accordance with the intent of the specifications. Check rating of all protective devices (circuit breakers and fuses).
2. Insulation resistance test for each circuit with equipment connected, except those containing electronic components, using a 1000-volt megger. The insulation resistance shall be no less than 25 megohms.
3. Every control circuit continuity test. Use all schematic diagrams.
4. All control devices functional performance test to determine that all devices are wired and function correctly when energized.
5. Simulated operating test for the entire system.

B. Information outlining the test methods and procedures to be followed shall be submitted to the Engineer for approval during the period of shop drawing submission. A copy of test forms to be used shall be furnished at the time.

C. The Engineer shall be permitted to inspect any equipment, material or work to be furnished under this specification and shall have the right to reject any parts considered defective, unsuitable for the purposes or not in accordance with these specifications. Free entry shall be permitted to the Engineer at all times and to all parts of the works engaged in the manufacturing of this equipment.

D. The Engineer shall be notified in writing at least two weeks before testing. This notification shall list all units to be tested. The Engineer reserves the right to require additional testing or to waive factory inspection or witnessing of tests. The Engineer will advise the Contractor which tests will be witnessed and which will be waived.

E. Facilities for any reasonable tests that may be considered necessary in connection with any inspection shall be furnished free of charge. The shop shall provide equipment, instruments, cables, tools and personnel required and shall bear all expenses incidental to the foregoing tests, including replacement of damaged parts and material.

F. During the witnessing of tests, all original test data shall be initiated by the Engineer, and at the conclusion of the tests he shall be furnished with one copy of all original test data. If any data was modified, the Engineer shall be apprised and such modification shall be subject to the approval of the Engineer.

G. The accuracy of the calibration of all instruments to be employed during the tests shall be ascertained and recorded at the beginning of the tests. All readings shall be directed and visible to the Engineer.

H. Five (5) certified copies of all test results shall be furnished to the Engineer. Certification shall be by a Professional Engineer, licensed in the State in which tests were performed and so stamped.

I. Release of equipment shall not relieve the Contractor of the responsibility of furnishing equipment conforming to all specification requirements.

PART 3. EXECUTION

3.01 EXAMINATION

A. Verify that electrical installations, structural, mechanical and other related Work satisfy the requirements for performance of the work of this Section in accordance with the Contract Documentation.

B. Before delivering the equipment to the site, the Contractor shall investigate the site conditions to determine the best method of shipment, what preparatory Work, if any, will be needed to bring the equipment onto the site, and what will be the best and quickest method of unloading the equipment and setting it in place.

C. Report immediately to the Engineer any electrical, structural or related construction defects in areas where control panels or cabinets are to be installed, and do not attempt to rectify any defect unless specifically instructed to do so by the Engineer.

D. Before unloading the equipment it shall be inspected for damage during shipment. Any damage shall immediately be brought to the attention of the Engineer for resolution.

3.02 PREPARATION

A. Install any channels, angles or other supports that are required to support or mount the control panels and enclosures/cabinets.

B. Use supports and fasteners as specified in the Section of the Specifications entitled "SUPPORTING DEVICES" or as shown on the Contract Drawings.

3.03 INSTALLATION

A. Surface and flush mounted enclosures/cabinets shall be installed with tops 6 feet-6 inches above the floor, unless otherwise shown on the Contract Drawings.

B. Control panels and enclosures/cabinet shall be installed true and plumb on supporting struts and shall not be mounted directly on concrete, concrete block walls, or any other walls subject to moisture. Leave a minimum gap of 1/2 inch between the back of the enclosure/cabinet and the wall, using stainless steel hardware.

C. Where mounting directly on the wall is unavoidable the back of the enclosure shall be painted with two coats, minimum, of a bituminous paint.

D. Cables shall be neatly racked and bundled with nonflammable nylon ties, routed and supported within the enclosures/cabinets, cable ducts or gutters. Minimum bending radii as recommended by cable manufacturers shall not be reduced.

E. After conduits and cables are installed, the enclosures/cabinets shall be inspected for foreign materials and shall be vacuumed clean. Prior to energization, the panels shall be tested as described below.

F. A new set of as-built drawings, neatly bound together in plastic covers, shall be placed in the print pocket of each enclosure/cabinet.

3.04 FIELD TESTS

A. Visually inspect each device in the panel and operate manually.

B. Check all connections for tightness.

C. Check rating of all protective devices (circuit breakers and fuses). To each pole of the circuit breakers apply current 3 times its rating, recording currents and breaker trip times. Apply rapidly increasing currents and record the value that consistently causes instantaneous tripping of the breaker. Compare these recorded times with manufacturer's time current curves.

D. Perform each panel control wiring tests to determine that all devices are function correctly when energized and in accordance with the intent of the Contract Drawings and Specifications.

E. Perform control system functional test. This test shall include step by step procedure to determine that entire control system (this control panel could be just part of it) operate properly.

F. All discrepancies found by the contractor shall be brought to the attention of the Engineer.

G. All testing shall be performed in the presence of and as directed by the Engineer. The Contractor shall notify the Engineer when the equipment is installed and ready for testing.

END OF SECTION

SECTION 16133

CONTROL PANELS, ENCLOSURES/CABINETS, AND TERMINAL BOXES

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

Shop drawings for each enclosure/cabinet shall include:

1. Job name
2. Item number
3. Quantity of each enclosure/cabinet configuration
4. Nameplate schedule in accordance with design drawings
5. Complete assembly drawings including plan, elevation and section views with dimensions. Show dimensioned location of all devices, terminal blocks, accessories and details for purchaser cable support. Indicate conduit entrance areas and mounting details.
6. Cabinet/Enclosure construction details, floor plan and channel base detail drawings
7. Specification for enclosure/cabinet mechanical and electrical parts, and assemblies.
8. Wiring interconnection and schematic diagrams as follows:
   a. The elementary diagrams supplied by panel vendor shall contain
      (1) Each device designation corresponding to panel layout drawing and wiring diagrams
      (2) All device terminal numbers corresponding to device vendor information
      (3) Contact development diagrams of all control, selector, and transfer switches, protection and auxiliary relays, pushbuttons, etc. Indicate connections to control panel terminal blocks
      (4) Contact diagrams for all alarm and indication circuits. Indicate connections to control panel terminal blocks
   b. Control panel internal connection wiring diagram shall contain
      (1) Each device designation corresponding to panel layout drawing and elementary diagrams. All device terminals shall be identified identical to device vendor drawing and arranged in correct physical relationship.
      (2) Sufficient information at each wire termination to locate the other termination without recourse to routing sheets, supplementary tabulations, or any other document.

(3) Terminal strips numbered sequentially from top to bottom and left to right. Show terminals requiring external connections. The terminal strips shall be shown on drawings spaced at least 4 inches apart, so as to permit purchaser's external wiring to be shown on the same drawings.

c. External connection diagram between the control panel and the equipment connected to it.

9. Bill of materials: Components shall be identified by manufacturer's catalog number, technical characteristics and settings required for the installation. Bill of materials shall correlate components to panel layout drawing and diagrams.

B. Catalog cuts

1. Enclosures

2. Cabinets

3. Terminal blocks

4. All factory or field mounted devices and equipment shown on the Control panel or Enclosure/Cabinet drawings

C. Schedules

1. Nameplate nomenclature

2. Terminal block designations

D. As-built Documentation

END OF APPENDIX "A"

SECTION 16133

CONTROL PANELS, ENCLOSURES/CABINETS, AND TERMINAL BOXES

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in this Section:

(1.02)	Any additional publications referenced in the Contract Documentation.
(1.03 B)	Environmental requirements if other then that specified.
(1.04)	Indicate address of delivery if other than construction site.
(2.01 A)	List of manufacturers (min. - three).

B. Suggested list of enclosure/cabinet manufacturers:

Hoffman Engineering Company
Robroy Industries

C. Control panels shall be normally purchased from the companies specializing in the type of control under consideration.

For power distribution control systems, Energy management or motor control the following companies may be used:

General Electric Company
Square D Company
Westinghouse Electric Corporation
Siemens Energy and Automation, Inc.
Automatic Switch Co.

D. Make a note that manufacturers of equal qualifications to those listed on the drawings will be acceptable if approved by the Engineer.

E. Before recommending specific manufacturer check that the specified equipment is currently produced by the vendor and if nonstandard requirements and modifications (if any) can be met.

F. Provide clear indication if any equipment or materials shall be furnished by one particular manufacturer with no substitution.

G. Indicate if this equipment shall be furnished as a package with other equipment, even when made by different manufacturer and choose the primary supplier.

(1.01 C)	Location of control panels and cabinets and their approximate dimensions.
(2.01 F)	Provide suggested device layout for the front and back of panel.
(2.02 A)	Indicate if swing panel is needed. Normally intermediate swing panel is not desirable.
(2.02 B.1)	Indicate material of the enclosure or cabinet.

(2.02 B.2)	Indicate if bolted panel is required instead of the hinged door.
(2.02 B.3)	Indicate surface-mounting, recessed installation or free standing installation of cabinets and trims.
(2.02 C.3)	Indicate number of spare contacts required in each device.
(2.02 D.1)	Indicate type of terminal blocks required for each control panel or cabinet.
(2.02 D.4)	Indicate terminal block rating
(2.02 E.3)	Provide information regarding fabrication of nameplates if other than that specified. Indicate letter sizes.
(2.02 F.2)	Indicate if control panel interior lighting and receptacles required.
(2.02 F.3)	Indicate if mimic bus is required and suggest desired configuration.
(2.02 F.4)	Indicate if ground bus is required and size if other than specified.
(2.03 B)	Indicate paint color of public area cabinets if other than specified.
(2.03 D)	Indicate if galvanized steel cabinets are to be painted.
(2.04)	Provide specific shop test requirements if other than specified.
(3.02 B)	Specify support material and installation requirements if other than specified.
(3.03 A)	Indicate installation requirements if other than specified.
(3.04)	Provide specific field test requirements if other than specified.

H. Other

1. Review submittal requirements to adjust to your particular requirements
2. Ensure that the following Sections are included in the Contract bucket:

   Section 16475, "OVERCURRENT PROTECTIVE DEVICES"
   Section 16190, "SUPPORTING DEVICES"

END OF INSTRUCTIONS

DIVISION 16

SECTION 16135

BOXES AND FITTINGS

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies requirements for electrical boxes and fittings.

B. Types of electrical boxes and fittings specified in this Section are:

1. Outlet Boxes
2. Device Boxes
3. Pull Boxes
4. Junction Boxes
5. Conduit Bodies
6. Fittings

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

	National Electrical Manufacturers Association (NEMA)
NEMA OS1	Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports
NEMA OS2	Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports
NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)
	National Fire Protection Association (NFPA)
NFPA 70	National Electrical Code
	Underwriters Laboratories Inc. (UL)
UL 50	Cabinets and Boxes
UL 514A	Metallic Outlet Boxes
UL 514B	Fittings for Conduit and Outlet Boxes
UL 514C	Nonmetallic Outlet Boxes, Flush Device Boxes, and Covers
UL 886	Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations

1.03 QUALITY ASSURANCE

Boxes and fittings, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years. A list of acceptable manufacturers is shown on Contract Drawing.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver material in manufacturer's original, unopened, protective packaging.

B. Store materials in a clean, dry space and protect them from weather.

C. Handle in a manner to prevent damage to finished surfaces.

D. Where possible, maintain protective coverings until installation is complete and remove such coverings as part of final cleanup.

E. Touch up any damage to finishes to match adjacent surfaces.

1.05 SUBMITTALS

"Submittal Requirements" shall be in accordance with APPENDIX A.

PART 2. PRODUCTS

2.01 MATERIALS

A. General

1. Locations, types and sizes of boxes and fittings are shown on the Contract Drawings.
2. Boxes and fittings shall be metallic, unless otherwise shown on the Contract Drawings, and shall conform to NEMA 0S1, NEMA 250, UL 50, UL 514A, UL 514B, and NFPA 70.
3. Nonmetallic boxes and fittings, shown on the Contract Drawings, shall conform to NEMA 0S2, NEMA 250, UL 50, UL 514C, and NFPA 70.
4. Boxes and fittings to be located in hazardous (classified) areas, as shown by "area plans" on the Contract Drawings shall conform to UL 886 & NFPA 70.
5. All electrical materials and equipment, for which there are established UL standards, shall bear the UL label.
6. Where the sizes or dimensions of a box are not shown on the Contract Drawings, all boxes, whether for use on power, communications, signaling, control, telephone, or other purposes, shall be sized as follows:

   a. In straight pulls, the length of the box shall not be less than 8 times the trade diameter (nominal inside diameter) of the largest raceway.

   b. Where angle or "U" pulls are made, the distance between each raceway entry inside the box and the opposite wall of the box shall not be less than 6 times the trade diameter of the largest raceway. The distance shall be increased for additional entries by the amount of the sum of the diameters of all other raceway entries in any row on the same wall of the box. The distance between raceway entries enclosing the same conductor shall not be less than 6 times the trade diameter of the larger raceway.

c. Where a conduit entry is in the wall of a box opposite a removable cover, the minimum distance between the entry and the cover shall be as follows:

Conduit Size	Distance Between Entry and Cover
Up to 1-1/4"	4"
1-1/4" and 1-1/2"	6"
2" and 2-1/2"	8"
3" and larger	12"

d. The minimum depth of a box shall be not less than two times the trade diameter of the conduit entries in a single row and not less than 1-1/2 times the sum of the trade diameter of the largest raceway in each row for multiple rows.

7. Weatherproof cast boxes shall be used for exterior or damp locations. Weatherproof boxes shall be hot-dipped galvanized cast-steel or cast-aluminum. Cast boxes shall be threaded conduit entrance type provided with mounting lugs. Materials shall match the type of conduit i.e., galvanized steel or aluminum, used in the conduit run.

8. Covers for boxes located in public spaces or where shown on the Contract Drawings shall be furnished with tamper-resistant hardware.

9. Cover plates for outlet boxes are specified in the Section 16140 entitled "WIRING DEVICES".

B. Interior Outlet and Device Boxes

1. Provide galvanized, flat-rolled, sheet-steel interior outlet wiring boxes, of types, shapes and sizes, including box depths, to suit each respective location and installation; construct boxes with stamped knockouts in back and sides, and with threaded screw holes with corrosion-resistant screws for securing box covers and wiring devices.

2. Outlet boxes shall be of proper sizes and shapes for conduits and wires entering them, and equipped with plaster ring or cover as necessary for the wiring devices to be installed.

3. Boxes for switches and receptacles shall be 4-inch square, minimum 2 1/8-inch deep, for up to two devices; solid, ganged boxes for over two devices; and installed so that device covers shall be tight and plumb with wall finish.

4. Provide suitable barrier in boxes where two or more 277-volt switches are to be installed, to isolate each on its own phase.

5. Boxes for lighting fixture installation shall be 4-inch square, minimum 2 1/8-inch deep, and provided with 3/8-inch studs.

6. Boxes to be installed in ceilings, plenums, or spaces used for supply or return of environmental air shall be UL listed for such use, without holes, openings or penetrations, and complete with gasketed cover plates.

7. Provide all sheet-steel boxes with suitable knockouts.

C. Exterior Outlet and Device Boxes

1. Provide corrosion-resistant, cast metal, weatherproof outlet wiring boxes, of types, shapes and sizes, including box depths, to suit each respective location and installation.

2. For outlet boxes to be installed flush or recessed in exterior walls, provide galvanized, sheet-steel boxes, with suitable depth and tile, plaster or masonry rings for the wall construction.

3. Provide cast-metal faceplates with spring-hinged, waterproof caps suitably configured for each application, including faceplate gaskets and stainless steel or brass screws or fasteners. Faceplate material shall match the type of box i.e., galvanized steel or aluminum.

D. Junction and Pull Boxes

1. General

a. Unless otherwise shown on the Contract Drawings, provide galvanized, code-gauge, sheet-steel junction and pull boxes and covers for interior locations and cast-metal boxes and covers for exterior locations of types, shapes and sizes to suit each respective location and installation, and equipped with stainless steel hinges, nuts, bolts, screws and washers.

b. Junction or pull boxes having any dimension larger than 36 inches shall contain racks or supports for all cables or conductors.

c. Provide pull boxes with suitable insulating barriers where shown on the Contract Drawings or required by code. Vertical-offset pull boxes shall contain cable supports at turns to prevent cables from resting on corners.

d. Where shown on the Contract Drawings, provide boxes with provisions for padlocking.

e. Special boxes shall be as shown on the Contract Drawings.

f. Where shown on the Contract Drawings, catches or vault handles shall be lockable. Locks shall be keyed alike for the same service, such as power, communications, signal or telephone. Each service type shall be keyed differently.

g. All covers in exposed exterior locations, or other areas as shown on the Contract Drawings, shall be gasketed.

h. For covers heavier than 20 pounds or more than 24 inches in any dimension, provide two replaceable studs, located on each side of the box flange, to support the cover during installation.

i. Boxes containing, or designated for, conductors operating at greater than 600 volts (phase-to-phase) shall be constructed of minimum 12-gauge steel.

2. Interior Junction and Pull Boxes

a. Finished Areas

(1) Junction and pull boxes, located in finished areas and having any dimension larger than 12 inches, shall be furnished with flush-mounting, lockable, hinged covers, similar to adjacent panelboard cabinets. Locks shall be keyed alike for the same service, such as power, communications, signal or telephone. Each service type shall be keyed differently. Hinged covers shall contain catches to keep covers closed. Covers having any dimension larger than 36 inches and all multiple-section doors shall contain 3-point vault handles. Covers shall be furnished shop-primed for field painting, and shall be finished with a color as selected by the Engineer.

(2) Boxes having any cover dimension 12 inches or less shall be furnished with flush-mounting, screw-on covers, unless otherwise shown on the Contract Drawings.

b. Unfinished Areas

Junction and pull boxes, located in electrical or telephone closets or rooms, in mechanical equipment rooms, in areas above hung or accessible ceilings or in areas shown on the Contract Drawings as "unfinished," shall be furnished with screw-on covers for boxes having any cover dimension 24 inches or less, and with either single or multiple-section hinged covers for boxes having any cover dimension larger than 24 inches.

3. Exterior Junction and Pull Boxes

a. Junction and pull boxes, located in sidewalks, decks and in areas shown on the Contract Drawings as "finished", shall be furnished with flush-mounting, screw-on covers.

(1) Boxes having any cover dimension 24 inches or less shall be cast-steel. Boxes shall be furnished with asphaltic paint finish on surfaces to be embedded in earth or concrete.

(2) Covers having any dimension larger than 24 inches shall be cast-steel "sidewalk" frames and covers, suitable for installation on a concrete box or handhole.

b. Unfinished Areas

Junction and pull boxes, located in areas shown on the Contract Drawings as "unfinished", shall be furnished with screw-on covers for boxes having any cover dimension 24 inches or less, and with hinged, bolt-on covers for boxes having any cover dimension larger than 24 inches.

E. Floor Boxes

Provide cast-steel, waterproof, adjustable floor boxes with threaded-conduit entrance hubs, and vertical adjusting rings, gaskets, brass floor plates and flush, screw-on covers. All unused conduit openings shall be closed with appropriate plugs.

F. Conduit Bodies

Provide galvanized, cast-metal, conduit bodies, of types, shapes and sizes to suit each respective location and installation; construct with threaded-conduit entrance hubs, removable covers, and stainless steel or brass screws.

G. Bushings, Locknuts and Knockout Closures

Provide corrosion-resistant knockout closures and conduit locknuts, and insulated, malleable-iron, conduit bushings and offset connectors, of types and sizes to suit each respective use and installation.

H. Supporting Devices

Provide inserts, expansion shield lugs, bolts with nuts and washers, shims or any other type of fastening devices required to secure boxes, in accordance with the Section 16190 entitled "SUPPORTING DEVICES". Unless otherwise shown on the Contract Drawings, all fasteners shall be hot-dipped galvanized and of sizes and types recommended by the equipment manufacturer and as approved by the Engineer.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install boxes and conduit bodies at the locations shown on the Contract Drawings and as required by NFPA 70 at any other location where they are required to facilitate the pulling, supporting or connection of wires and cables.

B. Securely mount all boxes in a manner approved by the Engineer and support the boxes independently of conduits entering them.

C. Install boxes and conduit bodies in classified (hazardous) locations in accordance with their listing or label requirements. Conduit seal fittings shall be packed and filled only after proper operation of equipment and systems has been demonstrated and approved by the Engineer.

D. Paint exteriors of boxes exposed in mechanical equipment rooms or in electrical rooms or closets or spaces shown as "unfinished" on the Contract Drawings, and the exteriors of boxes installed above hung or accessible ceilings, as follows:

1. Emergency: Orange
2. Fire Alarm: Red
3. High Voltage: Red with 1-inch, white block letters reading “HIGH VOLTAGE” on each exposed face and cover.

E. All installations shall conform to NFPA 70.

F. Dissimilar Metals

1. "Dissimilar metals" shall mean those metals which are incompatible with one another in the presence of moisture, as determined from their relative positions in the Electrochemical Series, or from test data.

2. Where dissimilar metals come in contact, paint the joint both inside and out with approved coating to exclude moisture from the joint, or provide a suitable insulating barrier separating the metals.

END OF SECTION

SECTION 16135

BOXES AND FITTINGS

APPENDIX A

SUBMITTAL REQUIREMENTS

Submit the following, for approval in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

A. Catalog Cuts

1. All boxes and fittings.

B. Shop Drawings

1. Special boxes.
2. Boxes larger than 12 inches.
3. Ancillary equipment if shown on Contract Drawings.

END OF APPENDIX "A"

SECTION 16135

BOXES AND FITTINGS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following:

(1.03) List of a minimum of three manufacturers concluded with the statement "or approved equal".

1. Suggested manufacturers for boxes other than special boxes are:

   Appleton, Electric
   Crouse Hinds, Co.
   Hubbell Inc.
   O-Z/Gedney
   Square D, Co.

2. List of a minimum of three manufacturers of special boxes concluded with the statement "or approved equal". The specifier must ascertain suitable manufacturers of special boxes.

(2.01 A.1)	Location, types and sizes of boxes and fittings
(2.01 A.2, 3)	Note any boxes that are to be nonmetallic
(2.01 A.4)	"Area Plans" for limits of hazardous (classified) locations
(2.01 A.8)	Location of covers for boxes in areas other than public areas, that require tamper-resistant hardware
(2.01 D.1.a)	Locations of boxes other than sheet-steel (interior) or cast-metal (exterior)
(2.01 D.1.c)	Locations of all boxes requiring insulating barriers
(2.01 D.1.d)	Locations of boxes requiring padlocks
(2.01 D.1.e)	Locations and design of special boxes
(2.01 D.1.f)	Locations of catches and handles that require locks
(2.01 D.1.g)	Locations of covers that require gaskets in areas other than exposed exterior locations
(2.01 D.2.a.(2)	Locations of all boxes with either dimension less than 12 inches or that do not have flush covers
(2.01 D.2.b)	Locations of "unfinished" areas for interior junction and pull boxes
(2.01 D.3.a)	Locations of "finished" areas for exterior junction and pull boxes
(2.01 D.3.b)	Locations of "unfinished" areas for exterior junction and pull boxes
(2.01 H)	Locations of fasteners other than hot-dipped galvanized, or special sizes or types
(3.01 A)	Locations of boxes and conduit bodies
(3.01 D)	Locations of "unfinished" areas for painting

B. Other Items

Ensure that the Specifications include the following Sections referenced in "Boxes And Fittings" Section 16135:

(2.01 A.9) "WIRING DEVICES", Section 16140

(2.01 H) "SUPPORTING DEVICES", Section 16190

1. Indicate additional submittal requirements on Contract Drawings.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16150

MOTOR POWER AND CONTROL WIRING

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for the furnishing, installation, connection and testing of motor power and control wiring.

A. Motor Power and Control Wiring

Furnish and install all conduits, wires and accessories, and make final connections to all motors, motor starters, motor control centers, control devices and appurtenances furnished under other Sections of the Specifications.

B. Motor Starters, Motor Control Centers, and Control Devices

Install motor starters, motor control centers, control devices (except as specified in the following sentence) and appurtenances furnished under other Sections of the Specifications. Control devices having piping connections shall be installed under other Sections, but shall be wired under this Section.

C. Wiring diagrams and Equipment Installation Schedules

Wiring diagrams and equipment installation schedules or functional and/or operational requirements are shown on the Contract Drawings. Coordinate and supplement the wiring diagrams and schedules with any additional functional or operational requirements specified in other Sections of the Specifications. In the event of a conflict between the wiring diagrams and schedules and the functional and operational requirements, the latter shall govern.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

	National Electrical Manufacturers Association (NEMA)
NEMA ICS 2	Industrial Control and Systems. Controllers, Contactors, and Overload Relays Rated Not More Than 2000 Volts AC or 750 Volts DC
NEMA ICS 4	Industrial Control and Systems, Terminal Blocks
	National Fire Protection Association (NFPA)
NFPA 70	National Electric Code

Underwriters Laboratories Inc. (UL)

ANSI/UL 65	Electric Wired Cabinets
ANSI/UL 486E	Equipment Wiring Terminals for Use With Aluminum and/or Copper Conductors
ANSI/UL 486A	Wire Connectors and Soldering Lugs for Use With Copper Conductors
ANSI/UL 969	Marking and Labeling systems
UL 1059	Electrical Terminal Blocks
ANSI/UL 467	Electrical Grounding and Bonding Equipment
ANSI/UL 508	Electric Industrial Control Equipment

1.03 QUALITY ASSURANCE

Entities performing the Work of this Section shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.04 SUBMITTALS

See Appendix "A" for Submittal Requirements.

PART 2. PRODUCTS

2.01 MATERIALS

A. Provide all conduits, wires, and accessories as shown on the Contract Drawings and as required to perform the Work.

B. Provide all conduits and wires in accordance with the Sections of the Specifications entitled "RACEWAYS" and "WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS).

C. Provide angle iron supports, brackets or hangers for mounting starters, control panels and control devices in accordance with the Section of the Specifications entitled "SUPPORTING DEVICES".

D. All fuses and circuit breakers provided under this Section shall be of the ratings and types as shown on the Contract Drawings or, if not shown on the Contract Drawings, shall be as recommended by equipment manufacturers.

E. All motor control equipment shall be manufactured in compliance with NEMA ICS 2, NEMA ISC 4, ANSI/UL 65, ANSI/UL486E, ANSI/UL486A, ANSI/UL 969, ANSI/UL 467, ANSI/UL 508 and UL 1059.

PART 3. EXECUTION

3.01 EXAMINATION

A. Prior to making electrical connections, check all electrical equipment furnished under other Sections of the Specifications for the specified voltages and directions of rotation.

B. Prior to energizing motors, verify the specified overload rating of all heater elements and relay settings, furnished with the motor starters under other Sections of the Specifications, so that, in cases, the proper running protection will be provided for the motors. Should the overload ratings not be correct, notify the Engineer.

3.02 INSTALLATION

A. Install all motor starters, motor control centers, control devices, conduits, wires and accessories in accordance with the requirements of NFPA 70 and the manufacturers' installation procedures. Make final connections in accordance with approved shop drawings.

B. Install all conduits, wires, accessories and supports in accordance with the requirements of Sections specified in 2.01 B and C.

3.03 FIELD TESTS

A. Perform tests, in presence of the Engineer, to demonstrate the following and give the Engineer 24 hours advance notice of tests.

1. That each control device and its related motor starter operates properly.
2. That each overload protective and safety device functions properly.

B. Tests shall be performed in accordance with the equipment manufacturers' start-up and field test instructions and made jointly with all affected trades.

C. Should the tests reveal any defects, promptly correct such defects and rerun the tests until the entire installation is satisfactory in all respects.

END OF SECTION

SECTION 16150

MOTOR POWER AND CONTROL WIRING

APPENDIX A

SUBMITTAL REQUIREMENTS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

Shop drawings shall include:

1. Job name
2. Item number
3. Specification for electrical parts, and assemblies.
4. Wiring interconnection and schematic diagrams as follows:

   a. The elementary diagrams supplied by equipment vendor shall contain

      (1) Each device designation corresponding to equipment layout drawing and wiring diagrams

      (2) All device terminal numbers corresponding to device vendor information

      (3) Contact development diagrams of all control, selector, and transfer switches, protection and auxiliary relays, pushbuttons, etc. Indicate connections to terminal blocks

      (4) Contact diagrams for all alarm and indication circuits. Indicate connections to control panel terminal blocks

   b. Connection wiring diagram shall contain

      (1) Each device designation corresponding to equipment layout drawing and elementary diagrams. All device terminals shall be identified identical to device vendor drawing and arranged in correct physical relationship.

      (2) Sufficient information at each wire termination to locate the other termination without recourse to routing sheets, supplementary tabulations, or any other document.

      (3) Terminal strips numbered sequentially from top to bottom and left to right. Show terminals requiring external connections. The terminal strips shall be shown on drawings spaced at least 4 inches apart, so as to permit purchaser's external wiring to be shown on the same drawings.

   c. External connection diagram between the equipment and devices connected to it.

B. Bill of materials. Components shall be identified by manufacturer's catalog number, technical characteristics and settings required for the installation. Bill of materials shall correlate components to equipment layout drawing and diagrams.

C. Catalog cuts

1. Protection and control devices
2. Terminal blocks
3. All factory or field mounted devices and equipment shown on Equipment drawings

D. Schedules

1. Terminal block designations

E. As-built Documentation

END OF APPENDIX A

SECTION 16150

MOTOR POWER AND CONTROL WIRING

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in this Section:

(1.01)	Provide wiring diagrams, schematics and/or functional and operational requirements.
(1.02)	Any additional publications referenced in the Contract Documentation.
(3.02)	Indicate installation requirements if other than specified.
(3.02 A)	Indicate number of spare contacts required in each device.
(3.02 A)	Indicate type of terminal blocks required for each control panel or cabinet.
(3.02 A)	Indicate terminal block rating
(3.02 B)	Specify support material and installation requirements if other than specified.
(3.03)	Provide specific field test requirements if other than specified.

B. Other

1. Review submittal requirements to adjust to your particular requirements.
2. Insure that the following Sections are included in the Contract book:
3. Section 16475 "OVERCURRENT PROTECTIVE DEVICES"
4. Section 16190 "SUPPORTING DEVICES"
5. Section 16120 "WIRES, CABLES, SPLICES, TERMINATIONS (600V OR LESS)

END OF INSTRUCTIONS

DIVISION 16

SECTION 16190

SUPPORTING DEVICES

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies requirements for hangers and supports, sleeves and fasteners used to support electrical raceways and equipment, except as specified in B below.

B. Supporting devices, furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Sections of the Specifications.

1.02 REFERENCE

The supporting devices, specified in this Section shall be constructed, installed and tested in accordance with requirements of the following publications:

	American Institute of Steel Construction Inc. (AISC)
AISC	Manual of Steel Construction
	American Iron and Steel Institute (AISI)
AISI	Specifications for the Design of Cold-Formed Steel Structural Members
	American Society for Testing and Materials (ASTM)
ASTM A 36	Structural Steel
	American Welding Society (AWS)
AWS D1.1	Structural Welding Code, Steel
	National Electrical Contractors Association (NECA)
NECA 5055	Standard of Installation
	National Fire Protection Association (NFPA)
NFPA 70	National Electrical Code

1.03 QUALITY ASSURANCE

Supporting devices, of types and sizes required, shall have been satisfactory used for purposes similar to those intended herein for not less than three years.

1.04 DELIVERY, STORAGE AND HANDLING

A. Deliver materials in manufacturer's original, unopened, protective packaging.

B. Store materials in a clean, dry space and protect them from weather.

C. Handle in a manner to prevent damage to finished surfaces.

D. Where possible, maintain protective coverings until installation is complete and remove such coverings as part of final cleanup.

E. Touch up damage to finishes to match adjacent surfaces, including re-coating of galvanized or plated surfaces where damaged, cut or drilled.

1.05 SUBMITTALS

See Appendix "A" For Submittal Requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide supporting devices of the acceptable manufacturers as shown on Contract Drawings.

2.02 HANGERS AND SUPPORTS

A. General

1. Unless otherwise shown on the Contract Drawings, provide hangers and supports as specified below.
2. Where more than one type of hanger or support is suitable for the intended use, selection is at the Contractor's option, subject to approval by the Engineer.
3. Hangers and supports, for which there are established Underwriters Laboratories Inc. (UL) standards, shall bear the UL label.

B. Raceway Support

1. Clevis Hangers

   For supporting horizontal conduit; galvanized steel; with hole for treaded steel rod.

2. Riser Clamps

   For supporting vertical conduits; galvanized steel; with two or three bolts and nuts, and 4-inch ears.

3. Reducing Couplings

   Steel rod reducing coupling; size as required; galvanized or plated steel

4. C-Clamps

   Black malleable iron or galvanized or plated steel; with hole for threaded rod.

5. I-Beam Clamps

   Galvanized or plated steel, 1-1/4-inch x 3/16-inch stock; 3/8-inch cross bolt; 2-inch flange width

6. Right Angle or Parallel beam Clamps

   Galvanized steel clamps for supporting or fastening conduit up to 2-inch trade size

7. One-Hole Conduit Straps

   For supporting up to 1-inch conduit or electrical metallic tubing (EMT); galvanized steel

8. Two-Hole Conduit straps

   For supporting conduit or EMT larger than 1-inch galvanized steel; 3/4" strap width.

9. Hexagon Nuts: galvanized steel

10. Round Steel Rod: galvanized or plated steel; threaded

11. Trapeze Hangers: Same as Specified in 2.02 C below

12. The following types of hangers and supports shall not be used:

    a. Perforated metal strapping;

    b. Slotted, perforated angles;

    c. Spring pressure or torsion clips, hangers or supports.

C. Equipment Supports

1. U-channel strut system shall be 12-gauge, hot-dipped galvanized steel. Provide with drilled or slotted holes as required for the application and with the following fittings which mate and match with U-channel:

    a. Fixture hangers

    b. Channel hangers

    c. End caps

    d. Beam clamps

    e. Wiring stud

    f. Thin wall conduit clamps

    g. Rigid conduit clamps

    h. Conduit hangers

    i. U-bolts

D. Supporting Steel Sections and Channels

Supporting steel sections and channels shall be fabricated of ASTM A 36 steel in accordance with the appropriate requirements of the AISC, AISI, and AWS publications specified in 1.02, and shall be hot-dipped galvanized after fabrication.

E. Cable Supports

1. Provide cable supports with insulating wedging plug for non-armored type electrical cables in risers. Assembly shall include body of galvanized malleable iron with insulating wedging plug.

2. Provide cable supports for armored type electrical cables in risers. Assembly shall include body and pressure plates of galvanized steel.

2.03 SLEEVES AND SEALS

A. General

1. Unless otherwise shown on the Contract Drawings, provide sleeves and seals as specified below.

2. Where more than one type of sleeve or seal is suitable for the intended use, selection is at the Contractor's option, subject to approval by the Engineer.

3. Sleeves and seals, for which there are established, UL standard, shall bear the UL label.

B. Pipe Sleeves

1. Provide pipe sleeves for conduits penetrating concrete or masonry floor and walls, as follows:

   a. Steel Pipe

      Fabricate from schedule 40, galvanized steel pipe; remove burrs.

   b. Iron Pipe

      Fabricate from cast iron or ductile iron pipe; remove burrs.

   c. Plastic Pipe

      Fabricate from either fiberglass or Schedule 40, PVC plastic pipe; remove burrs. Fiberglass sleeves may be utilized for interior or exterior usages, but PVC sleeves shall be utilized for exterior usage only.

2. Sleeves shall have a minimum inside diameter as shown below, based on the installed raceway diameter.

Raceway Diameter (inches)	Sleeve Inside Diameter (inches)
1 or less	2
1-1/4 to 2	3
2-1/2 to 3	4
3-1/2 to 4	5
5	6
6	7

3. Where a sleeve encloses only one conductor, phase or polarity, or a ground wire or cable, the sleeve shall be non-ferrous.

C. Interlocking Modular Seals

Provide interlocking modular type seals for conduit access located in exterior foundation and pit walls. The seals shall be multi-link, stainless steel bolted connection, high-temperature fittings.

D. Sealing Bushings

Provide sealing bushings for conduit access core-drilled through foundation walls or floors. The bushings shall be molded, one-piece neoprene sealing rings with PVC coated steel or uncoated aluminum pressure plates, stainless steel hex socket head cap screws and flat washers.

E. Fire Seals

Provide UL listed, 3 hour rating, silicone based foam, fire resistive, waterproof joint sealing system to prevent the passage of hot gases and fire.

F. Wall and Floor Seals

Provide watertight and pressure-tight wall and floor seals suitable for sealing around conduit passing through exterior concrete floors and walls. Assembly shall include steel sleeves, galvanized malleable iron body, neoprene sealing grommets and rings, metal pressure rings, membrane clamp were required by foundation design and pressure clamps with type 316 stainless steel hex head cap screws. Seal sizes shall be maximum published size for conduit to be installed therein.

2.04 FASTENERS

A. General

1. Unless otherwise shown on the Contract Drawings, provide fasteners as specified below.
2. Where more than one type of fasteners is suitable for the intended use, selection is at the Contractor's option, subject to approval by the Engineer.

B. Toggle Bolts

Toggle bolts shall be spring head, galvanized or plated steel, 1/4-inch to 1/2-inch sizes, length as required.

C. Expansion Anchors

Expansion anchors shall be metallic expansion anchors or shields, including drop-in anchors, wedge and sleeve anchors, and two-piece and three-piece shields for lag screws or machine screws or bolts.

D. Powder activated Fasteners

Powder activated fasteners shall be steel, pin or stud type, selected for proper length and penetration for the equipment, clamp or strap to be installed, and the base material.

E. Bolts, Nuts, Lockwashers and Washers

1. All hardware shall be galvanized or plated steel, unless otherwise shown on the Contract Drawings.
2. Bolts and nuts, 1/4-inch trade size and larger, shall be hex head or hex socket type, standard American sizes.
3. Lockwashers shall match the finish of the furnished bolts and nuts, and generally be installed one-per-bolt, at the nut end of the assembly.

4. Washers shall be standard or fender type, as required, and sized to match the installed bolts or screws.

F. The following types of fasteners shall not be used:

1. Lead anchors or studs;
2. Wooden plugs or anchors;
3. Plastic anchors;
4. "Nail-in" anchors, either of plastic or metal type.

PART 3. EXECUTION

3.01 EXAMINATION

A. Verify that electrical installations, structural, mechanical and other related Work satisfy the requirements for performance of the Work of this Section in accordance with the Contract Documents.

B. Report immediately to the Engineer any electrical, structural or related construction defects in areas where supporting devices are to be installed, and do not attempt to rectify any defect unless specifically instructed to do so by the Engineer.

3.02 PREPARATION

Before installation the supporting devices, the Contractor shall investigate the site condition to determine, what preparatory work, if any, will be needed.

3.03 INSTALLATION

A. General

1. Install hangers and supports, sleeves and fasteners in accordance with approved printed manufacturer's installation procedures, and as specified.
2. Coordinate all affected trades and all aspects of the electrical work, including installation of raceways and wiring as necessary to interface installation of supporting devices with other work.
3. Install hangers and supports, and attachments to properly support raceways, equipment and accessories from building structure. Arrange for grouping of parallel runs of horizontal conduits to be supported together on trapeze hangers where possible. Install hangers and supports with maximum spacing not to exceed that permitted by NFPA 70 and NECA 5055, as applicable, unless otherwise shown on the Contract Drawings.
4. Secure threaded rod couplings, trapeze hangers or supports or similar horizontal elements, using lock washers and jam nuts to prevent loosening.

B. Conduit and Raceway supports

1. Do not support raceways from hung ceiling supports or members, or metal roof deck.
2. Do not support raceways from mechanical ductwork, ductwork supports, piping or piping supports.

3. Threaded rod for the support of conduits, raceways or trapeze hangers of the given size, shall be not less than the following:

Conduit, Raceway, Hanger Size (inches)	Threaded Rod Size (inches)
2 or less	3/8
2-1/2 to 3-1/2	1/2
4 to 5	5/8
6	3/4

4. Where trapeze hangers are used, bolt or clamp the raceways in place to at least every third hanger and to the first hanger on each side of a bend, fitting, junction or pull box or change in direction.

C. Sleeves

1. Unless otherwise shown on the Contract Drawings, extend sleeves for raceways and risers one inch beyond top of finished floor, curb or building element being penetrated.
2. Install sleeves level and plumb, accurately located and positioned to conform to the requirements of the equipment and in accordance with the approved layout drawings.
3. Install interlocking modular seals in tandem, one at the interior and one at the exterior face of the pipe sleeve.
4. Tighten sleeve seal nuts until sealing grommets have expanded to form watertight seal.

D. Fasteners

1. Wood screws, lag screws, carriage bolts or machine screws shall be utilized for wood or materials of similar fibrous nature.
2. Welded or blazed threaded studs, bolts or machine screws or clamps shall be utilized for structural and miscellaneous steel, iron or other metals.
3. Metallic expansion shields, wedge anchors or drop-in anchors, with lag screws, bolts or machine screws shall be utilized for solid masonry or concrete.
4. Sleeve anchors, drop-in anchors or toggle bolts shall be utilized for concrete masonry units (CMU). Do not use powder-activated fasteners in CMU.

E. Dissimilar Metals

1. "Dissimilar metals" shall mean those metals which are incompatible with one another in the presence of moisture, as determined from their relative positions in the Electrochemical Series, or from test data.
2. Where dissimilar metals come in contact, paint the joint both inside and out with approved coating to exclude moisture from the joint, or provide a suitable insulating barrier separating the metals.

END OF SECTION

SECTION 16190

SUPPORTING DEVICES

APPENDIX A

SUBMITTAL REQUIREMENTS

Submit for approval the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

Submit layout drawings for dimensioned locations of inserts, sleeves and anchors when required by the Contract Drawings.

B. Catalog Cuts

1. Hangers and supports
2. Sleeves
3. Fasteners

C. Submit calculations for the following:

1. Supporting steel sections and channels, properly reflecting installed and future loading, including:
   a. Safety factors of not less than 4 to 1;
   b. Deflection ratio of not greater than 1/240.
2. Special hangers and supports shown on the Contract Drawings
3. Hangers, supports and fasteners when required by but not specifically shown on the Contract Drawings.

END OF APPENDIX "A"

SECTION 16190

SUPPORTING DEVICES

INSTRUCTION TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in this section:

(2.01) Include the name of special supporting device products, only if required by the particular design, in the Contract Drawings

1. The following is the suggested list of manufacturers of supporting devices (indicate on the Contract Drawings minimum of three appropriate manufacturers):

   Appleton Electric
   B-Line Systems, Inc.
   Crouse-Hinds, Div. of Cooper Industries, Inc.
   O-Z/Gedney, Div. of General Signal
   Thunderline/Link-Seal
   Unistrut Corp.
   Thomas & Betts

(2.02 A.1)	Layout drawings, when required
(2.02 A1)	Hangers and supports other than specified
(2.02 A.1) (2.04 A.1)	Hangers, supports and fasteners, requiring load calculations
(2.03A.1)	Sleeves and seals other than specified
(2.04 A.1)	Fasteners other than specified
(2.04 E.1)	Finishes of bolts, nuts, lockwashers, and washers other than galvanized or plated steel
(3.03 A.3)	Maximum spacing of hangers and supports other than specified
(3.03 C.1)	Lengths of sleeve extensions other than 1" beyond top of finished floor, etc.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16250

TRANSFER SWITCHES

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for all low voltage transfer switches and appurtenances.

1.02 REFERENCES

The following is a listing of publications referenced in this Section:

	Underwriters' Laboratories, Inc. (UL)
UL 1008	Standard for Automatic Transfer Switches.
	National Fire Protection Agency (NFPA)
NFPA 70	National Electrical Code.
NFPA 72	National Fire Alarm Safety Code.
NFPA 20	Centrifugal Fire Pumps.
NFPA 110	Emergency and Standby Power Systems.
	Institute of Electrical and Electronics Engineers (IEEE)
IEEE 446	Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications.
IEEE 241	Recommended Practice for Electric Power Systems in Commercial Buildings.
IEEE 472	Relays and Relay Systems Associated with Electric Power Apparatus.
IEEE 587	Surge Immunity in Solid State Control System.
	National Electrical Manufacturers Association (NEMA)
NEMA ICA10	AC Automatic Transfer Switches (formerly ICS2-447).
NEMA ICA-2	Standard for Industrial Control Devices and Controller and Assemblies.

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

The automatic transfer switches shall be designed and manufactured in accordance with the applicable provisions of ANSI, IEEE, NEMA, NFPA and UL. Where a discrepancy exist between the standards, the most stringent requirements shall apply. In addition, specific provisions cited herein, and those shown on the Contract Drawings shall govern for the associated specific application.

1.04 QUALITY ASSURANCE

A. Transfer Switch and all components of the type and size indicated shall have been satisfactorily used in a similar purpose for not less then three years.

B. Tests requiring certified reports and those requiring factory or field inspection shall be conducted and reported to the Engineer in conformance with the standards herein specified. All electrical materials and equipment for which there are established UL standards shall bear the UL label.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Store materials in the original packaging in a manner to prevent soiling, damage, wetting or corrosion, prior to installation.

B. Handle in a manner to prevent damage to finished surfaces.

C. Where possible, maintain protective coverings until installation is complete, and remove such covers as part of final cleanup.

D. Touch-up damages to finishes to match adjacent surface, including recoating of galvanized or plated surface where damaged, cut or drilled.

1.06 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section and as shown on the Contract Drawings, provide automatic transfer switch products of manufacturers listed on the Contract Drawings.

2.02 MATERIALS

A. Automatic Transfer Switches (ATS)

Furnish and install the ATS with number of poles, amperage, voltage and accessories as required or indicated on the Contract Drawings, and options as indicated on the Contract Drawings. The ATS shall have a Withstand and Closing Rating (WCR) greater than the available fault current at the switch terminal. The ATS shall conform to the requirements of NEMA CS 10, UL 1008, and shall be rated for a total system load as per NFPA-70, NFPA-110 and NFPA-72.

1. Accessories

a. Switching Neutral: Unless otherwise shown on the Contract Drawings, the ATS for all 3 phase 4 wire systems shall be provided with switching neutral contacts.

b. Isolation Bypass Switch: Unless otherwise shown on the Contract Drawings, the ATS for the building emergency riser (where interruption in power distribution can not be afforded for maintenance or repair work) shall be provided with an isolation bypass switch.

2. Options

a. Feeder over current protection: Provide over current and short circuit protection on both incoming feeders (emergency and normal power) using fused switch units or molded case circuit breakers. The protection ratings shall be coordinated with the distribution system.

b. In-Phase Load Transfer Controls: Provide when connected loads are motor loads or when the load characteristic is unknown and the transfer switch will frequently transfer between both available sources. An arrangement of the adjustable time delay during the switching (the time when loads are isolated from both sources) is acceptable only when switching is coordinated with the connected load characteristic and their protection.

c. Engine Generator Controls: Provide when connected emergency power is directly fed from the individual generator.

d. Monitoring Network interface: Provide if the switch is intended to interface with the building management system.

B. The complete ATS shall be factory assembled and tested prior to shipment.

C. Unless otherwise shown on the Contract Drawings, the enclosure for the ATS up to 400 amps shall be NEMA 1B non-ventilated wall mounted.

2.03 CONSTRUCTION FEATURES

A. Automatic Transfer Switch

1. Transfer switch shall be rated to carry 100 percent of the rated continuos current. Transfer switch shall be continuously rated in ambient temperatures of -20 to +50 degrees C, relative humidity up to 95% (non-condensing), and altitudes up to 10,000 feet.

2. Transfer switch shall withstand the magnitude of fault current available at the switch terminals or as specified on the Contract Drawings.

3. Transfer switch shall be double-throw, mechanically interlocked, and mechanically held in either position.

4. Main switch contacts shall be high-pressure silver alloy. Contact assemblies shall have arc chutes for positive arc extinguishment. Arc chutes shall have insulating covers to prevent interphase flashover.

5. Provide auxiliary contacts (2 N.O. and 2 N.C.) rated 10 amps at 250vac on both "Normal" and "Emergency" sides, to be operated by the transfer switch.

6. Electrical operation shall be accomplished by a linear, operating mechanism that receives power from the source to which the load is being transferred. Fuse or thermal protection of the main operator is prohibited. The operating transfer time in either direction shall be one-sixth of a second or less. Main operator shall be momentarily energized to operate, and mechanically held.

7. Transfer Switch shall have a fully rated insulated neutral bus unless otherwise specified with a switching neutral.

8. Enclosure shall be UL listed. The enclosure shall provide NEC required wire bending space. The cabinet door shall be key locking. Controls on cabinet door shall be key operated. Provide switch position indicator lamps and power available lamps for both sources (four total) on the outside cabinet door.

9. Transfer switch shall be mounted in an enclosure as designated on the Contract Drawings. The enclosure shall be NEMA type as specified. The cabinet shall be provided with NEC required wire-bending space at point of entry as shown on the Contract Drawings. Manual operating handle and all control switches (other than key-operated switches) shall be accessible to authorized personnel, only by opening the key-locking cabinet door.

10. Control shall be solid-state and designed for a high level of immunity to power line surges and transients, and demonstrated by test to IEEE Standard 587-1980.

11. Voltage sensors shall simultaneously monitor all phases of both sources. The control panel shall be microprocessor and/or solid state analog type with adjustable sensing and timing functions. All sensing and time delay functions shall be adjustable over the ranges indicated and shall operate with minimum drift (not to exceed +10 percent of set frequency, +2 percent of set voltage, and +10 percent of set time delay) over the temperature range of -20 degrees to +50 degrees C. The control panel shall be provided with a protective cover. All control wires between the control panel and main transfer switch shall be terminated on a terminal strip.

    The following operational characteristics shall be provided:

    a. Voltage Sensing

        (1) Normal Source: Differential voltage of all phases (pickup adjustable from 85-100 percent of nominal voltage and drop out adjustable from 75-98 percent of pickup voltage) shall be factory set to pick up at 95 percent and drop out at 85 percent of nominal voltage. Sensing shall be on the line side of the transfer switch main controls unless otherwise shown on the Contract Drawings.

        (2) Emergency source: Independent single phase voltage (85-100 percent for dropout) and frequency (90-100 percent for pick-up) sensing to prevent premature transfer shall be factory set to pickup at 90 percent of nominal frequency and 100 percent voltage, and dropout at 85 percent voltage.

    b. Time Delay Setting

        (1) Time delay on momentary dips in normal source (0.5 -6.0 seconds) shall be factory set at 1.0 second.

        (2) Time delay on transfer to emergency shall be 0 to 2 minutes, factory set to 0 minute or as shown on the Contract Drawings. If specified at more than 2 minutes, an additional extend time delay component shall be provided.

        (3) Time delay on retransfer to normal source shall be 0-30 minutes, factory set at 30 minutes, and an additional retransfer bypass switch (toggle switch) shall be provided.

12. Provide a key operated selector switch or momentary test switch in a secure location to simulate failure of normal source and restore back to normal.

13. Transfer switch shall be equipped with manual operators for service use, to operate under a de-energized condition.

14. Accessories

a. Switching Neutral

Switching neutral shall be the 4th pole, 100 percent rated and simultaneously operated with other power poles using the same actuator. This feature shall provide one of the following schemes unless otherwise indicated on the Contract Drawings.

(1) Fourth pole similar to other power poles to be connected to a common crossbar with operation arranged to break before make and lagging in opening and leading in closing as compared to the power poles.

(2) Overlapping switching neutral connected to a common operator with operation arranged to make before break.

b. Bypass Isolation Switch

Bypass Isolation switch shall be constructed to provide a safe means for manually bypassing the transfer switch from either source (Normal or Emergency) to the load, while under load without interruption, and to isolate the transfer switch from both sources. The switch equipment shall be UL listed per Standard 1008, CSA approved; with continuos current rating, voltage and frequency ratings, and withstand closing ratings equal to the transfer switch ratings and provide the following construction features.

(1) The bypass-isolation and switch shall be mechanically held in each position. The switch mechanism shall be of a stored energy contact type. No interruption of power is acceptable. The speed of the contact operation shall be independent of the force applied to the operating handles, which permit manual operation under load.

(2) The bypass switch shall provide bypass to either normal or emergency source by use of a permanently mounted, external operating handle.

(3) The bypass switch shall provide manual bypass without load break.

(4) Positive electrical and mechanical interlocks shall prevent all possible source to source interconnections. The interlock system shall assure a properly sequenced, mechanically guided bypass and isolation action.

(5) A drawout isolation mechanism shall provide closed-door isolation of the transfer switch, using a permanently mounted, external handle. The isolation mechanism shall be interlocked so that either the transfer switch must be bypassed or the transfer switch must be open before the mechanism will permit isolation of the transfer switch. The isolation mechanism shall provide for a three-position operation; Connected, Test and Isolated.

(6) In the Connected position, isolation contacts shall be fully engaged and closed with the control cable connected. In the Test position, isolation contacts shall be open with the control cable connected. The Test position shall allow operational testing of transfer switch and controls without power disruption to the load. In the Isolated position, the transfer switch and control cable shall be completely isolated from all power sources. In the Isolated position, safety shutters shall close to cover bypass switch power terminals, minimizing the possibility of accidental contact with energized parts.

(7) In the Isolated position, the transfer switch shall be capable of being withdrawn from the cabinet. When re-installing the transfer switch, the isolation mechanism shall not permit connection of the transfer switch unless it is in the open position, or closed position on the same source as the bypass switch.

15. Options

a. Feeder over current protection shall be provided using either fused switch units or molded case breakers. The proper isolation shall be provided between the ATS and over current protection enclosures. The power connection shall be supplied with silver plated copper bus bars. The protection rating shall be coordinated with feeder size, available short circuit levels and connected loads.

b. In-phase load transfer control shall be similar to automatic synchronized transfer, by sampling the source voltage and residual voltage (slipping frequency) of the load side. The control shall be coordinated with the transfer switch speed and actively interfaced with residual voltage and frequency. The switching time delay feature can be acceptable only if it meets system distribution needs and is specified on the Contract Drawings. The switching time delay shall be field adjustable with a range of 0 to 7.5 seconds.

c. Engine generator controls shall integrate engine start and engine exercising features with transfer switch controls, and shall be provided with a voltmeter, ammeter and frequency meter.

d. Monitoring network interface shall be capable of interfacing through a standard IEEE bus and open protocol.

16. Enclosure

The enclosure type shall be as designated on the Contract Drawings. Enclosure construction shall be welded steel. Wire bending space shall comply with National Electrical Code for the maximum size and number of conductors the terminal lugs will accept. A key locking handle shall be provided.

PART 3. EXECUTION

3.01 FIELD SUPERVISION

A. Provide the services of a qualified, factory-trained ATS manufacturer's representative to provide technical field support in the installation and testing of the equipment specified in this Section. The manufacturer's representative shall provide technical direction and assistance in the following:

1. Direct the ATS installation and field control wiring connection.
2. Perform Required Field Testing.
3. ATS load transfer control parameters setting.

3.02 EXAMINATION

The Contractor is responsible for notifying the Engineer as soon as he finds conditions that prevent the proper installation of materials or methods specified in this Section.

3.03 INSTALLATION

A. The ATS shall be transported to the construction site, unloaded, uncrated, handled, stored, installed, including assembly of all component parts, and wired in accordance with the manufacturer's recommendations, applicable IEEE (formerly ANSI) standards, and the requirements specified in this Section.

B. Provide all equipment, supervision, labor, rigging, tools, including, but not limited to, special equipment such as cranes.

C. Before setting the ATS, the openings for conduits and bus entrances shall be checked for accuracy of position.

D. All floor-mounted ATS units shall be set on a concrete pad at the locations shown on the Contract Drawings. Provide floor seals at the penetration. The ATS shall be set, aligned, and leveled in place, using shims where necessary.

E. Bus splices shall be cleaned and bolted together and insulated, either by taping, or by use of insulating boots if provided for that purpose.

F. The Contractor shall complete all internal and external power and control connections. All field-installed control wiring shall be identified using heat-shrinkable wire sleeves with origin/destination markings typed on them.

G. Install, wire, and connect the controls in accordance with the Contract Drawings and manufacturer's drawings and instructions.

H. All damaged paint areas shall be properly prepared by the Contractor for an application of primer and finish coats of paint, which shall be supplied by the manufacturer for this purpose. The Contractor shall apply the primer and finish paint coats.

I. After each item of equipment is installed and connected, the Contractor shall make a thorough inspection of the installation and cleaning, prior to final acceptance of the Work.

J. All control cables shall be neatly racked and bundled with nonflammable nylon ties, routed and supported within the enclosures. Minimum bending radius recommended by cable manufacturers shall not be reduced.

3.04 FIELD TESTS

Field tests shall be performed in accordance with Approved Performance Test Plan of Appendix "A". Advise the Engineer, in writing, upon failure of any equipment or material to pass the tests performed, or to function properly as intended. In the event that testing does not meet the requirement for proof of satisfactory performance specified herein, the Contractor shall repeat the test. The Engineer reserves the right to decide whether a test must be repeated.

3.05 PROTECTION

Protect ATS and facilities against damage, mechanical or otherwise and provide maintenance until issuance of the Certificate of Final Completion. The switchgear and equipment shall be kept clean, dry, and protected at all times.

3.06 TRAINING

A. Provide training sessions for the number of Authority personnel, as specified on the Contract Drawings.

B. The training sessions shall be conducted by a manufacturer's qualified representative. The training program shall consist of the instruction on the operation of the assembly and major components within the assembly.

C. For additional training time requirements, see Section 16000 of these Specifications.

END OF SECTION

SECTION 16250

TRANSFER SWITCHES

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of DIVISION 1 - GENERAL PROVISIONS.

A. Shop Drawings

1. Schematic wiring diagrams.
2. Control wiring diagrams.
3. Dimensional data.
4. Description of operation.

B. Catalog Cuts

1. Transfer switches.

C. Test Reports

1. Factory test reports.
2. Certified Laboratory Test Data.
3. Prepare and submit to the Engineer for approval a Performance Testing Plan for the entire system a minimum of 30 days in advance of the earliest, approved, scheduled inspection and test date. The system shall be divided into the following stages:
   a. Inspection upon arrival at the construction site.
   b. On-site inspection and test immediately following the complete installation of the system to demonstrate compliance with the requirements of this Section.
   c. A 30-day operational test commencing with the successful completion of the on-site inspection and test.

D. Spare Parts

1. Submit a complete list of recommended spare parts, which shall include those spare parts required to be furnished in compliance with the requirements of this Section for approval by the Engineer.
2. Submit a list of recommended spare parts together with indications of what the price and delivery time of each part, starting from receipt of order, will be if such parts are ordered.

E. Prior to delivery, the Contractor shall submit procedures covering storage and preventative maintenance requirements to be applied after the receipt of the circuit breakers at the construction site.

F. Training

Prior to the on-site inspection and test of the system, prepare and submit to the Engineer for approval an emergency load transfer system curricula, in accordance with the requirements of this Section.

END OF APPENDIX "A"

SECTION 16250

TRANSFER SWITCH

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in this Section:

(2.01) List of manufacturers of the Automatic Transfer Switch.

1. List a minimum of two manufacturers and include "or approved equal". If an item is unique of "sole source", then a "sole source" letter will be required.

2. Suggested List of Manufacturers

   Automatic Switch Company (ASCO)
   Onan

(2.02 A)	Indicate the following: Voltage and Ampere rating Number of Poles Withstand and Closing rating Accessories and Options
(2.02 C)	Indicate NEMA class for enclosure if other than NEMA 1B non-ventilated and/or wall mounted.
(2.03 A)	Indicate available fault current at point of use of the transfer switch.
(2.03 A.7)	Indicate fully rated insulated neutral bus or switched neutral
(2.03 A.11.a.1)	Indicate sensing points, if other than on line side of transfer switch.
(2.03 A.11.b.2)	Indicate range and factory setting for time delay to transfer to emergency.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16315

MEDIUM VOLTAGE LOAD INTERRUPTER SWITCHES

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements of medium voltage, load interrupter switches.

1.02 REFERENCES

Not Used.

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

Design and performance of components and methods herein shall comply with the applicable provisions of the codes, standards and recommendations of the following entities:

American National Standards Institute (ANSI)
American Welding Society (AWS)
Institute of Electrical and Electric Engineers (IEEE)
National Electrical Manufacturers Association (NEMA)
National Fire Protection Association (NFPA)
Underwriters Laboratories (UL)

In addition, specific provisions cited herein as shown on the Contract Drawings shall govern for the associated specific application.

1.04 QUALITY ASSURANCE

Switchgear and all components of types and sizes required shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Switchgear shall be delivered to the site as complete as possible and in shipping splits that are as large as practical. All accessories, including but not limited to breakers, meters and relays, shall be in place and wired. Packing materials shall be such as to prevent damage to components due to vibration, jarring or the like during transportation and handling.

B. If any accessories must be shipped loose, they shall be delivered in the manufacturer's original unopened protective packaging and shall be identified with a noncorrosive tag.

C. The switchgear shall be handled in a manner to prevent damage to finished surfaces.

D. Touch up any damage to finishes to match adjacent surfaces.

1.06 SPARE PARTS AND SPECIAL TOOLS

A. Furnish 25 percent spare fuses of each size and type used in the switchgear with a minimum of six of each size and type.

B. Furnish one set of all special tools required for the erection, operation, and maintenance of all equipment furnished and installed under this Section. Covered under these Specifications for each independent area shall be furnished by the Contractor and one set of all special tools and wrenches required for assembly or disassembly of the load interrupter switchgear and for the removal of fuses.

C. Furnish a list of recommended spare parts for the switchgear and accessories. The list shall contain the prices and availability of the spare parts recommended.

D. Furnish two aerosol cans, each not less than 12 ounces, of touch-up paint required by other Sections.

1.07 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with the requirements of this Section, provide medium voltage load interrupter switch assemblies from one of the following manufacturers:

A. Load Interrupter Switch

General Electric Company
Westinghouse Electric Company
Asea Brown Boveri Incorporated (ABB)
Siemens Incorporated
Power Con (NEPA)
Square D Company
S & C Electric Company
Electrical Equipment Incorporated (EEI)

B. Load Interrupter Switch Assemblies

Load interrupter switch assemblies shall include the load interrupter switch and all appurtenances from one of the following manufacturers:

1. General Electric Company
   Westinghouse Electric Corporation
   Asea Brown Boveri Incorporated (ABB)
   Siemens Incorporated
   Power Con (NEPA)
   Powell Electrical Manufacturing Company
   Nelson Electric
   Controlled Power Corporation
   Pacs Industries Incorporated
   Square D Company
   S & C Electric Company
   Electrical Equipment Incorporated (EEI)

2.02 CONSTRUCTION FEATURES

A. General

1. Switchgear shall be factory assembled, of the indoor and/or outdoor type, as shown on the Contract Drawings, dead front, metal enclosed, free standing, self supporting, front accessible only and completely equipped with load interrupter switches, fuses, instrument transformers, relays, metering, switches, and associated devices as specified in this Section and as shown on the Contract Drawings.

2. If shown on the Contract Drawings the load interrupter switchgear shall be provided with a throat connection or a transition section to match with a bus duct, a transformer throat or flange, or a metal clad switchgear. Provisions shall be made for extension of the switchgear in both directions.

3. Unless otherwise shown on the Contract Drawings, provide a set of intermediate class lightning arresters.

4. All relays, meters, switches, pilot lights or other force-mounted equipment shall be arranged as shown on the Contract Drawings.

5. Each vertical section shall be furnished with a factory wired space heater (120 volts) and thermostat. The space heater shall be installed within a grounded, perforated, galvanized steel guard.

B. Enclosure Design

1. The load interrupter switchgear shall consist of rigid self-supporting and self-contained electrically welded steel cubicles. Each cubicle shall be completely enclosed with formed steel sheets of #11 gauge (minimum) cold-rolled steel adequately braced to prevent distortion under normal conditions as well as during interruption of short circuit currents.

2. The structural details of each cubicle shall be identical. The cubicles shall be uniform in height, and built to form a continuous structure lining-up in front.

3. All louvers or other ventilating openings shall be furnished with filters and shall be so arranged and located as to prevent the entrance of water dripping from above or splashing from the floor into the switchgear. No openings shall be placed in the top cover of the switchgear enclosure unless the construction of the unit prevents the entrance of dust, water, and other foreign materials.

4. Sheet steel doors, #11 gauge minimum, fully gasketed, with galvanized, zinc plated, or stainless steel hinges and stainless steel hinge pins, shall be provided for access to the switch and fuse compartment(s).

5. Each door shall be furnished with one or more handles, knurled steel screws, or a combination of these, in order to firmly hold door closed.

6. Doors shall be mechanically or key interlocked with interrupter switches to prevent opening door when switchgear is energized and prevent closing of switch when door is open.

7. Each switch compartment door shall be furnished with a safety glass observation window(s), large enough to permit viewing of all poles and the position of the switch.

8. Provisions shall be provided for locking the switches in both the open and closed positions.

9. Sufficient space shall be provided within each unit to be able to apply stress cones to the incoming cables and to terminate them with compression or crimp type lugs.

10. Doors providing access to fuses or fused voltage transformers shall have provisions to store spare fuses and/or refill units.

11. Each switch vertical section shall be either of the following door designs:

    a. A separate top door for access to the interrupter switch and a separate bottom door to access the fuse compartment. Door to fuse compartment shall be mechanically or key interlocked with switch to prevent gaining access unless the switch is open.

    b. An inner screened barrier covering either the switch section completely or running the full height of the vertical section, where single door construction is provided, to prevent inadvertent contact with live parts.

12. Barriers shall separate secondary control devices from primary live parts.

13. The arrangement of equipment shall allow sufficient space for proper maintenance within the structure.

C. Outdoor Load Interrupter Switch

1. Outdoor switchgear shall be weatherproof and designed so that driving rain, snow, sand, or other materials will not interfere with the successful operation of the switchgear. The housing shall be constructed and ventilated so that the heating effects of solar radiation will not produce total temperature(s) rises in the equipment beyond those allowed by the applicable provisions of the Standard codes.

2. Suitable means shall be provided to prevent the condensation of moisture on the inside of the roof of the enclosure and the dripping of this moisture on live parts.

3. The undersurface of the enclosure shall be covered with a sealing undercoating of 1/8 inches minimum.

4. Space heaters rated 240 volts AC, sized for operation at 120 volts AC, with differential thermostats or other controls as recommended by the manufacturer shall be furnished to keep the air inside the enclosures sufficiently above the dew point to prevent condensation. The 120-volt power will be from an external source unless otherwise shown on the Contract Drawings. The heaters shall be located so that wiring, bus, equipment, and control devices will not be overheated. Heaters shall be fused. Fuses shall be accessible when the load interrupter switch and assembly door are closed.

5. A minimum of 120-volt AC duplex outlet shall be provided for convenience power up to 2400 watts. Receptacles shall have polarized grounding outlets with ground fault protection.

6. Interrupter switches and grounding switches shall have a readily visible open gap when in the open position to allow positive visual verification of correct switch position. High impact viewing window(s) shall be provided that permit full view of the position of all switchblades through the closed door.

7. A grounding pad shall be provided on the interior of each cubicle. For switch enclosures that are mounted directly to a transformer, the Contractor shall install a #4/0 AWG, bare copper ground jumper between the two enclosures.

D. Bus Design and Rating

1. All buses shall be silver plated hard drawn copper and shall be mounted on NEMA rated porcelain or glass polyester insulators. All bussing shall be braced for the fault current rating of switch as shown on the Contract Drawings. For switches that are bussed together in pairs, the connecting bus shall be insulated.

2. Splice and tap connections shall be either plated or wire brushed and coated with an oxide-inhibiting compound after drilling or punching. Connections shall be securely bolted to maintain maximum contact pressure and minimum joint resistivity.

3. Provisions shall be made in the design for expansion and contraction of current carrying parts and metal housings due to temperature changes.

4. Bus phasing shall be A, B, C, or 1, 2, 3 from left to right, top to bottom, front to rear, when viewing the switch from the front.

5. A ground connection for a single vertical section assembly or a ground bus for multiple section assemblies shall be provided running the full length of the assembly.

6. Ground bus shall be solidly connected to each assembly section.

7. Compression crimp type cable terminals shall be supplied suitable for copper cable of the number and sizes shown on the Contract Drawings. All splice plates and cable terminations, other than central cables, shall be 2-hole, NEMA spaced, terminal lugs, complete with non-ferrous, non-magnetic stainless steel hardware. Sufficient vertical space, but not less than 15 inches shall be supplied for stress cones termination for cable shown on the Contract Drawings.

8. Ground bus shall consist of copper and connections and splices shall be made in the same manner as the power buses.

9. Two clamp type terminal lugs capable of accommodating #2 AWG through 500 MCM cable shall be provided, one at each end of ground bus, for connection to station ground.

10. Ground lugs shall also be provided to connect incoming cable shield ground wires, and ground switches connection, as required.

11. All buses shall be designed for future extension in either direction.

12. External connections to the power bus and/or switches shall be in accordance with the requirements as shown on the Contract Drawings. Bus pads shall be NEMA drilled and two bolt compression crimp type lugs shall be furnished for the cable size as shown on the Contract Drawings.

13. Insulators shall be porcelain or cycloaliphatic epoxy resin.

E. Air Interrupter Switches

1. Air interrupter switches shall be of quick-make, quick-break, stored energy type utilizing direct acting spring charged mechanism for both the closing and opening functions.

2. The speed and force of opening and closing the switchblades shall be constant and independent of the operator. Blow out forces shall not be transmitted to the operating handle.

3. The switch mechanism shall be equipped with either an operating handle with provisions for locking in the open and closed position, or a removable operating handle to prevent inadvertent operation of the switch. The operating handle shall be located on the front of the unit and shall be provided with position indication. A convenient storage area shall be provided for removable handles.

4. The switch mechanism shall be a one piece assembly with an all welded or bolted fabricated steel support frame to facilitate removal of the entire unit without affecting contact alignment and adjustment.

5. The arcing contacts of the switch shall operate in an arc chute or similar device designed to emit a high dielectric strength gas to assist interruption.

6. Switch operators with motors, where shown on the Contract Drawings, shall:

   a. Open and close the associated interrupter switch electrically;

   b. Have the capability of being decoupled from the switch mechanism to permit testing and exercising, and manual operation; and

   c. Shall be mounted in the low voltage compartment.

7. Interrupter and grounding switch contacts shall be of silver-to-silver construction for optimal current transfer, and shall be backed up by stainless-steel springs to provide constant high contact pressure.

F. Fuses

Fuses shall be of the type shown on the Contract Drawings.

1. Fault protection shall be furnished by fuses of one of the two types specified below.

   a. One Time

      One time type shall utilize refill-unit-and-holder or fuse-unit-and-end fitting construction. This type of fuse will expel gases and vapors but shall be readily refusible with low cost refill units.

b. Current Limiting

Current limiting type of the self-contained design to provide fast interruption with minimum let-through current.

2. The fuse and fused switch ratings shall be as shown on the Contract Drawings.

3. Fusible elements shall be non-aging and non-damageable so that upon fuse operation it shall be unnecessary to replace unblown companion fuses due to suspicion of damage.

4. Fusible elements for refill units shall be helically coiled.

5. Fuse mounts shall be designed for a positive clamp in position while having provisions for easy removal.

6. Fuses shall be capable of detecting and interrupting all faults - large, medium, or small - and have melting time current characteristics which will permit coordination with protective relays, automatic circuit reclosures, and other fuses.

7. If shown on the Contract Drawings a blown fuse indicator shall be provided to show visible evidence of fuse operation while installed in fuse mounting. A double pole double throw 125-volt D.C. contact shall be operated by blown fuse indicator for remote indication.

8. A spare set of fuses or fuse refills shall be provided for each fused switch.

G. Lightning/Surge Arresters

Lightning/surge arrester where shown on the Contract Drawings shall be of the class and rating shown.

H. Grounding Switch

1. Ground switch where shown on the Contract Drawings shall be 3 phase and shall be provided on the line side of the interrupting switch, in order to ground incoming line.

2. Key interlocks used in conjunction with key interlocking of the interrupter switch and the feeder breaker or switch, shall be employed to prevent closing the ground switch while load interrupter switch is closed and when the feeder breaker or switch supplying power to load interrupter switch is closed.

3. Where shown on the Contract Drawings, provide a three (3)-phase grounding switch. Unless otherwise shown on the Contract Drawings, the ground switch shall be provided on the line side of the interrupter switch and mechanically interlocked to permit closing the grounding switch when the interrupter switch is in the open position.

4. Grounding switches shall have the three phases on the load (hinge) side bussed together and grounded to the enclosure ground lugs. Ground bus shall be sized for short circuit current as shown on the Contract Drawings.

I. Automatic Transfer

Automatic transfer shall be installed in switches as shown on the Contract Drawings.

1. Where shown on the Contract Drawings, an automatic transfer feature for split bus, three-switch operation shall be provided.

2. A three position selector switch for "Automatic-Semi Automatic-Manual" control, necessary control switches, relays, timers, and position and source indicating lights shall be provided. Selector switch shall be furnished with 2 normally open and 2 normally closed extra contacts for each position.

3. "Automatic-Semi Automatic-Manual" Selector Switch

   a. In automatic or semi-automatic mode the automatic control system shall continuously monitor the voltage of each of the power sources. Should voltage be lost or reduced to a predetermined level on either source, for a sufficient period of time, to determine that the voltage loss is not transient, the automatic controller shall open the switch associated with the affected source and then close the bus tie switch. A 0-30 second timer shall be furnished for the time delay feature.

   b. In automatic mode, when the voltage is restored to the affected source, the tie switch shall be opened and then the source switch closed.

   c. In semi-automatic mode, upon return of normal conditions to the affected source the load retransfer shall be manual if the second source conditions are also normal. However, should normal conditions return to the affected source while the second source experiences abnormal conditions, such as undervoltage, the retransfer shall be automatic.

   d. Should only one source be energized, undervoltage conditions shall not open the switch; in neither the automatic nor the semi automatic modes.

   e. In the manual mode, total manual control of the switches shall be required.

4. In addition to the control interlocking of the automatic control system which shall prevent more than two switches being closed in either of the three modes, an electromechanical device such as a limit switch or auxiliary switch shall be installed for each of and acting directly from the operating shaft of the interrupter switches.

5. Provided for anti-pumping on transient conditions.

J. Instruments and Controls

1. Instruments and controls shall be installed where shown on the Contract Drawings.

2. Instrument transformers shall be of the dry type. Current transformers shall be either of the wound or bar type and shall have 5-ampere secondaries. The rating and accuracy class of the transformers shall be as shown on the Contract Drawings.

3. Potential transformers shall be of the stationary type and shall have a voltage ratio as shown on the Contract Drawings. They shall be capable of carrying rated load continuously without excessive heating or damage to the unit. The maximum ratio and phase angle errors, when carrying full rated secondary load, shall not exceed ANSI standard classification 0.3W, X, Y. Suitable current limiting fuses shall be provided for the primaries and non-renewable cartridge type fuses for the secondaries.

4. Control power transformers shall have ratings as shown on the Contract Drawings and shall be protected by two (2) current limiting fuses on the primary side and one leg on the secondary shall be fused and the other grounded.

5. Relays and meters shall be furnished for the application and have the characteristics shown on the Contract Drawings.

6. All meters and relays shall be semi-flush mounted on the front door or a panel separated from the high voltage section. Protective relays and watt-hour meters shall be of the drawout type with built in test capabilities. All protective relays shall be equipped with built-in targets, which indicate a trip condition.

7. All controls, such as selector switches, and pilot lights, shall be mounted on a separate inner hinged panel or outer covered panel. Unless otherwise shown on the Contract Drawings, all controls shall be 125V DC.

8. Kirk key interlocks shall be provided as shown on the Contract Drawings.

K. Wiring

1. All control, potential transformer and current transformer wiring shall not be smaller than #12 AWG stranded, single conductor, copper wire, having heat resistant, type SIS switchboard insulation, rated 600 volts. All low voltage wiring shall be isolated and barriered from medium voltage components by rigid steel conduit or grounded metal barriers.

2. Wiring from current transformers shall be #10 AWG minimum. The wiring of current transformer secondaries shall be arranged so that the secondary leads of each current transformer will be brought out to self-shorting terminal blocks in the terminal compartment.

3. Four normally open and four normally closed dry, convertible, auxiliary contacts shall be provided for remote indication of switch position and interlocking. Provisions shall also be made for remote control of motor operated switches. Two normally open and two normally closed contacts shall be provided to indicate ground switch position. Contacts shall be rated for 125V DC application.

4. Terminal blocks shall be of the add-on, barrier, sliding link, with marking strips and plastic covers.

5. Each end of each wire shall be clearly marked for ease of identification and shall be terminated with ring type lugs.

L. Signs and Nameplates

1. Warning signs shall be furnished on door of assembly in accordance with OSHA requirements.

2. Stainless steel or laminated phenolic nameplates with white or silver background and black letters shall be provided identifying each component, and on the front doors of each compartment identifying the switch and indicating the switch ratings and the manufacturer's identification number.

2.03 FABRICATION

A. Each switchgear line-up shall be completely assembled as shown on the Contract Drawings and factory tested as a single unit. After testing it may be separated into convenient shipping splits.

B. Shipping splits shall be kept to the minimum practical for shipping and handling. Wire and cable running between splits shall be disconnected at one end and coiled. Wires and cable shall be tagged for reassembly.

C. Surfaces to be welded shall be clean and free from dirt, rust, or other foreign matter. The welding processes shall be in accordance with the requirements of the current editions of the American Welding Society.

2.04 PAINTING

A. Surfaces to be painted shall be prepared by the removal of all grease, oil, rust, scale, or other foreign material.

B. A prime coat and 2 finish coats of ANSI 61 light gray paint shall be applied.

2.05 FACTORY INSPECTION AND TESTS

A. The switchgear shall be completely assembled, wired, and tested at the factory in accordance with ANSI, NEMA and IEEE standards. Submit a written factory acceptance testing plan, not less than 30 days prior to testing, for review by the Engineer. Equipment shall not be shipped until inspected and accepted by the Engineer.

B. Tests shall include but not be limited to the following:

1. High potential tests of all power and control circuits.
2. Continuity check of all control wiring.
3. Operational tests of all control and instrument circuits.
4. Operational tests of all switch mechanisms and interlock devices.

C. Not less than 30 days prior to factory acceptance testing; submit complete information outlining the test methods and procedures to be followed for review by the Engineer. Furnish copies of test forms and sample computations to be employed.

D. Notify Engineer not less than two weeks prior to the beginning of testing.

E. At the conclusion of the tests, furnish to the Engineer one copy of all original test data. If any data is modified, the Engineer shall be apprised and such modifications shall be subject to review by the Engineer.

F. The accuracy of the calibration of all instruments to be employed during the tests shall be ascertained and recorded at the beginning of the tests. All readings shall be direct and visible.

G. The Engineer will inspect any equipment, material or work to be furnished under this Section and will reject any part(s) considered defective or unsuitable for the uses and purposes intended.

H. Free entry shall be permitted to the Engineer at all times to all parts of the facilities engaged in the manufacture of this equipment. Facilities for any performance tests that may be considered necessary in connection with any inspection shall be furnished free of charge.

PART 3. EXECUTION

3.01 EXAMINATION

The Contractor shall notify the Engineer as soon as he finds conditions that prevent the proper installation of materials or methods specified in this Section.

3.02 INSTALLATION

A. The load interrupter switchgear shall be installed and connected in accordance with the manufacturer's recommendations and as shown on the Contract Drawings.

B. Rubber matting, 36 inches wide, conforming to ASTM D 1278, Type 2, shall be furnished and installed along the entire length, front and rear of the switchgear.

C. All packing materials shall be removed from both inside and outside of the switchgear, switchgear parts, devices and associated equipment.

D. All removable parts, instruments, and devices furnished loose shall be installed and wired, and wiring between shipping splits shall be connected.

E. All feeder cables, control wires, instrument wiring and ground wires shall be pulled into switchgear and terminated.

F. The tightness of all bolted connections shall be checked and tightened as necessary.

G. All fuses shall be checked and installed or replaced as necessary.

H. The equipment shall be vacuumed to remove all dust and dirt.

I. Prior to energizing the switchgear it shall be field-tested.

3.03 FIELD TESTING

A. Prior to energizing the switchgear, the insulation resistance on each bus shall be measured from phase to phase and phase to ground.

B. After installation is completed, all switches shall be functionally tested.

C. All protective functions shall be tested and all remote functions simulated to determine if the units have been wired properly.

D. All testing of the completed installations shall be performed in the presence of and as directed by the Engineer. The Contractor shall notify the Engineer when the equipment is installed and ready for testing.

E. Testing shall be performed in the following manner:

1. All control and power cable connections shall pass inspection for workmanship, tightness, and continuity.

2. All switchgear shall be tested for equipment grounds. Maximum acceptable resistance shall be 1 ohm.

3. The switchgear bus shall be given a phase-to-phase and phase-to-ground megger test with all switches open, all current transformers shorted, all potential transformer fuses removed and all feeder switch load terminals grounded.

4. Megger tests on the bus shall be applied between each phase and ground with phases not under test also grounded.

5. Each switch shall be given a megger test in the open and closed position. A 1000 volt motor-driven megger shall be used. Megger tests shall be applied between each phase to ground and to each other phase. All test readings shall be recorded.

6. All alarm devices shall be adjusted and set.

7. All control circuits shall be given operational tests from the supply source for which they were designed. This shall include normal operation 3 times from each control point, and activation of alarm devices.

8. Ratio and polarity test shall be performed on all instrument transformers.

9. Potential transformers shall also be given a megger test. Each current transformer shall be given a ratio test applying full rated current to the primary winding and measuring both primary and secondary currents. With approximately normal instrument burden on its secondary winding, each potential transformer shall be tested with proper voltmeter for ratio. Megger tests on potential transformers shall be applied between each winding and ground using a 500 volt motor-driven megger and winding not under test grounded. Test results shall be within the manufacturer's recommended values.

10. Voltmeters shall be checked against potential transformer ratios. Pointers shall be set on zero scale, with no voltage, then after energizing, voltmeter reading shall be checked with test voltmeter.

11. Watt meters and watt-hour meters shall be checked for proper current and potential transformer ratios. Pointers shall be set on zero scale with no load and energized to check for proper rotation of meter.

12. All switchgear shall be given operational tests. This shall include mechanical operation, as well as operation by control circuits, and tripping devices. Operating voltage at closing and tripping coils shall be checked to determine that voltage is of proper value.

13. All switches shall be operated through at least 3 open-close cycles by manual operation and by control circuits from each control point. All indication lights, annunciator alarms and targets shall be observed to determine correct operation and switch mechanism shall be observed for correct alignment, freedom of binding and good contact.

14. All test results shall be in accordance with the manufacturer's recommendations.

END OF SECTION

SECTION 16315

MEDIUM VOLTAGE LOAD INTERRUPTER SWITCHES

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Mechanical parts and assemblies, including electrical components, complete connection details, torque requirements, and a complete list of parts with full identification.
2. Outline drawings indicating overall dimension, weights, locations of switchgear devices on the panel, aisle space required for drawout equipment, cable entrances and reference tables to other drawings furnished.
3. One-line diagram showing all ratings, main connections and the locations of all current, potential and auxiliary transformers.
4. Complete assembly drawings showing elevations and section views of each non-identical unit.
5. Foundation plan drawings showing locations of channel sills, anchor bolts, and conduit and grounding entrances.
6. Complete three-line diagrams showing all controls and instruments, including terminal wiring designations.
7. Instrument transformer characteristic curves and burdens.
8. Structure drawings showing available space for all conduit and cable connections.
9. Schematic (elementary) control diagrams, both AC and DC, for switch control, interlocks, relays and instruments.
10. Complete point to point wiring diagrams.
11. Family of time-current characteristic curves for all types and sizes of fuses, relays and trip devices furnished with the switchgear.
12. Bills of material of all equipment, devices, components and nameplates, which shall include complete descriptions, ratings and locations.

B. Catalog Cuts

1. High voltage switches.
2. Meters and protective relays.
3. Current and potential transformers.
4. Relays, instruments, transformers and control devices.
5. Key interlocks.

C. Test Reports

Submit 5 certified copies of all test results.

END OF APPENDIX "A"

DIVISION 16

SECTION 16316

MEDIUM VOLTAGE METAL-CLAD SWITCHGEAR

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for medium voltage metal-clad switchgear.

1.02 REFERENCES

The following is a listing of publications referenced in this Section:

	American National Standards Institute (ANSI)
ANSI C 37.04	Standard Rating Structure for AC Circuit Breakers Rated on a Symmetrical Current Basis
ANSI C 37.06	Standard for Switchgear - AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis Preferred Ratings and Related Required Capabilities
ANSI C 37.09	Standard Test Procedure for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
ANSI C 37.20.2	Standard for Metal-Clad and Station-Type Cubicle Switchgear
ANSI C 37.21	Standard for Control Switchboards
ANSI C 37.46	Standard Specifications for Power Fuses and Fuse Disconnecting Switches
ANSI C37.54	Standard for Switchgear - Indoor Alternating Current High-Voltage Circuit Breakers Applied as Removable Elements in Metal-Enclosed Switchgear Assemblies – Conformance Test Procedures
ANSI C37.55	Standard for Switchgear - Metal-Clad Switchgear Assemblies - Conformance Test Procedures
ANSI C 37.90	Relays and Relay Systems Associated with Electric Power Apparatus
ANSI C 57.13	Requirements for Instrument Transformers
	National Electrical Manufacturers Association (NEMA)
NEMA ICS2	Standard for Industrial Control Devices and Controllers and Assemblies
NEMA ICS 4	Terminal Blocks for Industrial Equipment and Systems
NEMA SG 4	Alternating-Current High-Voltage Circuit Breakers
	National Fire Protection Agency (NFPA)
NFPA 70	National Electric Code
	Underwriters' Laboratories, Inc. (UL)
UL 94	Tests for Flammability of Plastic Materials for Parts in Devices and

Appliances

UL 198 C High-Interrupting Capacity Fuses Current Limiting Types

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

The switchgear shall be designed, manufactured, and tested in accordance with the latest revision of the applicable ANSI, NEMA and UL Standards. Where a discrepancy exists between the various standards, the most stringent requirements shall apply.

1.04 QUALITY ASSURANCE

A. Switchgear and all components of types and sizes required shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Entities manufacturing equipment shall have experience on at least two projects involving complexities similar to those required under this Contract.

C. Circuit breakers shall be of the type and rating approved by Consolidated Edison Company of New York and/or Public Service Electric and Gas Co. of New Jersey for use in their systems.

D. The switchgear assembly and circuit breakers shall be suitable for and certified to meet all applicable seismic requirements of Uniform Building Code (UBC) for zone 4 application. Guidelines for the installation consistent with these requirements shall be provided by the switchgear manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, UBC: a peak of 0.75g, and a Zero Period Acceleration (ZPA) of 0.38g. The tests shall fully envelop this response spectrum for all equipment natural frequencies up to at least 35 Hz.

1.05 DELIVERY, STORAGE AND HANDLING

A. Prior to shipment, the switchgear assembly shall be cleaned by wiping with a clean, dry cloth. Oil and grease marks shall be removed and wiped dry. All insulation shall be cleaned thoroughly. Dirt, soot, grease or paint shall be removed from the circuit breaker contacts and surface of the entire current carrying structures.

B. All relays and instruments shall be firmly blocked to prevent damage during shipment.

C. The overall dimensions and weight of each shipping section shall be limited to the maximum allowable by applicable state and local codes governing shipment of materials over public roads, or construction site handling limitations, whichever is less. Each shipping section shall have a label indicating dimensions and weight.

D. All equipment and materials shall be suitably wrapped, crated, boxed or otherwise prepared for shipment to prevent damage during handling and shipping. All openings shall be properly protected to prevent the entrance of any dirt or debris. All parts not constructed to be normally exposed to the weather shall be suitably weatherproofed.

E. Each box or crate shall be equipped with suitable lifting devices to facilitate unloading and shall contain a detailed packing list.

F. Packaging shall be labeled and numbered so that each section or assembly may be identified before being uncrated. Any items not fully assembled to the switchgear structure shall be packaged separately. Removable circuit breaker units shall be packaged and shipped separately.

G. Where switchgear sections must be separated for shipment, all information, materials, and equipment to facilitate reassembly and reconnection of interconnecting bus work and wiring in the field shall be furnished.

H. The Contractor shall outline measures he shall take with respect to storage and preventive maintenance requirements following delivery of the switchgear to the construction site.

I. Adequate means shall be provided for lifting by fork lifts and cranes and for moving the equipment on rollers. Lift points shall be marked on each crate.

J. Indoor switchgear that cannot be installed immediately shall be stored in a dry, clean location within a heated building. During storage, the switchgear shall be placed on a level surface.

K. Outdoor switchgear that cannot be installed immediately shall have its space heaters temporarily connected and energized to prevent condensation of moisture within the housing.

L. After delivery, a final inspection of the materials will be made by the Engineer. If any materials have been damaged or for any reason do not comply with the requirements hereof, the Contractor will be notified in writing and he shall replace the materials at his own expense.

1.06 SPARE PARTS AND SPECIAL TOOLS

A. A minimum of six (6) spare fuses of each size and type used in the switchgear and Control Panel shall be furnished.

B. Furnish one set of all special tools required for the erection, operation, and maintenance of all equipment furnished.

C. Furnish a minimum of three (3) half-pint containers of paint matching the exterior finish of the enclosure.

D. Furnish six (6) spare indicating lamps of each type installed.

E. Furnish one (1) container of contact lubricant.

1.07 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide medium voltage metal-clad switchgear products of manufacturers listed on the Contract Drawings.

2.02 RATINGS

The switchgear shall have the following ratings as shown on the Contract Drawings:

A. Service Voltage

B. Rated Maximum Voltage

C. Rated Voltage Range Factor K

D. Nominal 3-Phase MVA Class

E. Rated Insulation Level

1. Low Frequency Withstand Voltage
2. Impulse Withstand Voltage

F. Rated Short-Circuit Current at Rated Maximum Voltage (Sym)

G. Maximum Symmetrical Interrupting Capability and Rated Short-Time Current (Sym) - 3 Seconds

H. Circuit Breaker Closing and Latching Capability

I. Circuit Breaker Interrupting Time (Cycles)

J. Rated Continuous Current

K. Rated System Frequency

L. Rated Control Voltage

2.03 CONSTRUCTION FEATURES

A. General

1. The switchgear assembly shall be of the metal-clad type, suitable for indoor or outdoor use as shown on the Contract Drawings, containing drawout vacuum circuit breakers. The switchgear assembly shall be furnished complete with fuses, instrument transformers, relays, meters, control switches, associated devices described herein, and as shown on the Contract Drawings, and conforming to ANSI C37.04, C37.06, C37.09, C37.20.2, C37.54, C37.55 and NEMA SG4.
2. When shown on the Contract Drawings, the switchgear shall be arranged for close coupling to the transformer through a transition compartment.
3. Provisions shall be made for extension of the switchgear in both directions.
4. All circuit breakers shall be arranged as shown on the Contract Drawings.
5. No polyvinyl chloride (PVC) materials, insulation or products shall be used in switchgear, except for removable insulating boots on bus work.

B. Assembly Features

1. The switchgear shall consist of rigid self-supporting vertical sections bolted together to form a metal-clad switchgear assembly. The sides and rear of each vertical section shall be covered with removable bolt-on covers. Each cubicle shall be completely enclosed with formed steel sheets adequately braced to prevent distortion under normal conditions as well as during interruption of short circuit currents.

2. The structural details of each cubicle for the same breaker rating shall be identical. The cubicles shall be uniform in height and depth, and built to form a continuous structure lining up in front and rear.

3. All louvers or other ventilating openings shall be protected against falling of dust, water, or other foreign material. No louvers or ventilation openings shall be located on top of the switchgear unless they are made drip-proof and their design approved by the Engineer prior to fabrication.

4. Sheet steel doors shall be provided for access to the circuit breaker compartments, and instrument compartments. Doors shall be provided with galvanized, zinc-plated, or stainless steel hinges.

5. Doors shall be furnished with one or more handles, knurled steel screws, or a combination of these in order to firmly hold door closed. Doors shall be padlockable. Stops shall be provided to hold doors in the open position. Doors must open at least 135 degrees.

6. An insulating flash shield shall be mounted above each circuit breaker to prevent flashover from arc chutes to ground.

7. All insulating materials used for bus supports, barriers, or covers shall be of high dielectric strength, low moisture absorbing, flame retardant, arc resistant, and high impact strength material.

8. All combustible materials used for barriers, covers, and the like shall meet the flammability test criteria of UL 94 for materials classified 94V-0.

9. Space heaters, with mechanical guards to prevent inadvertent contact of personnel with thermal element, shall be provided in each vertical section. Heaters shall be of the low temperature type, rated 240 volts and operated at 120 volts, each protected by an individual single pole molded case circuit breaker of suitable rating. The heaters shall be sized to keep the air inside the cubicle above its dew point. Heaters shall be thermostatically controlled. Thermostats shall be of the differential type.

C. Circuit Breaker Compartment

1. The primary connection between the stationary units and the removable circuit breakers shall be made by means of a set of self-aligning, disconnecting devices mounted on the breaker studs or in the stationary structure, which shall positively engage with solid studs mounted in the stationary structure or on the circuit breaker, respectively. Firm contact pressure shall be maintained by means of steel springs. All primary contact surfaces shall be silver-plated to prevent corrosion.

2. Each circuit breaker cubicle shall be equipped with an automatic safety shutter to close the entrances of the stationary primary disconnecting devices when the breaker is removed or in the test position.

3. The removable breaker element shall be connected to and disconnected from its operating position by a suitable engaging mechanism. Guides shall be provided to assure perfect alignment of all engaging parts of the removable circuit breaker element with the corresponding parts in the stationary structure. A positive stop shall prevent over-travel of the removable breaker element when it is advanced to the connected and test positions.

4. Each circuit breaker cubicle shall be equipped with a mechanical interlock which shall prevent the circuit breaker from being inserted or withdrawn from the connected position unless the circuit breaker is opened. Another mechanical interlock shall prevent the circuit breaker from being closed unless the primary disconnecting devices are in full contact or separated by a safe distance, such as in the test or disconnected position.

5. Each circuit breaker cubicle shall be furnished with provisions for locking the circuit breaker in the disconnected position.

6. Circuit breaker cubicles assigned as TIE circuit breakers shall be equipped with stop blocks that shall inhibit the insertion of any Ground and Test (G&T) device.

D. Cable Compartments

1. Size the cable compartment to accommodate all incoming and outgoing cables in compliance with NFPA 70. Cable compartments shall include cable supports. Where connections are to be made to bus ducts, all necessary bus adapters, bolting, insulating supports, and metal flanges shall be provided. Ground sensing current transformers, when shown on the Contract Drawings, shall be mounted in the respective cable compartments.

2. All cables will enter the equipment as shown on the Contract Drawings. Two-hole compression crimp-type cable lugs shall be provided for power cables. Lugs shall have standard NEMA bolt hole spacing.

3. Each incoming and each outgoing feeder shall be fitted with four ground studs, one on each phase and one on the ground bus. The ground studs shall be provided with covers. The covers shall be constructed to allow for easy removal with a "hotstick."

E. Barriers

1. Each individual vertical section shall be segregated from adjacent sections by means of steel barriers extending all the way to the rear of the section.

2. Each individual cable compartment shall be provided with a steel barrier between the cable compartment and the main bus to protect against inadvertent contact with the main or vertical bus bars, and to ensure that no live connections are accessible in the rear of each section except the circuit breaker load connections.

3. Each individual vertical section adapted for a two-tier or two-high circuit breaker installation shall be provided with a movable steel barrier separating the circuit breakers' outgoing cables.

F. Buses

1. Buses shall be supported on isolated supports of high-impact, not-tracking, high quality insulation material and braced to withstand the magnetic stresses developed by currents equal to the largest circuit breaker close, carry and interrupting ratings. Bus bars shall be high conductivity copper having silver-plated joints. All buses, taps and primary interconnections shall be insulated with an approved insulating material for the full BIL rating and the service voltage shown on the Contract Drawings and approved by the Engineer. Tapes or rigid sleeving are not acceptable as an insulating material for bus.

2. Bus joints shall be bolted. Contact surfaces at bolted joints shall be silver-plated.

3. Insulating barriers shall be provided where primary buses pass through from one vertical section to another.

4. A copper ground bus extending the entire length of the switchgear cable compartments shall be provided. All the metal parts of the structure shall be effectively connected to this bus. Ground bus shall be of rectangular cross section, not less than 1/4 inch by 4 inches.

G. Utility Metering Section

1. Where indicated on the Contract Drawings, provide a separate barriered-off utility metering compartment complete with hinge sealable door. Bus work shall include provisions for mounting utility company current transformers as required by the utility company.

2. Service entrance switchgear section shall comply with UL requirements that include Service Entrance Label, incoming line isolation barriers, neutral connection to switchgear ground for solidly grounded wye systems.

H. Control and Auxiliary Power Wiring

1. Control wiring for each cubicle shall be enclosed in a raceway or in compartments isolated from the primary circuits and shall conform to NEMA ICS 2.

2. Control and secondary cable shall be tinned copper, minimum class B, stranded. Cable shall have insulation type SIS, rated 90 degrees C, 600 volt, heat resistant, and flame retardant. Wires crossing hinged joints and swing panels shall be flexible class, K stranded.

3. All control wiring, leaving the switchgear, shall be wired to terminal blocks. Direct connections between devices located in different vertical sections are not acceptable. Connections made on terminal blocks and on internal devices shall be by means of flanged spade or ring type gripping insulated terminals. On devices that do not permit flanged spade or ring type terminals, control wiring shall be held by screw-type compression connectors. Internal wiring shall have no splices, nor shall more than two wires be terminated on one terminal point.

4. Control wire bundles shall be secured with nylon ties and anchored to the assembly with the use of pre-punched wire lances. All current transformer secondary leads shall first be connected to easily accessible short circuit terminal blocks, before connecting to any other device. All groups of control wires leaving the switchgear shall be provided with terminal blocks with suitable numbering strips. Where feasible, provide plug-in terminal blocks for all shipping split wires.

5. Wire markers shall be provided at the end of all control wiring, identified by printing on wire sleeve with "origin" and "destination" markings.

6. Wiring shall be sized for the duty required. Control wiring shall be 14 AWG minimum; current transformer wiring shall be 10 AWG minimum. Wiring crossing hinged joints and swing panels shall be 12 AWG.

7. The control circuits between the stationary units and the removable circuit breakers shall be made by means of self-aligning, multi-contact, male and female devices. Only the female contacts shall be energized when the circuit is disconnected. The female contacts shall be recessed to prevent accidental shorting of the control circuits. All contact surfaces shall be silver-plated.

   a. Suitable means shall be provided for completing the control circuits between the stationary unit and the removable circuit breaker when the breaker is withdrawn to the test or disconnect position. If jumpers consisting of a plug and receptacle connected by a flexible cable are used, the contact enclosures shall be polarized to assure proper insertion of the plug in the receptacle. If jumpers are used, two sets of control jumpers shall be furnished.

   b. If the stationary secondary disconnecting devices are used, re-engagement shall not be effected manually unless the circuit breaker is in the test position and its frame is connected to the switchgear ground bus. Circuit arrangement shall permit trip and close checks and checking of circuit breaker, interlocking system when in the test position.

8. Unless otherwise shown on the Contract Drawings, auxiliary power circuit shall run the entire length of the switchgear. The circuit shall be one phase, 120 volt AC. The source of power shall be as shown on the Contract Drawings.

9. The protection for control and auxiliary power circuits shall be provided by pull-out-type fuse blocks and dual element time delay fuses.

I. Circuit Breakers

1. Each removable circuit breaker unit shall include a mechanically and electrically trip free three-pole vacuum break interrupting device, designed so that when operating within the specified rating, neither combustible material nor flame will be emitted.

   The circuit breaker shall be furnished complete with operating mechanisms, primary and secondary disconnecting devices, mechanical position indicator and mechanical interlocks on a mobile frame. Design shall be such as to permit three positions of the breaker: connected, test, and disconnected.

2. The removable circuit breaker units and stationary structure shall be assembled in accurate jigs to insure that circuit breakers of the same type and ratings shall be interchangeable with the exception of key interlocks, which reflect individual assignments for a particular breaker position. Like parts of all circuit breakers of the same type and rating shall be interchangeable. A check of interchangeability shall be made in the factory and again in the field by inserting a common circuit breaker in each stationary unit of the same type and rating and inserting each breaker in its own unit.

3. The circuit breaker shall be equipped with a minimum of ten convertible auxiliary position switches in addition to the auxiliary switches required for normal breaker control and indication.

4. An auxiliary switch (TOC) shall be mounted on the stationary housing (switchgear metal barrier) to indicate the connected position of the removable circuit breaker. In addition to the contacts required for the operation of the circuit breaker, the position switch shall consist of two (2) normally open, and two (2) normally closed spare contacts.

5. When the auxiliary switch on the circuit breaker cannot meet the number of contacts required, an auxiliary switch (MOC) mounted on the stationary housing shall be provided. In addition to the contacts required for the operation of the circuit breaker, the position switch shall consist of two (2) normally open, and two (2) normally closed spare contacts.

6. All trip and closing circuits shall be interlocked with an appropriate circuit breaker auxiliary contact to open the tripping or closing circuit after the required operation has been achieved. An anti-pumping device shall be provided in the control scheme.

7. Unless otherwise shown on the Contract Drawings, the circuit breaker shall be permanently mounted on wheels in such a manner that will permit the circuit breaker to be easily removed from its cubicle and moved within the switchgear room without the use of any accessory devices. The use of separate hand truck or lifting device for removal of the circuit breaker is not permitted, unless it occupies the upper cubicle in a two-tier arrangement.

8. The circuit breaker shall use a stored energy mechanism for opening and closing operation.

9. The charging mechanism shall automatically be discharged before the circuit breaker can be withdrawn from or inserted into the switchgear.

J. Ground and Test (G&T) Device

1. Ground and test device shall be provided for the switchgear assembly. The quantity of devices required shall be as shown on the Contract Drawings. The ratings of the G&T device shall be the applicable ratings of the circuit breakers, except the fault interrupting rating.

2. Ground and test device shall use a stored energy mechanism for closing. The charging motor shall have the operating voltage rating as the circuit breaker.

3. The charging mechanism shall automatically be discharged before the G&T device can be withdrawn from or inserted into the switchgear.

4. The G&T device shall be key interlocked in the closed position.

5. Facilities shall be provided to operate the G & T device from a remote position via a twenty-five (25)-foot minimum umbilical cord with a pushbutton control station.

6. When shown on the Contract Drawings, facilities shall be provided to operate the G&T device from the associated circuit breaker control switch at the Control Panel. The normal red and green circuit breaker indicating lights shall not function when the ground switch is operated. A separate pair of blue and amber indicating lights shall be provided on the circuit breaker cubicle door and also on the Control Panel. The blue light shall indicate that the G&T device is "CONNECTED" and closed, the amber light shall indicate that the G&T device is "DISCONNECTED" and open.

7. Each G&T device shall be equipped with key interlocks as described herein and as indicated on the Contract Drawings to allow for the grounding and testing of the medium voltage feeders.

8. A group of three, fully rated, voltage test receptacles shall be provided on the front of the G&T device with individual connections to a corresponding phase on the line or the load side, as shown on the Contract Drawings, of the G&T device for the testing of medium voltage feeder. The receptacle group shall be furnished with a shutter to isolate the receptacles while not in use. The shutter shall be key interlocked in such a manner that it cannot be opened unless the G&T device is closed and the ground is applied. The key interlock shall allow the G&T device to be tripped open only after the test receptacle shutter is closed or after the proper test probes are inserted and locked into the receptacles. The receptacles shall be interlocked with the operation of the G&T device to insure that the probes can only be removed when the G&T device is in the GROUNDED position.

9. When shown on the Contract Drawings, each G&T device shall be equipped with a manually operated selector switch to ground either the line side or the load side of the G&T device. The manually operated selector switch shall have a key interlock to inhibit operation of the switch unless the electrical distribution system has been secured. The G & T shall have line and load set of test receptacles similar to those described above.

10. Each G &T Device shall be equipped with a compartment position switch. When the compartment position switch is set in the UPPER position, interlocks shall set up an interference so that the device cannot be inserted into the lower compartment. Likewise, with the compartment selector switch set to the LOWER position, the device cannot enter the upper compartment.

11. One set of test probes and cables included as attachments shall be provided with each G&T device. The probes and cables shall be rated at the same voltage and insulation rating as the associated switchgear and circuit breakers.

12. Key interlocks shall be supplied on shutter so that the G&T device cannot be raked-in when shutters are open.

13. Unless otherwise shown on the Contract Drawings, a switchgear section similar to the switchgear section for the vacuum circuit breakers shall be provided to house each G&T device. The housings shall be designed to keep the G&T device free of dust and dirt. A complete set of circuit breaker controls similar to the ones noted herein after shall be provided on the housing to test both the G&T device and the vacuum circuit breakers. An umbilical control cord shall be provided to allow the testing of the G&T device and vacuum circuit breakers outside of the housing.

K. Circuit Breaker Test Cabinet

A circuit breaker test cabinet shall be provided for the switchgear assembly. The test cabinet shall permit the operation of the circuit breaker or G&T device outside the switchgear. The test cabinet shall be equipped with the following devices:

1. On/Off Control power switch.

2. Control power indicating light.

3. Close button.

4. Open button.

5. Cord and female secondary disconnect device similar to switchgear stationary unit.

L. Enclosures

1. When specified on the Contract Drawings, outdoor walk-in or shelter aisle enclosures shall be provided with the following features:

   a. Switchgear shall be enclosed in an outdoor, walk-in enclosure conforming to ANSI C37.20.2. The enclosure shall have a roof sloping toward the rear. Outer sections shall be the same widths as indoor structures, except the end sections of a walk-in enclosure shall be wider than the inner sections to permit opening the inner door. Each end of the outdoor structure shall have an end trim. Front aisle depth for walk-in structures shall be meet circuit breaker manufacturers recommendation.

   b. The enclosure shall be provided with rear hinged doors for each section. Aisle doors shall be supplied with provisions for padlocking. A steel floor shall be provided in walk-in aisle space and under each vertical section. Ventilating openings shall be provided complete with replaceable fiberglass air filters.

   c. Provide panic door hardware on aisle doors at each end of the line-up. External locking of the aisle doors shall not prevent operation of the panic hardware from the interior of the enclosure. The construction of the enclosure shall be modular so future sections can be added without affecting its integrity. Provide interior aisle lights, 3-way switches, and GFI protected receptacles.

   d. The enclosure shall be provided with undercoating applied to all members in contact with the foundation surface to retard corrosion.

   e. Power for the space heaters, lights, and receptacles shall be obtained from a control power transformer (CPT) within the switchgear, unless otherwise shown on the Contract Drawings. Supply voltage shall be 120 VAC.

2. When specified on the Contract Drawings, outdoor, non-walk-in type switchgear shall be provided with the same features as described above for the outdoor walk-in type switchgear except for the aisle. In addition, the front of each vertical section shall have a weatherproof door.

M. Lifting Device

1. Provide portable lifting device capable of lifting either circuit breaker(s) or the G & T device, but not simultaneously, to a height sufficient to permit installation of circuit breaker(s) or G & T device into any cubicle in the switchgear assembly and shall also be capable of transporting said circuit breaker(s)or the G & T device to other locations at the same floor elevation.

2. The lifting device shall be supplied from the manufacturer of the circuit breaker.

N. Instrument Transformers and Meters

1. Instrument transformers, where shown on the Contract Drawings, shall conform to ANSI C 57.13.

2. Voltage transformers shall be 120 volt secondary rating, ratio as shown on the Contract Drawings, and accuracy class. Voltage transformers shall be capable of a burden at least double the connected load, to allow for portable instruments connected to the test blocks. Voltage transformers shall be provided with primary current limiting fuses. Voltage and or control power transformer and fuse assemblies shall be mounted on drawout carriages with primary and secondary disconnecting devices, so arranged than upon withdrawal of the carriage the fuses are disconnected and transformer primaries grounded. Shutter shall isolate primary bus stabs when carriages are withdrawn.

3. All current transformers shall be 5 amps secondary, ratio and accuracy class as shown on the Contract Drawings. Current transformers shall not saturate when operated at 20 times rated current. Current transformers shall be capable of a burden at least double the connected load to allow for portable instruments connected to the test blocks. All current transformers shall be terminated in shorting blocks.

4. All current transformers shall be selected to withstand the thermal and mechanical stresses imposed by the maximum available system fault. The current transformer ratings and supporting calculations shall be submitted to the Engineer for approval.

5. Instrument transformer secondaries shall be grounded with a copper conductor not smaller than #10 AWG and connected to a ground bus located as closely as possible to the transformer.

6. Voltage and control power transformers primaries, where connected to ground, shall be grounded with a copper conductor not smaller than #6 AWG which shall be insulated for line to ground voltage and terminated at the grounding bus in a lug. The connection to the bus shall be so designed that it can be easily disconnected and isolated for proof testing. Each ground wire shall be one continuous run without intervening splices or terminal blocks between the transformers and the ground point.

7. Metering system shall be as shown on the Contract Drawings and shall be one of the following:

   a. Digital Metering System (DMS)

      The Digital Meter System shall be compact, all-in-one built, panel mounted, for measuring current, volts, KW, KVA, KVAR, HZ and power factor. It shall be installed on each unit of the switchgear where metering is required. It shall be connected through current and potential transformers as shown on the Contract Drawings and in accordance with the manufacturer's instructions. The DMS shall be mounted on the front of the switchgear within reach of an observer near eye-level. The DMS shall be capable of being used as a stand-alone monitoring unit, or as one element of a larger SCADA (supervisory control and data acquisition) network. The DMS shall have the capability to communicate via an RS-232 or RS-485 port. A minimum of three output relays shall be provided in the DMS unit that can implement alarm, control, or protective trip functions. The DMS shall be supplied with the manufacturer's standard software, which shall be capable of adequately representing all of the functions described herein.

   b. Conventional Metering System (CMS)

      The CMS shall consist of current transformers, voltage transformers, meters, and switches as shown on the Contract Drawings, and as described below.

(1) Instruments and meters shall be of the semi-flush, switchboard type, with rectangular dust-proof enclosing cases and anti-glare glass.

(2) Indicating instruments shall be 4 1/2 inches in diameter and have white dials with black marking, scales approximately 250 degrees and 7 inches in length, accuracy within plus or minus 1 percent of full scale, and external zero adjustment.

(3) Kilowatt-hour and kilowatt demand meters shall be of the integrating type and shall be draw-out type, with provision for testing, and shall be equipped with potential lights.

O. Relays, Control Switches and Fuses

1. Protective relays, as shown on the Contract Drawings, shall conform to ANSI C 37.90 and be of the semi-flush mounted, removable type, with built-in test facilities. Current transformer secondaries shall be automatically short-circuited when the relay is removed from its case. Auxiliary relays shall be surface mounted and front connected, and shall be as specified on the Contract Drawings.

2. Protective relay ranges shall be as shown on the Contract Drawings.

3. Lockout relays shall be hand-resettable, panel mounted, with mechanical target on the escutcheon plate for indication of relay position. The contacts shall be rated for operation at 600 VAC and a continuous current of 20 Amperes. The relay shall be enclosed with a dust cover.

4. Control transfer and instrument switches shall be of the heavy-duty rotary, multi-position, cam operated, multi-stage type, with dust cover. Switch contacts shall be silver to silver, rated for 600 VAC and a continuous current of 20 Amperes. Each circuit breaker control switch shall have red and green target. Each switch shall be equipped with engraved plastic escutcheon or nameplate identifying its function and position. Handle styles shall be pistol grip for control, and oval for instrument or transfer switches.

5. Each circuit breaker shall be provided with a control switch on the door of each circuit breaker cubicle for performing breaker open operation. A spring-return mechanism shall return the switch handle to the normal vertical position.

6. Medium voltage fuses shall be "E" rated, current limiting type, conforming to ANSI C 37.46.

7. Low voltage fuses in control circuits shall be Class J and Class L 600V, conforming to UL 198C.

P. Indicating Lamps

Indicating lamps shall be light emitting diodes (LED) of the low voltage, low burden series resistor type, with lens colors as approved by the Engineer. Lamps shall be replaceable from the front of the panel.

Q. Terminal Blocks

All terminal blocks shall have screw type terminals, barrier type, and be rated for 600VAC, 20 amperes minimum, with identifying marker strips. Terminal blocks in each cubicle shall have at least 20 percent spare terminals and shall be in accordance with NEMA ICS 4. Terminal blocks for current transformer secondary connections shall be of the short circuiting type.

R. Nameplates and Signs

1. Nameplates shall be screw mounted and shall be provided for each switchgear cubicle and for major externally and internally mounted devices including, but not limited to instruments, meters, control switches, and relays to identify its function and where applicable, its position.

2. Nameplates shall consist of letters and numbers back engraved on a laminated thermosetting plastic material, providing white letters and numbers on a black background. Size of letters and figures shall be approximately 1/8 inch for device nameplates and 7/16 inch for cubicle nameplates, and 1 inch for switchgear designations.

3. Nameplates shall be fastened with two oval-head stainless steel machine screws.

4. Number, location, and designation of nameplates shall be as approved by the Engineer.

5. Mimic bus shall be provided on the face of the switchgear representing actual bus arrangements within the assembly. Circuit breaker control switches and indicating lights shall be located in the proper position on the mimic bus. The mimic bus shall be made of 1/8-inch thick by 3/4-inch wide high strength thermosetting plastic material, secured every twelve (12) inches with self tapping screws.

6. Suitable warning signs shall be provided for each switchgear having the following description: "WARNING - HIGH VOLTAGE - KEEP OUT". The sign shall be approximately 5 inches by 9 inches and shall be fabricated from sheet metal with white lettering on a red background. Lettering shall be approximately one-inch high normal block lettering. Fasten signs with four flathead, stainless steel machine screws.

2.04 ACCESSORIES

All manufacturers' standard accessories shall be provided for all equipment, devices or components required by this Section.

2.05 SHOP PAINTING

A. Prior to assembly and before shop painting, all surfaces of the switchgear enclosure shall be thoroughly cleaned of rust, oil, grease, dirt and mill scale and receive a phosphatizing treatment, and then be primered with one coat of rust-inhibitor for a dry film thickness of 1-2 mills.

B. The exterior and interior of the switchgear shall be given two or more finish coats of corrosion resistant paint for the final dry film thickness of at least 2-4 mills. The color of the finish on the switchgear shall be ANSI number 61 light gray.

C. Alternate painting process, such as electrostatically applied paint, can be utilized subject to the approval of the Engineer.

2.06 CONTROL PANEL

A. The control panel shall conform to ANSI C37.21 and be the operating point for all circuit breakers. It shall house remotely mounted circuit breaker control switches, indication equipment and supervising/local control transfer switches. The control panel shall have a mimic bus showing the bus arrangement of the switchgear and the breaker control switches and indication lights shall be located in the proper position on the mimic bus.

B. The control panel shall be located as shown on the Contract Drawings and shall be metal enclosed, indoor type structure, factory assembled and tested containing units and devices as shown on the Contract Drawings and specified hereinafter.

C. The control panel shall be designed for freestanding installation. Doors shall be fitted with a piano-hinged, 3-point latching and provisions for locking. Suitable doorstops shall be provided to prevent damage to hinges.

D. The control panel shall be constructed from highest quality sheet steel. Front panel shall be constructed from #11 gauge steel minimum. Side sheets and top members shall be constructed from #13 gauge steel minimum. Suitable stiffeners shall be used to prevent warping. The control panel enclosure shall be NEMA 12 rated.

E. Adequate ventilating openings shall be provided complete with filters located behind each opening to retard the entrance of dust, foreign matter, insects and rodents.

F. Control and transfer switches shall be as described in section 2.03-0.

G. Indicating lamps assemblies shall be as described in section 2.03-P.

H. Mimic bus shall be 1/8-inch thick by 1/2-inch wide red colored high strength thermosetting plastic. Nameplates shall be used to identify the system components such as, circuit breakers, feeders and transformers.

I. All control and auxiliary relays shall be as described in section 2.03-O.

J. Control panel wiring and markers shall be as described in section 2.03-H

K. All incoming wires to the control panel shall terminate on terminal strips. Terminal blocks shall be as described in section 2.03-Q. Provide twenty percent spare unassigned terminals.

L. Nameplates shall be as described in section 2.03-R.

M. The control panel shall be painted as described in section 2.05.

2.07 ANNUNCIATOR

A. When shown on the Contract Drawings, the annunciator shall be a solid state unit, factory wired, assembled and tested, complete with components required for its proper operation. The annunciator shall be furnished with a flasher and shall be suitable for flush mounting. In addition, the annunciator shall be provided with the following features:

1. Acceptance of normally open or normally closed field contacts. Field contact voltage shall be supplied by the annunciator internal power supply.
2. Momentary input signals shall lock in and require manual reset.
3. The annunciator shall include an integral power supply that can operate on 125VDC unless otherwise shown on the Contract Drawings.
4. Number of points and annunciator window size shall be as shown on the Contract Drawings.

B. The following annunciator accessories shall be provided:

1. "Test", "Silence", "Acknowledge", and "Reset" pushbuttons, mounted on the annunciator.
2. One audible horn, mounted behind a perforated grill on the Control Panel.
3. Each point shall be equipped with an auxiliary repeat type relay to facilitate transmission of trouble condition(s) to remote location.
4. The annunciator shall have the capability to communicate via a RS-232 or RS-485 port.

2.08 FACTORY TESTING

A. The switchgear shall be completely assembled, wired, adjusted, and tested at the factory. After assembly, the complete switchgear shall be tested to assure the accuracy of the wiring, and the functioning of all the equipment.

B. The switchgear shall be tested in accordance with the Production Test outlined in ANSI C37.20.2 and ANSI C37.55 and shall include but not be limited to the following:

1. Dielectric Tests
2. Mechanical Operation Tests
3. Grounding of Instrument Transformer Cases Tests
4. Electrical Operation and Control Wiring Tests

C. All circuit breakers shall be tested in accordance with the Production Tests outlined in ANSI C37.09 and C37.54 and shall include but not be limited to the following:

1. Current transformer test.
2. Nameplate check.
3. Resistors, heaters, and coils check tests.
4. Control and secondary wiring check tests.
5. Clearance and mechanical adjustment check tests.
6. Mechanical operational tests.
7. Timing test.
8. Store energy system test.
9. Low-frequency withstand voltage tests on major insulation components.
10. Low-frequency withstand voltage tests on control and secondary wiring.

D. Factory tests, as outlined above, shall be witnessed by the Engineer. The manufacturer shall notify the Engineer two (2) weeks prior to the date the tests are to be performed.

PART 3. EXECUTION

3.01 FIELD SUPERVISION

Provide the services of a qualified, factory-trained switchgear manufacturer's representative to provide technical field support in the installation and start-up of the equipment specified in this Section. The manufacturer's representative shall provide technical direction and assistance in the following:

A. Direct the Switchgear Assembly.

B. Perform Required Equipment Alignment

C. Equipment Checkout and Calibration

D. Trouble Shooting

3.02 EXAMINATION

The Contractor is responsible for notifying the Engineer as soon as he finds conditions that prevent the proper installation of materials or methods specified in this Section.

3.03 INSTALLATION

A. Switchgear shall be transported within the construction site, unloaded, uncrated, handled, stored, installed, including assembly of all component parts, and wired in accordance with the manufacturer's recommendations, applicable ANSI standards, and the requirements specified in this Section.

B. Provide all equipment, supervision, labor, rigging, tools, including, but not limited to, special equipment such as cranes.

C. Before setting the switchgear, the floor members and openings for conduits and bus entrances shall be checked for accuracy of position.

D. Switchgear shall be set on foundations at the locations shown on the Contract Drawings. Provide floor sills, and set level in concrete. Follow the manufacturer's recommendations for preparation of the mounting surface and the fastening of the equipment. The switchgear shall be set, aligned, and leveled in place, using shims where necessary, and shipping sections bolted together.

E. Bus splices shall be cleaned and bolted together and insulated either by taping or by use of insulating boots if provided for that purpose.

F. The removable circuit breakers shall be installed in the housings and the rails adjusted, if required, for smooth travel of the circuit breakers. Main and secondary contacts on the removal and stationary sides shall be checked for tightness and adjusted if loose. Covers or enclosures shall be securely bolted in place.

G. Install, wire, and connect the Control Panel in accordance with the Contract Drawings and manufacturer's drawings and instructions.

H. All damaged paint areas shall be properly prepared by the Contractor for an application of primer and finish coats of paint, which shall be supplied by the manufacturer for this purpose. The Contractor shall apply the primer and fish paint coats.

I. After each item of equipment is installed and connected, the Contractor shall make a thorough inspection of the installation, cleaning all insulators that are exposed, and cleaning all cubicles and compartments of debris and foreign matter. Prior to final acceptance of the Work, and field testing, the Contractor shall clean the equipment of all construction dust and dirt. A careful check shall be made to ensure that all members included for shipping purposes have been removed.

3.04 FIELD TESTS

Field tests and inspection for commissioning medium voltage switchgear shall be performed in accordance with SECTION 16998 entitled, "MEDIUM VOLTAGE SYSTEM COMMISSIONING TESTS," of these Specifications. Advise the Engineer, in writing, upon failure of any equipment or material to pass the tests performed, or to function properly as intended.

In the event that testing does not meet the requirement for proof of satisfactory performance specified herein, the Contractor shall repeat the test. The Engineer reserves the right to decide whether a test must be repeated. Devices failing the repeated tests and deemed unrepairable by the Engineer, shall remain the property of the Contractor.

3.05 PROTECTION

Protect switchgear, equipment, and facilities against damage, mechanical or otherwise and provide maintenance until issuance of the Certificate of Final Completion. The switchgear and equipment shall be kept clean, dry, and protected at all times.

3.06 TRAINING

A. Provide training sessions at the construction site for the number of Authority personnel, as specified on the Contract Drawings for two (2) eight (8)-hour days.

B. The training sessions shall be conducted by a manufacturer's qualified representative. The training program shall consist of the instruction on the operation of the assembly, circuit breakers and major components within the assembly.

C. For additional training time requirements, see Section 16000 of these Specifications.

END OF SECTION

SECTION 16316

MEDIUM VOLTAGE METAL-CLAD SWITCHGEAR

APPENDIX "A"

SUBMITTAL REQUIREMENTS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Legend, Abbreviations, General Notes, and Drawing List
2. Outline drawings indicating overall dimensions, shipping sections, weights, and aisle space requirement for removable equipment
3. Switchgear rigging and installation drawings including anchoring Details, locations of sills, and anchor bolts
4. Elementary diagrams (terminal configurations) for removable circuit breakers, relays, control switches, and meters
5. Structural drawings showing available space for busway, conduit, and cable connections
6. Bus arrangement including dimensions and ampere rating of all bus bars
7. Bill of materials for all equipment including item description, rating, and location
8. One line diagram showing all ratings, main connections, and location of all instruments including relays, transformers, and meters
9. Three line diagrams showing all instrument connections including relays transformers and meters
10. Kirk key interlock diagram with functional description
11. Removable circuit breaker's elementary diagrams
12. G & T device elementary diagram
13. Front view of each vertical section showing all panel mounted equipment
14. Front view of all internal panels of switchgear cubicles and Control Panel, showing all control devices such as relays
15. Front view of Control Panel
16. Complete point to point wiring diagrams or schedules indicating the internal wiring of each component and the interconnections between components
17. Nameplate schedule and details
18. List special tools required for operation and maintenance of all equipment

B. Catalog Cuts

1. Relays
2. Control switches
3. Indicating lamps
4. Control wiring
5. Wire markers
6. Terminal blocks
7. Switchgear space heaters
8. Thermostats
9. Bus insulation materials
10. All types of lugs
11. All types of fuses and circuit breakers
12. Family of time-current characteristics curves for all types of fuses, relays, and trip devices
13. Instrument transformer characteristic curves and burden
14. Conventional metering system (CMS) devices
15. Digital Metering System (DMS) hardware and software

C. Test Reports

1. Submit factory tests and field tests forms for approval prior to implementation of the tests
2. Submit certified test reports as specified in 2.08 and 3.04 of this Section
3. Submit Seismic Certification
4. Submit certified test report for paint qualification test performed as per ANSI C37.20.2

D. Operation and Maintenance Manuals

1. Maintenance documentation, including manuals shall include descriptive material that will enable the Authority to maintain a supplied equipment at the component level. The document shall provide guidelines for isolating the cause of malfunction and for the removal, repair, and replacement of all devices.
2. Each manual, in addition to the information described above, shall contain the following:
   a. Calibration data, curves, wiring diagrams, and other pertinent information for all components provided
   b. Operational procedure, both manual and automatic
   c. Recommended preventive maintenance schedules
3. After installation and subsequent test are completed, provide nine (9) copies of manuals for all supplied equipment

E. Spare Parts List

Furnish a list of recommended spare parts, the list shall contain the prices and availability. Recommendation for spare parts does not obligate the Authority to purchase any such parts.

END OF APPENDIX "A"

SECTION 16316

MEDIUM VOLTAGE METAL-CLAD SWITCHGEAR

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in this Section:

(2.01) List a minimum of two (2) manufacturers for each item and include "or approved equal." If an item is unique of "sole source", then a "sole source" letter will be required.

1. Suggested list of Manufacturers

a. Switchgear Assembly

ABB Power Distribution, Inc.
C.G.I. Systems
Cegelec Automation
Control Power Corporation
Cutler-Hammer
General Electric Company
NEPA Inc.
PACS Industries
Powell Electrical Manufacturing Co.
Square D Company

b. Circuit Breakers

ABB Power Distribution, Inc.
Cutler-Hammer
General Electric Company
Square D Company

c. Annunciator

Allen-Bradley
Panalarm Division - Suggested model: Series 90
Rochester Instruments - System Suggested model: Series AN-3100C

(2.02) Show the following Switchgear ratings:

Service Voltage (e.g. 4.16KV, 13.6KV, 26.4KV)	= ___KV
Rated Maximum Voltage	= ***KV
Rated Voltage Range Factor K	= ***
Nominal 3-Phase MVA Class	= ___MVA

Rated Insulation Level:

Low Frequency Withstand	= ***KV
Impulse Withstand Voltage	= ***KV
Rated Short-circuit Current (at rated maximum voltage SYM)	= ***KA
Maximum Symmetrical Interrupting Capability and Rated Short-time Current (SYM) – 3 seconds	= ***KA
Closing and Latching Capability (ASYM)	= ***KA, Crest
Rated Interrupting Time	= 5 Cycles
Rated Continuous Current (e.g. 1200A, 2000A or 3000A)	= ____Amperes
Rated Frequency	= 60 Hz
Rated Control Voltage	= ____Volts

***Fill in Data from Values given in Table 1 ANSI C37.06 and Table 1 of ANSI C37.20.2.

(2.03 A.1) Indicate whether the switchgear is indoor or outdoor type.

(2.03 A.1) Single line diagram. Show relative (without dimensions) allocations of space (boxed-out) in the switchgear line-up for incoming lines, utility company metering and distribution circuit breakers. Show instrument transformers and associated ratings, and their connection to meters and protective relays.

(2.03 A.1) Indicate transition section between switchgear and transformer if required.

(2.03 A.4) Provide front elevation of switchgear with physical arrangement of circuit breakers, devices on front panel of each vertical section, including relays, instruments, indicating lights, etc.

(2.03 D.1) In one line diagram show ground and neutral sensors and zero sequence current transformers and their relay connection.

(2.03 D.2) Indicate cable entry into cubicle - top, bottom, or both.

(2.03 G.1) Indicate, if required, utility metering for each incoming and outgoing feeder section in single line diagram and switchgear physical arrangement.

(2.03 H.8) Indicate if switchgear needs more than one 20A, 120VAC circuit to feed space heaters.

(2.03 H.8) Indicate branch circuit designation and size of circuits supplying power to the switchgear space heaters, receptacles, or lighting fixtures.

(2.03 I.7) Indicate if non roll-in type of circuit breaker is required for installation.

(2.03 J.1) Indicate quantity of Ground and Test Device.

(2.03 J.6) Indicate Ground and Test Device controls from Control Panel, if required.

(2.03 J.7) Show Kirk -key interlocking diagram and functional description.

(2.03 J.8) Indicate if only line side of Ground and Test Device needs grounding. Indicate if only load side of Ground and Test Device needs grounding.

(2.03 J.9) Indicate Ground and Test Device with Line and Load Selector, if required.

(2.03 J.13)	Indicate if a separate switchgear section to house the Ground and Test Device is not required.
(2.03 L.2, 3)	For outdoor installation, indicate walk-in shelter aisle construction, or aisle-less enclosure. Show dimensioned equipment layout plan.
(2.03 N.1)	Indicate ratings for all instrument transformers and make part of one line diagram.
(2.03 N.2)	For Voltage Transformers accuracy class- choose values from the following table:

Voltage Class	Accuracy Class
5.0KV	1.2Z
15.0KV	0.6Z
38.0KV	0.3Z

(2.03 N.3)	Indicate Current transformers' accuracy class, see ANSI C57.13 and Con Edison requirements, where applicable.
(2.03 N.7)	Indicate metering system either Digital Metering System (DMS), or Conventional Metering System (CMS).
(2.03 O.1, 2)	In tabular form, indicate protective relay characteristic and make.
(2.03 O.1)	In tabular form indicate auxiliary relay ratings and make.
(2.06 B)	Show location of control panel on substation floor plan.
(2.06 B)	Show front elevation of control panel. Size to provide space for future expansion of electrical system
(2.07 A)	Indicate, if required, annunciator location. Provide spare annunciator windows for future expansion of electrical system.
(2.07 A.3)	Indicate external power supply to feed field contacts, if required.
(2.07 A.4)	Indicate annunciator window size, number of points, and nameplate designation for each window.
(3.03 D)	Show location of switchgear on substation floor.
(3.06 A)	Indicate number of Authority personnel for switchgear training sessions.

B. Other

1. Choose from "Appendix A Submittal Requirements" items applicable for project. Add items not listed in the Appendix, but necessary to effect a complete Contract.

2. Insure that the following Sections are included in the Contract Booklet:

   Section 16000, ELECTRICAL GENERAL REQUIREMENTS
   Section 16998, MEDIUM VOLTAGE SYSTEM COMMISSIONING TESTS

END OF INSTRUCTIONS

DIVISION 16

SECTION 16320

DRY-TYPE TRANSFORMERS
GENERAL PURPOSE - 600 VOLTS OR LESS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for general purpose, dry-type transformers 600 volts or less.

1.02 REFERENCES

Not Used.

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

The transformers shall be designed, manufactured and tested in accordance with the applicable provisions of the codes, standards and recommendations of the following entities:

American Welding Society (AWS)
American National Standards Institute (ANSI)
Institute of Electrical and Electric Engineers (IEEE)
National Electric Manufacturers Association (NEMA)
National Fire Protection Association (NFPA)
Underwriter Laboratories Inc. (UL)

In addition, specific provisions cited herein and as shown on the Contract Drawings shall govern for the associated specific application.

1.04 QUALITY ASSURANCE

A. The manufacturer of transformers shall have manufactured equipment of the voltage and KVA rating(s) described herein and as shown on the Contract Drawings, and they shall have been satisfactorily used for the purposes similar to those intended herein for a minimum of three years. When directed by the Engineer, the Contractor shall have the manufacturer provide a list of installations and contracts for which he has produced such materials.

B. All Work of this Section shall be performed and completed in a thorough, workmanlike manner and shall follow the best modern practice in the manufacture of high-grade equipment. All Work of this Section shall be performed by mechanics skilled in their respective trades.

C. All parts shall be made accurately to standard gauge, where applicable, for ease of replacement and repairs.

D. All material selected for the manufacture of the transformer units shall be the best available for the purpose for which they are intended to be used, considering strength, ductility, durability and the best engineering practice.

E. All parts shall be readily accessible and like parts shall be interchangeable insofar as possible.

F. Surfaces to be welded shall be clean and free from dirt, rust or other foreign matter. The welding processes shall be in accordance with the requirements specified by AWS.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Transformers shall be delivered complete, in the manufacturer's original, unopened protective packaging. All accessories, including but not limited to meters, temperature gauges, lightning arrestors, fan controls and relays, shall be in place and wired. Packing materials shall be such as to prevent damage to components due to vibration, jarring or the like during transportation and handling.

B. Accessories or spare parts shipped loose shall be delivered in the manufacturer's original unopened protective packaging and shall be identified with a non-corrosive tag.

C. The transformers shall be handled in a manner to prevent damage to finished surfaces.

D. Where possible, maintain protective coverings until installation is complete and remove such coverings as part of final cleanup.

E. Touch up any damage to finishes to match adjacent surfaces.

1.06 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 CONSTRUCTION FEATURES

A. General

Unless otherwise shown on the Contract Drawings, transformers shall conform to the following requirements:

1. Transformers shall be self-cooled, with properly designed steel enclosures. Openings for ventilation or similar use shall be so designed as to deflect foreign objects inserted through these openings away from contact with energized parts. Enclosures shall be suitable for floor or wall mounting, as required to fit within the constraints of each specific application. Transformers larger than 112.5 KVA shall be designed for floor mounting only. Outside dimensions of enclosures shall not exceed the dimensions shown on the Contract Drawings.

2. Transformers shall be provided with four 2-1/2 percent full capacity taps in the primary winding, two above and two below the nominal voltage rating. The taps shall be factory-wired to terminals accessible only by removal of external access plates or panels.

3. The maximum temperature at any spot on the exterior surface of the enclosure shall not exceed 50 degrees C rise above a 40 degrees C ambient.

4. Each transformer as a unit shall be capable of withstanding the stresses resulting from operating conditions, including external and internal short circuits, without distortion or other damage.

B. Core and Coil

1. Core and coil shall be completely isolated from the enclosure by rubber vibration isolating pads. The core shall be visibly grounded to the enclosure by a flexible grounding conductor, sized in accordance with applicable NEMA, IEEE and ANSI standards.

   a. Transformer neutral lead shall be ungrounded and brought-out to an isolated terminal.

   b. The enclosure shall include ground connection lugs for the incoming and outgoing conduits, and provisions for grounding the isolated neutral lead, all as shown on the Contract Drawings.

2. All cores shall be constructed of high grade, non-aging silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Magnetic flux densities shall be kept well below saturation to allow for a minimum of 10 percent overvoltage excitation. Cores shall be clamped with structural angles and bolted to the enclosure to prevent damage during shipment or rough handling. All laminations shall be cut with the direction of the grain and be free of burrs, core plated and stacked without gaps.

3. Windings shall be copper-formed wire or sheet, continuous from start to finish. Splices in windings will not be permitted. Material incorporated must have at least a minimum of one year of proven field usage. Accelerated laboratory tests will not be acceptable.

4. Internal primary and secondary bus shall be rectangular copper. All buses shall be hot-dipped, silver-plated over the entire area where incoming or internal cable or bus are to be bolted.

5. Transformer impedance shall be within 7-1/2 percent of the impedance value shown on the Contract Drawings.

6. All joints and leads to the transformer terminals shall be braced or welded.

7. The basic impulse level (BIL) windings shall be a minimum of 10 KV.

C. Insulation Systems

Transformers shall be vacuum-impregnated with non-hygroscopic thermosetting varnish.

1. Transformer capacity shall be based upon a temperature rise of 80 degrees C for transformers 30 KVA and larger, and 115 degrees C for transformers less than 30 KVA above an ambient temperature of 40 degrees C.

   a. Transformer design for 115 degrees C rise shall be capable of delivering a 15 percent continuous overload, above nominal rating, without exceeding 150 degrees C rise above a 40 degrees C ambient temperature.

   b. Transformer design for 80 degrees C rise shall be capable of delivering a 30 percent continuous overload, above nominal rating, without exceeding 150 degrees C rise above a 40 degrees C ambient temperature.

2. Transformer insulation systems shall be 220 degrees C for transformers 30 KVA and larger, and 185 degrees C for transformers less than 30 KVA. All insulating materials shall conform to the requirements of NEMA ST 20, for 220 degrees C, UL recognized insulation systems.

D. Sound Levels

Transformers shall operate at sound levels at or below ANSI C 89.1, and as follows:

Transformer Size	Maximum Sound Level
0.1 to 9 KVA	40 db
10 to 50 KVA	45 db
51 to 150 KVA	50 db
151 to 300 KVA	55 db
301 to 500 KVA	60 db

E. Painting

The entire transformer enclosure shall be degreased, cleaned, phosphatized, primed and finished with two coats of ANSI 61 light gray, baked enamel.

2.02 FACTORY INSPECTION AND TESTS

A. The Engineer reserves the right to inspect each transformer 112.5 KVA and larger at the factory and to witness each factory test. The Engineer shall be notified 15 working days in advance of each test. Failure to notify the Engineer of testing may necessitate retesting in the presence of the Engineer at no additional cost to the Authority.

B. The accuracy of the calibration of all instruments to be utilized during the tests shall be ascertained and recorded at the beginning of the tests.

C. Factory tests shall include, but not be limited to, the following:

Submit certified test data of new transformer designs, or of electrically duplicate transformer designs. The required test data shall be:

1. Efficiency at 25, 50, 75 and 100 percent load.

2. Percent regulation at 80 and 100 percent power factor.

3. No load and full loss in watts.

4. Impedance based on reference temperature.

5. Sound level in db of transformer in enclosure.

6. Average temperature rise based on 40 degrees C ambient temperature.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install transformers in accordance with the Contract Drawings, the manufacturer's instructions and in compliance with the applicable requirements of ANSI, IEEE, NFPA and UL.

B. All conduit and bus connections to the transformer enclosures shall be made with flexible or other approved vibrationless connectors.

3.02 FIELD TESTS

A. General

1. Provide all labor and materials for functional tests required. Unless otherwise shown on the Contract Drawings, power for the tests will be furnished by the Authority.

2. Should the tests reveal any defects in transformers installed under this Section, promptly correct such defects and rerun the tests until the entire installation is satisfactory to the Engineer.

B. Perform the following field test in the presence of the Engineer to demonstrate the proper phasing of each transformer installation and submit a written field report to the Engineer for record:

1. Verify that the proper phase sequence is maintained.

2. Use a phase sequence meter or demonstrate the proper rotation of a small 3-phase motor whose direction of rotation was verified prior to the transformer installation.

3. Should the foregoing test reveal any incorrect phasing, promptly correct such defects and retest until the entire installation is satisfactory to the Engineer.

END OF SECTION

SECTION 16320

DRY-TYPE TRANSFORMERS
GENERAL PURPOSE - 600 VOLTS OR LESS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Physical dimensions of each transformer.
2. Nameplate drawing for each transformer.
3. Drawings showing location of all specified accessories.
4. Technical specification for proposed transformer.
5. Wiring diagram of fan cooling provisions.
6. Details of current transformers.

B. Catalog Cuts

1. Temperature gauges.
2. Lightning arrestors.

C. Test Reports

Submit six copies of the certified test reports.

END OF APPENDIX "A"

SECTION 16320

DRY - TYPE TRANSFORMERS
GENERAL PURPOSE
600 VOLTS OR LESS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(10.4 A)	Voltage and KVA ratings(s).
(2.01 A)	Project specific requirements modifying the specification requirements.
(2.01 A.1)	Limitations on enclosure dimensions.
(2.01 B.5)	Impedance value.
(3.01 A)	Locations and installation requirements.
(3.02 A.1)	Power source for field tests, if other than Authority furnished power.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16326

CAST COIL, DRY-TYPE TRANSFORMERS (MEDIUM VOLTAGE)

PART 1. GENERAL

1.01 SUMMARY

This section specifies requirements for substation grade, cast coil, dry-type transformers.

1.02 REFERENCES

The following is a listing of publications referenced in this Section:

American National Standards Institute (ANSI)

ANSI C 57.12.01	General Requirements for Dry-Type Distribution and Power Transformers Including those with Solid-Cast and/or Resin-Encapsulated Windings
ANSI C 57.12.50	Ventilated Dry Type Distribution Transformer, 1 to 500 KVA, single phase and 15 to 500 KVA, Three-phase, with High Voltage 601 to 34500 Volts, Low Voltage 120 to 600 volts. Requirements for Dry Type Distribution
ANSI C 57.12.51	Dry Type Power Transformer, 501 KVA and Larger, Three-phase, with High Voltage 601 to 34500 Volts, Low Voltage 208Y/120 to 4160 Volts. Requirements for Ventilated Transformers
ANSI C 57.12.54	Recommended Practice for Installation, Application, Operation and Maintenance of Dry Type General Purpose Distribution and Power Transformers
ANSI C 57.12.55	Conformance Standards for Dry-Type Transformers Used in Unit Installations, Including Unit Substations
ANSI C 57.12.60	Procedure for Thermal Evaluation of Insulation Systems for Solid-Cast and Resin-Encapsulated Ventilated Dry Type Power and Distribution Transformers.
ANSI C 57.12.58	Guide for Transient Analysis of Dry Type Transformers
ANSI C 57.12.90	Distribution and Power Transformer, Test Codes
ANSI C 57.12.91	Test Code for Dry Type Distribution and Power Transformer
ANSI C 57.12.96	Guide for Loading Dry Type Distribution and Power Transformers
ANSI C 57.114	Seismic Guide for Power Transformers and Reactors
ANSI C 57.124	Recommended Practice for the detection of Partial Discharge and Measurement of Apparent Charge in Dry-Type Transformers

ANSI C 62.11	Surge Arrestors - Intermediate Class, Metal Oxide Type
ANSI ST 1	Specialty Transformers (Except General Purpose Type)
ANSI Z 55.1	Gray Finishes for Industrial Apparatus and Equipment

American Welding Society (AWS)

AWS D 1.1	Structural Welding Code, Steel

National Electrical Manufacturers Association (NEMA)

NEMA ST 20	Dry Type Transformers for General Application

National Fire Protection Association (NFPA)

NFPA 70	National Electric Code

National Building Code (BOCA)

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

The transformer shall be designed, manufactured, and tested in accordance with the latest revision of the applicable ANSI, NEMA and UL Standards. Where a discrepancy exists between the various standards, the most stringent requirements shall apply.

1.04 QUALITY ASSURANCE

A. Transformers of the voltage and KVA rating shown on the Contract Drawings shall be of a design that has been in satisfactory use for not less than three years in 20 installations, for purposes similar to those intended herein.

B. Transformers shall conform to ANSI C 5.7.12.01 and be tested in accordance with ANSI C 57.1291. Transformers produced to IEC Standards will not be acceptable.

C. All parts shall be made accurately to standard gauge, where applicable, for ease of replacement and repairs.

D. All materials selected for the manufacture of the transformers shall be the best available for the purpose for which they are used, considering strength, ductility, durability and the best engineering practice.

E. All parts shall be readily accessible and like parts shall be interchangeable, insofar as possible.

F. Surfaces to be welded shall be clean and free from dirt, rust or other foreign matter. The welding process shall be in accordance with AWS D1.1.

G. All Electrical System Equipment, Components Etc. and the means of their attachments and supports shall be designed and constructed to resist the effects of earthquake motion determined in accordance with ANSI C 57.114 and BOCA National Building Code for seismic hazard exposure group III. The Effective Peak Velocity Related Acceleration (A) which shall be utilized to determine seismic forces shall be 0.12. For this purpose of classification, this equipment and its enclosures are considered to be emergency or standby Electrical Equipment as defined in Table 1612.6.4(1) of BOCA National Building Code. Submit certification of the above requirements by a Professional Engineer licensed in the state of installation of the Transformer.

1.05 DELIVERY, STORAGE AND HANDLING

A. Transformers shall be delivered complete, in manufacturer's original, unopened protective packaging. All accessories, including, but not limited to, meters, temperature gauges, lightning arrestors, fan controls and relays shall be in place and wired. Packing materials shall be such as to prevent damage to components due to vibration, jarring, or the like, during transportation and handling.

B. Accessories or spare parts shipped loose shall be delivered in the manufacturer's original unopened protective packaging and shall be identified with a suitable non-corrosive tag.

C. Each box of crate shall be equipped with suitable lifting devices to facilitate unloading and shall contain a detailed packing list.

D. Adequate means shall be provided for lifting by fork lifts and cranes and for moving the equipment on rollers. Lift points shall be marked on each crate.

E. Contractor shall outline measures he shall take with respect to storage and preventive maintenance requirements following delivery of the transformer to the construction site.

F. The transformer shall be handled in a manner to prevent damage to finished surfaces and assemblies. Touch up any damage to finishes to match adjacent surfaces.

G. Where possible, maintain protective covering until installation is complete and remove such coverings as part of final cleanup.

H. After delivery, a final inspection of the materials will be made by the Engineer. If any materials have been damaged or for any reason do not comply with the requirements hereof, the Contractor will be notified in writing and he shall replace the materials at his own expense.

1.06 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide transformers of manufacturers as shown on the Contract Drawings.

2.02 CONSTRUCTION FEATURES

A. General

1. Locations, sizes, ratings, types and special features shall be as shown on the Contract Drawings. The transformers shall be cast coil type manufactured in accordance with ANSI C 57.12.01-1989 and applicable requirements of ANSI C 57.12.50, C 57.12.51 and C 57.12.55. Unless otherwise shown on the Contract Drawings, the transformers shall be three-phase connected in delta on the primary and in wye on the secondary. The ratings shall be as shown on the Contract Drawings and shall be based on continuous operation in a 30 degrees C average ambient temperature, as defined by ANSI C 57.12.01 over 24 hours and not exceeding 40 degrees C. Unless otherwise shown on the Contract Drawings, the self-cooled temperature rise shall not exceed 80 degrees C. and the maximum hottest spot temperature shall not exceed 110 degrees C. for 150 degree C insulation temperature class. For insulation temperature classes in excess of 150 degrees C, the insulation temperature class shall be determined from a thermal evaluation test of a complete winding assembly in accordance with ANSI C 57.12.60.

2. Transformers shall be provided with full capacity taps in the primary windings as shown on the Contract Drawings. The taps shall be factory-wired to terminals accessible only through removal of external access plates or panels. Links or jumper wires shall be insulated for 133 percent of the rated voltage.

3. The transformer as a unit shall be capable of withstanding the stresses resulting from operating conditions, including external and internal short circuits, without distortion or other damage.

4. The transformer assembly shall have ample strength to withstand, without damage, all stresses incidental to shipping and installation. Lifting hooks or eyes and jacking pads on all four corners of the transformer base shall be provided. The transformer base shall be constructed so as to be suitable for rolling or skidding in any direction and shall also have provisions for being lifted and moved by fork lift. All parts requiring removal during installation shall be clearly marked on the unit and identified in the installation instructions.

5. Unless otherwise shown on the Contract Drawings, each primary coil shall be protected with a solid state intermediate class surge arrestor manufactured in accordance with ANSI C62.11 (General Electric Company, Tranquell type, or equal) suitably sized and coordinated with the rated voltage. The arrestors shall be located in the transformer housing between the incoming feeder connector and the primary coil connection link. Primary coil connection link shall be connected on the line side of each arrestor, and the internal ground bus shall be connected to the ground side of each arrestor.

6. Transformer losses shall be calculated at 20 degrees C above rated temperature, at 100 percent KVA rating of transformer at rated voltage. Maximum core and coil losses shall be as shown on the Contract Drawings. Transformers with losses in excess of those specified will not be accepted.

7. Core and coil shall be completely isolated from the enclosure by cast epoxy supports and spacer blocks or by rubber vibration isolating pads. There shall be no rigid metal-to-metal contact or mechanical connection between them.

8. Transformers shall operate at sound levels at or below the requirements of NEMA ST20 as follows:

Transformer Size	Maximum Sound Level
57 to 150 KVA	55 db
151 to 300 KVA	58 db
301 to 500 KVA	60 db
501 to 700 KVA	62 db
701 to 1000 KVA	64 db
1001 to 1500 KVA	65 db
1501 to 2000 KVA	66 db
2001 to 3000 KVA	68 db
Larger than 3000 KVA	As shown on the Contract Drawings

9. Transformer impedance shall be as shown on the Contract Drawings at rated KVA, at rated voltage tap, with a permitted variance of 7-1/2 percent of specified impedance. The X/R ratio shall not be greater than seven unless otherwise shown on the Contract Drawings. Default value of transformer impedence shall be 5.75%.

10. Transformer neutral lead shall be ungrounded and shall be brought out to an insulated terminal.

11. Enclosure shall include an internal copper ground bus, minimum size to be 1/4 inch by 2 inches, with ground connection pads, lugs for equipment grounding the incoming and outgoing conduits, and provisions for grounding the isolated neutral lead. Ground connection pads shall be copper, minimum size 1 inch by 2 inches by 1/4-inch thick, located near the base, diagonally opposite each other, and supplied with two clamp-type copper ground connectors suitable for terminating #4/0 AWG copper cable.

12. Primary and secondary termination space and bushing locations shall allow sufficient space for proper terminations, but not less than 24 inches between the conduit entry and the termination. Alarm control and indication contacts shall terminate in a separate termination box or compartment with separate access through the enclosure. All wiring of contacts for alarm, control or indication shall be wired to terminal strips.

    a. All current transformers and all contacts for remote connection shall be wired to a terminal board in this box. All current transformers shall be terminated in shorting blocks.

    b. Designation strips shall be provided on each terminal board.

    c. Wiring shall be 600 volts rated, type SIS.

13. Internal primary and secondary bus shall be rectangular copper. All buses shall be hot-dipped, silver-plated over the entire area where incoming or internal cable or bus is to be bolted.

    a. All buses shall be fully insulated up to the cable termination lugs for the full, ungrounded, system voltage. The method to be used may be tape, sleeves, heat shrink material or any other approved method. The type and size of the line and load conductors and the type of termination shall be as shown on the Contract Drawings.

    b. Where fan cooling is shown on the Contract Drawings, buses shall be sized to comply with the fan-cooled rating.

14. Primary cables shall terminate with crimp-type, compression cable connections, UL listed for use on high voltage terminations. Screw type mechanical lugs are not acceptable.

    a. All cable connections shall be bolted to the equipment using a minimum of two non-magnetic stainless steel hex-heads bolts, each including hardware with two flat washers, two Belleville (cupped) washers and a nut.

    b. All bolted connections shall be properly torqued using an automatic self-releasing wrench. The Contractor shall certify that each connection is properly torqued, and shall include the values in a written field report submitted to the Engineer.

    c. After completion of connections, the Contractor shall tape each connection with high voltage insulating tape to the full design voltage value for the equipment. The insulating tape shall be covered with a final layer of non-tracking silicone tape.

B. Enclosure

1. Transformers shall be self-cooled, unless otherwise shown on the Contract Drawings with properly designed, heavy-gauge, sheet steel enclosures. Openings for ventilation, or similar openings, shall be so designed as to deflect foreign objects inserted through the openings away from contact with energized parts in compliance with NFPA 70.

    a. Enclosures shall be suitable for floor mounting. The base shall be constructed of structural steel members to permit skidding or rolling in any direction, with jacking pads designed to be flush with the enclosure, and with removable lifting devices bolted or welded to the base.

    b. Enclosure dimensions shall be coordinated to provide adequate working clearances around the transformer in accordance with NFPA 70.

    c. Unless otherwise shown on the Contract Drawings, the transformer enclosure shall be indoor type, ventilated, with louvered openings backed with a number 8 square mesh made with .035 inch diameter copper wire. The sheet steel shall be a minimum of 11 gauge galvanized steel. The top shall be of turndown construction for proper bolting of removable side panels for front and rear access respectively. Panels shall be equipped for padlocking and be provided with handles for easy opening and/or removal.

d. The transformer enclosure, termination chambers and components shall be shotblasted prior to application of a rust-inhibiting prime coat. The transformer base shall be painted with Minnesota Mining and Manufacturing Company (3M) type undercoat or approved equal. All surfaces shall then be finished with two coats of ANSI 61 light gray paint in accordance with ANSI Z 55.1. The underside of all equipment not readily accessible for repainting shall be coated with bituminous paint.

e. All transformers 500 KVA and larger shall have provisions for future forced air cooling on all units when fan cooling is not shown on the Contract Drawings. Provisions for future forced-air cooling shall include mounting provisions only for fans and bussing sized to comply with the fan-cooled rating. Forced-air cooling shall increase the nameplate KVA rating by at least 33% of the self-cooled KVA.

2. The maximum temperature at any spot on the exterior surface of the enclosure shall not exceed a 50 degree C rise above a 40 degree C ambient temperature.

C. Core and Coil

1. Both the primary and secondary windings shall be individually cast coil construction with the primary to encompass the secondary. The entire coil of each shall be cast in a fiberglass reinforced epoxy resin using a vacuum impregnation process to insure the absence of voids or air bubbles. The primary and secondary coils shall incorporate air convection ducts for optimum cooling and minimizations of overall size.

2. Windings shall be high conductivity copper, and shall be continuous from start to finish. Splices in windings will not be acceptable. Materials incorporated must have at least a minimum of two years of proven field usage. Accelerated laboratory tests will not be acceptable. All joints and leads to the transformer coils shall be brazed or welded.

3. The transformer insulation shall be designed to withstand without flashover or any apparent damage a Basic Impulse Level (BIL) test: One at reduced voltage; one at full wave; and two chopped wave all in accordance with ANSI Test Code C 57.12.90. In addition, the insulation shall be rated 34.5KV for 34.5KV class, 15KV for the 15KV class, 8.7KV for the 5KV class and 2.4KV for the 600-volt class. Windings shall have a minimum basic impulse level (BIL) as follows unless otherwise shown on the Contract Drawings.

Voltage Class	BIL Rating
0.6 KV	10 KV
5 KV	60 KV
15 KV	110 KV
34.5 KV	150 KV

4. All cores shall be manufactured from a high grade, non-aging silicone steel with high magnetic permeabilities, low hysteresis and eddy current losses. Magnetic flux densities shall be kept well below saturation to allow for a minimum of 10% voltage excitation. Cores shall be clamped and bolted to the enclosure to prevent damage during shipment or rough handling. All laminations shall be cut with the direction of the grain and be free from burrs, and shall be core-plated and stacked without gaps.

5. Where shown on the Contract Drawings, an electrostatic shield shall be placed between primary and secondary coils and connected to the enclosure ground.

D. Fan Cooling System

Where shown on the Contract Drawings, the fan cooling system shall include the following:

1. Provide a solid state, temperature control system complying with the requirements of 2.02 E.1 below, with factory preset, three level switching to maintain winding temperature. Unless otherwise shown on the Contract Drawings, branch circuit power for fans shall be 120 volts, single phase, 60 hertz, obtained from a separate auxiliary power transformer internally wired to the outgoing bus of the transformers. The auxiliary transformer shall be provided with primary and secondary overcurrent protection.

2. All low voltage elements of the fan system shall be isolated or barriered from the medium voltage components with conduit and steel boxes and shall be furnished with separate access through the enclosure.

3. Multiple cooling fans shall be provided, at the base of each coil, located front and rear, with a minimum of six fans on a three-phase transformer.

4. Provide thermal sensors in the hot-spot area of each winding, wired to the temperature Control system.

5. The sequence of operation shall be as follows:

   a. When temperature in any phase rises above the normal self-cooled rating, a relay shall be activated and the fans shall start.

   b. Upon reaching the next preset temperature in any phase, a second relay shall operate to initiate a transformer mounted audible alarm and red warning light, and shall simultaneously allow for initiation of remote alarms and indications.

   c. Upon reaching the maximum temperature setting in any phase, a third relay shall be activated. This relay shall be wired to the control termination compartment, for alarms or for shutdown of the transformer.

E. Accessories

Each transformer shall be provided with NEMA standard accessories and maintenance devices. In addition, the following accessories are required.

1. Transformers with a fan cooling system shall be provided with a Three-phase electronic temperature monitor unit accepting input from three (3) thermal sensors. The monitor shall track the temperature of the transformer with automatic digital displays and functions controlled by the signal received from the hottest phase. Unit features shall include temperature monitoring of each transformer coil, hottest phase temperature display, temperature display of any phase, DPDT contacts for both local and remote fan control, temperature alarm, and trip functions, manual fan operation, local alarm with local and remote silence feature, supervision of thermocouple circuits, automatic activation of fail/safe fan and alarm circuits upon loss of supply power. Monitor unit shall be suitable for use on 120 volts single phase AC.

2. If shown, bushing-mount current transformers of the size, type, and class shown on the Contract Drawings, shall be provided.

3. A "Hot Spot" dial type temperature indicator located in each low voltage coil (3 per transformer) each with a manual resettable maximum indicator and two independently, full range adjustable contacts to open on rise of temperature above design normal. The contacts to be rated for 125 volts AC, 10A.

2.03 IDENTIFICATION

Provide a machine-engraved, identification plate on the front of the transformer, with filled black letters, 1/4-inch minimum size, on a silver or brass non-corrosive metal background. Identification plate shall indicate transformer designation, as shown on the Contract Drawings.

2.04 FACTORY INSPECTION AND TESTS

A. Transformers shall be inspected and tested at the place of manufacture in the presence of the Engineer. Tests shall be performed on a completely assembled unit with current transformer secondaries shorted and grounded. Transformers shall not be shipped until they have been inspected and approved. The Engineer shall be notified in writing a minimum of fifteen working days prior to the scheduled date for inspection and tests.

B. The accuracy of the calibration of all instruments to be utilized during the tests shall be ascertained and recorded at the beginning of the tests.

C. The tests shall be conducted in accordance with C 57.12.91 and shall be certified and include, but not be limited to, the following:

1. Resistance measurement for each winding on the rated voltage connections prorated to the reference temperature. Data sheets shall indicate resistance of each individual coil.

2. Turns ratio and rated voltage connection and on all taps.

3. Polarity and phase rotation on the rated voltage connection.

4. Excitation loss at rated voltage and 110 percent voltage.

5. Excitation current at rated voltage and 110 percent voltage.

6. Impedance and load losses (No load and full load).

7. Heat run at rated voltage, conducted on one transformer of each KVA rating. The transformer to be so tested will be selected by the engineer at the time of inspection and test. The test shall incorporate 100 percent of rated voltage core losses at stated temperature. Certified test results of previously built similar units will be accepted in lieu of actual tests.

8. Applied potential.

9. Induced potential.

10. Impulse test on one transformer of each KVA rating. The transformer to be so tested will be selected by the Engineer at the time of inspection and test. If one unit fails the test, all other units shall be tested. Certified test results of previously built similar units will be accepted in lieu of actual tests.

11. Transient voltage analysis test in accordance with ANSI C 57.12.58. Certified test results of previously built similar units will be accepted in lieu of actual tests.

12. Partial discharge test shall be performed on each coil and on each fully assembled unit in accordance with ANSI C 57.124. All transformers shall be partial discharge free at the specified test voltage. All tests to be performed at highest voltage tap.

34.5 KV Class Coils:	55KV, if inception occurs, the extinction voltage must not be less than 41KV
15 KV Class Coils:	23KV, if inception occurs, the extinction voltage must not be less than 18KV
5 KV Class Coils	13.0KV, if inception occurs, the extinction voltage must not be less than 10KV
600 Volt Class Coils:	3.6KV, if inception occurs the extinction voltage must not be less than 3.0KV

13. Short circuit test - Certified test results on previously built similar constructed units will be accepted in lieu of actual tests.

14. Power frequency test at two times insulation system rated voltage.

D. Certified copies of all test results shall be furnished to the Engineer. Calculated hottest-spot temperature rises and time constants of the primary and secondary windings shall be shown on the certified test report. Certification shall be by a licensed professional engineer and so stamped.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install transformers as shown on the Contract Drawings, in accordance with the manufacturer's instructions and in compliance with the applicable requirements of ANSI C 57.12.54, IEEE, NFPA and UL.

B. All conduit and bus connections to the enclosure shall be made with flexible or other approved vibration free connectors.

3.02 FIELD TESTS

A. General

1. Provide all labor and materials for functional tests required. Power for the tests will be furnished by the Authority.

2. Should the tests reveal any defects in the transformer installation under this Contract, promptly correct such defects and rerun the tests until the entire installation is satisfactory to the Engineer in all respects.

B. Perform the following field tests in the presence of the Engineer to demonstrate the proper phasing of each transformer installation:

1. Verify that the proper phase sequence is maintained.

2. Use a phase sequence meter or demonstrate the proper rotation of a small three-phase motor whose direction of rotation was verified prior to the transformer installation.

3. When transformer is used in a "Secondary Selective" or "Network" arrangement, verify that the phases of the transformers match.

END OF SECTION

SECTION 16326

CAST COIL, DRY TYPE TRANSFORMERS (MEDIUM VOLTAGE)

APPENDIX A

SUBMITTAL REQUIREMENTS

A. Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - General Provisions:

1. Shop Drawings
   - a. Physical dimensions and weights to each transformer.
   - b. Nameplate drawing for each transformer.
   - c. Drawings showing location of all accessories.
   - d. Technical specifications for each transformer including all ratings.
   - e. Description of Painting procedure.
   - f. Description of Vaccum Impregnation procedure.
   - g. Wiring diagram of fan cooling provisions.
2. Catalog Cuts
   - a. Temperature gauges.
   - b. Lighting arrestors.
   - c. Magnetization curves for current transformers.
   - d. All other specified accessories.

B. Submit six copies of certified test reports.

C. Submit six copies of written field reports for the following:

1. High Voltage Termination torque values
2. Phasing

D. Submit six copies of Operations and Maintenance Manuals with recommended Spare Parts List.

END OF APPENDIX "A"

SECTION 16326

CAST COIL, DRY-TYPE TRANSFORMERS (MEDIUM VOLTAGE)

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(1.03 A)	Show voltage and KVA rating
(2.01)	Show list of acceptable manufacturers (See Item 2)
(2.02 A.l)	Show connections if other than delta primary and wye secondary; specify temperature rise if greater than specified in this paragraph
(2.02 A.5)	Show surge arrestor type if other than Intermediate class and if not required
(2.02 A.6)	Specify the maximum acceptable core and coil losses from the Table attached
(2.02 A.8)	Specify the maximum sound level for transformers larger than 3000 KVA
(2.02 A.9)	Specify transformer indedence at rated KVA. Specify X/R ratio desired if greater than seven. Specify taps if other than shown in specification
(2.02 A.13.a)	Specify type and size of line and load conductors and type of termination
(2.02 B.1c)	Specify outdoor type if required
(2.02 C.3)	Specify basic impulse level (BIL) if higher value is desired for the voltage class
(2.02 C.5)	Specify if electrostatic shield is required
(2.02 D)	Specify fan cooling if required
(2.02 D.1)	Specify voltage and number of phases if branch circuit power for fans is supplied from an external source
(2.02 E.2)	Specify size, type and class of Bushing mount current transformers if required
(2.03)	Show transformer designation per project requirements
(3.01)	Show physical installation of the transformers

B. Other Items

1. Specify required submittals by editing Appendix A "Submittal Requirements".

2. Acceptable manufacturers are:

   May and Christi
   Square D
   ABB
   Dynapower

   Verify the acceptability and availability of the transformers from these manufacturers prior to inclusion in the Contract Drawings.

TRANSFORMER LOSS DESIGN SPECIFICATIONS

KVA	NO-LOAD LOSSES	TOTAL LOSSES
500	1400	7000
750	1980	10500
1000	2520	12370
1500	3370	15070
2000	4550	19870
2500	5070	23170
3000	6000	27000
3750	7500	33500
5000	10000	43500
7500	15000	65000
10000	20000	87000

END OF INSTRUCTIONS

DIVISION 16

SECTION 16327

MEDIUM VOLTAGE LIQUID FILLED POWER TRANSFORMERS 15MVA AND SMALLER-BASE RATING

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for liquid filled transformers with all equipment and devices assembled as specified hereinafter.

1.02 REFERENCES

The following is a listing of publications referenced in this Section:

	American National Standards Institute (ANSI)
ANSI C 2	National Electrical Safety Code
ANSI C 37.91	Guide for Protection Relay Applications to Power Transformers
ANSI C 57.12.00	Standard General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers
ANSI C 57.12.10	Safety Requirements 230 Kv and Below 833/958 through 8333/10417 KVA, Single Phase, and 750/862 through 60,000/80,000/100,000 KVA, Three Phase Without Load Tap Changing; and 3750/4687 Through 60,000/80,000/100,000 KVA, Three Phase with Load Tap Changing Transformers
ANSI C 57.12.13	Conformance Requirements for Liquid-Filled Transformers Used in Unit Installations, Including Unit Substations
ANSI C 57.12.22	Requirements for Pad-Mounted Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers With High-Voltage Bushings, 2500 kVA and Smaller: High-voltage 34,500 Grd Y/19920 Volts and Below; Low Voltage, 480 Volts and Below
ANSI C 57.12.26	Standard for Transformers - Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers for Use with Separable Insulated High-Voltage Connectors, High-Voltage 34,500 GrdY/19920 Volts and Below; 2,500 KVA and Smaller
ANSI C 57.12.27	Conformance Requirements for Liquid-Filled Distribution Transformers Used in Pad-Mounted Installations, Including Unit Substations
ANSI C 57.12.28	Standard for Switchgear and Transformers - Pad-Mounted Equipment - Enclosure Integrity

ANSI C 57.12.90	Standard Test Code for Liquid-Immersed Distribution, Power and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers
ANSI C 57.13	Standard Requirements for Instrument Transformers
ANSI C 57.13.1	Guide for Field Testing of Relaying Current Transformers
ANSI C 57.91	Guide for Loading Mineral Oil-Immersed Overhead and Pads-Mounted Distribution Transformers Rated 500 KVA and Less with 65°C or 55°C Average Winding Rise
ANSI C 57.92	Guide for Loading Mineral Oil-Immersed Power Transformers Up to and Including 100MVA with 55°C or 65°C Average Winding Rise
ANSI C 57.98	Guide for Transformers Impulse Tests
ANSI C 57.100	Standard Test Procedure for Thermal Evaluation of Oil-Immersed Distribution Transformers
ANSI C 57.105	Guide for Application of Transformer Connections in Three-Phase Distribution Systems
ANSI C57.106	Guide for Acceptance and Maintenance of Insulating Oil in Equipment
ANSI C57.109	Guide for Transformer Through-Fault-Current Duration
ANSI C57.111	Guide for Acceptance of Silicone Insulating Fluid and Its Maintenance in Transformers
ANSI C57.114	Seismic Guide for Power Transformers and Reactors
ANSI C57.120	Guide for Loss Evaluation Power Transformers and Reactors
ANSI C57.121	Guide for Acceptance and Maintenance of Less Flammable Hydrocarbon Fluid in Transformers
ANSI C 62.1	Standard for Gapped Silicone-Carbide Surge Arrestors for AC Power Circuits
ANSI C 62.2	Guide for the Application of Gapped Silicone-Carbide Surge Arrestors for Alternating-Current Systems
ANSI C 62.11	Standard for Metal-Oxide Surge Arrestors for AC Power Circuits
ANSI C 62.22	Guide for the Application of Metal-Oxide Surge Arrestors for AC Power Circuits
ANSI C 62.31	Standard Test Specifications for Gas-Tube Surge-Protective Devices
ANSI C 62.32	Standard Test Specifications for the Low-Voltage Air Gap Surge-Protective Devices (Excluding Valve and Expulsion Type Devices)
ANSI Z 551.1	Gray Finishes for Industrial Apparatus and Equipment
	American Society of Testing and Materials (ASTM)
ASTM D 178	Specification for Rubber Insulating Matting
	American Welding Society (AWS)
AWS D1.1	Structural Welding Code, Steel
	National Electrical Manufacturers Association (NEMA)
	National Fire Protection Association (NFPA)
NFPA 70	National Electric Code

International Electrical Testing Association (NETA)

NETA ATS Acceptance Testing Specification for Electrical Power Distribution Equipment and Systems

BOCA National Building Code

State and Local Codes

Occupational Safety and Health Administration (OSHA)

1.03 ENVIRONMENTAL REQUIREMENTS

Transformers will be installed at sea level in an ambient temperature range of -20 degrees F to 122 degrees F and they shall be suitable for indoor or outdoor locations as shown on the Contract Drawings.

1.04 DESIGN AND PERFORMANCE REQUIREMENTS

The transformer shall be designed, manufactured and tested in accordance with the latest revisions of the applicable ANSI, NEMA and UL Standards. Where a discrepancy exists between the various standards, the most stringent requirements shall apply.

1.05 QUALITY ASSURANCE

A. The manufacturer of transformers shall have manufactured equipment of the voltage and KVA rating(s) described herein and as shown on the Contract Drawings, and they shall have been satisfactorily used for the purposes similar to those intended herein for a minimum of three years. The Contractor shall have the manufacturer provide a list of installations and contracts for which he has produced such materials.

B. All parts shall be made accurately to standard gauge, where applicable, for ease of replacement and repairs.

C. All materials selected for the manufacture of the transformers shall be the best available for the purpose intended, considering strength, ductility, durability and the best engineering practice.

D. All parts shall be readily accessible and like parts shall be interchangeable, insofar as possible.

E. Surfaces to be welded shall be clean and free from dirt, rust or other foreign matter. The welding process shall be in accordance with the requirements of AWS D1.1.

F. All Electrical System Equipment, Components and the means of their attachments and supports shall be designed and constructed to resist the effects of earthquake motion determined in accordance with BOCA National Building Code for seismic hazard exposure group III. The Effective Peak Velocity Related Acceleration (A_V) which shall be utilized to determine seismic forces shall be 0.12.

For the purpose of classification, this equipment and its enclosures are considered to be emergency or standby electrical equipment as defined in Table 1612.6.4(1) of BOCA National Building Code.

Submit certification of the above requirements by a Professional Engineer licensed in the state of installation.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Transformers shall be delivered complete, in the manufacturer's original, unopened protective packaging. All accessories, including, but not limited to, meters, temperature gauges, surge arrestors, fan controls and relays shall be in place and wired. Packing materials shall be such as to prevent damage to components due to vibration, jarring or the like, during transportation and handling.

B. Accessories or spare parts shipped loose shall be delivered in the manufacturer's original unopened protective packaging and shall be identified with a non-corrosive tag.

C. The transformer shall be handled in a manner to prevent damage to finished surfaces and assemblies.

D. Where possible, maintain protective covering until installation is complete and remove such coverings as part of final cleanup.

E. Where bushings are exposed, they shall be protected from falling objects.

F. Touch up any damage to finishes to match adjacent surfaces.

1.07 SUBMITTALS

See Appendix "A' for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with the requirements of this Section, furnish and install transformers of manufacturers as shown on the Contract Drawings.

B. When shown on the Contract Drawings, the manufacturer must have prior approval from the Utility Company before its product will be accepted.

2.02 CONSTRUCTION FEATURES

A. General

1. Locations, sizes, ratings, types, type of dielectric fluid and special features shall be as shown on the Contract Drawings. Unless otherwise shown on the Contract Drawings, the transformers shall be three-phase connected in delta on the primary and in wye on the secondary. The ratings shall be based on continuous operation in a 30 degrees C average ambient temperature over 24 hours and not exceeding 40 degrees C.

2. Transformers shall be capable of withstanding stresses resulting from operating conditions, including external and internal short circuits, without distortion or other damage.

3. Transformers shall have provisions to facilitate moving and maintenance as follows:

   a. A structural steel base with jack step skids to provide movement in either direction and means for attaching shipping skids.

b. Pulling eyes.

c. Lifting lugs for lifting complete transformer.

d. Lugs for lifting cover only to expose the core and coil in the field for repair purposes.

4. Maximum core and coil losses shall be as shown on the Contract Drawings. Transformers with losses in excess of those specified will not be accepted. Transformer losses shall be calculated at:

a. 20 degrees C above rated temperature.

b. 100 percent KVA rating.

c. Lowest temperature rise rating of transformer at rated voltage.

5. Transformer neutral lead shall be ungrounded and shall be brought out through an insulated terminal.

6. Alarm control and indication contacts shall terminate in a separate termination box or compartment with separate access through the enclosure. All wiring of contacts for alarm, control or indication shall be wired to terminal strips.

a. All current transformer taps, and all contacts for remote connection shall be wired to a terminal board in this box.

b. Designation strips shall be provided on each terminal board.

c. Wiring shall be 600 volts rated, type SIS.

7. The type and method of neutral grounding shall be as shown on the Contract Drawings.

8. Polarity, angular displacement and lead markings shall be as shown on the Contract Drawings.

9. All accessories shall be located in accordance with ANSI standards.

B. Transformer Tank Construction

1. The transformer shall be of sealed tank construction made with welded steel plates. The tank cover shall be bolted on.

2. A minimum of one manhole or handhole shall be provided in the cover, with a minimum diameter of 18 inches, for access to the interior of the tank.

3. All gasketed joints shall have machined surfaces on both sides and shall be provided with gasket retainers and metal-to-metal stops to assure even and effective pressure and to avoid over-stressing the gaskets. Gaskets shall maintain liquid tightness of joints under all service conditions. Joints shall be designed so that gaskets are not exposed to the weather when transformer is installed outdoors.

4. Construction shall withstand internal pressures without showing leaks when using warm fluid and without permanent deformation at pressures 25 percent greater than the maximum fluid pressure resulting from the system of fluid preservation used.

5. Provisions shall be made for drawing full vacuum, filling and drying in the field.

6. The tank shall be provided with tanking guides for neutering core and coil assembly.

7. The tap changer box shall have provisions for key interlocking and padlocking. The key interlock code will be furnished by the Authority.

8. Primary and secondary bushing compartments shall be furnished of sufficient size to accommodate connections of the incoming conduits, cables, stress cones, bus ducts and other such items, but shall not be less than the dimensions shown on the Contract Drawings. Where shown on the Contract Drawings, the high voltage compartment shall also contain surge arresters as described in 2.02 F of this Section.

C. Transformer Internal Construction

1. General

a. The transformer shall be capable of withstanding both the electrical and mechanical stresses resulting from handling and operating conditions, including external and internal short circuits, without distortion or other damage.

b. All joints and leads to the transformer terminals shall be brazed for service at or below 600 volts and shall be mechanically crimped for service above 600 volts.

c. All fittings required for connection to external devices through the tank wall shall be first installed into the wall with a thread connection and then completely fillet welded into place.

d. All gauges shall be visible from outside of any enclosure.

2. Core and Coil Construction

a. Cores shall be constructed of mitre-cut, high-grade, grain-oriented, non-aging, silicone steel with high magnetic permeabilities, and low hysteresis and eddy current losses. Magnetic flux densities shall be kept well below saturation, to allow for a minimum of 10 percent overvoltage excitation.

b. Core laminations shall be free of burrs, core plated, and stacked without gaps.

c. Insulation materials, film varnishes and compound in contact with insulating liquid shall neither affect the liquid nor be affected by it. Materials incorporated must have at least a minimum of two years proven field usage. Accelerated laboratory tests will not be accepted.

d. Cores shall be clamped to either formed or structural angles and bolted to the enclosure to prevent damage during shipment and rough handling. Cores shall be grounded to the clamps with detachable straps.

e. Coils shall be copper of wound or sheet construction. Windings shall be continuous from start to finish; splices in the windings are not acceptable.

f. The serial number shall be stamped on the core in a conspicuous place.

g. Coil windings shall be fully protected from voltage stresses and mechanical stresses due to shock, stresses of operation or fault conditions.

h. The core and coil assembly shall be of such design that the core can be exposed in the field for repair purposes.

3. Insulation and Ratings

a. Transformer ratings shall be in accordance with ratings shown on the Contract Drawings and shall be based on an average ambient temperature of 30 degrees C, not exceeding 40 degrees C, for a period of 24 hours.

b. Unless otherwise shown on the Contract Drawings the transformer insulation shall be designed to withstand, without flashover or any apparent damage, the basic lightning impulse insulation level (BIL) as specified in ANSI C 57.12.90. In addition, the insulation shall be rated for the NEMA voltage class for the voltages shown on the Contract Drawings.

c. Hot spot temperature rise shall not exceed 15 degrees C above the temperature rating of the transformer.

d. The transformer X/R ratio shall not be greater than that shown on the Contract Drawings. Transformer with greater X/R ratio will not be accepted.

e. The transformer impedance shall be based on the lowest self-cooled rating and shall be within 7 1/2 percent of the impedance in accordance with ANSI standard unless shown on the Contract Drawings. However, the variation within a group of transformers to be operated in parallel shall not exceed plus or minus 0.2 percent.

D. Cooling System

1. The cooling system shall consist of radiators, fans, heat exchangers and/or pumps, separately or in such combination as shown on the Contract Drawings. All cooling equipment shall include supports, mountings, automatic control equipment, conduits and wiring as required.

2. Unless otherwise shown on the Contract Drawings, all radiators and/or cooling assemblies on transformers rated 2001 KVA and larger, shall be arranged so that they can be removed while the transformer is in operation. Header connections to the main tank shall be provided with shutoff valves and bolted flanges to facilitate removal of radiators or cooling equipment assemblies. Radiators shall be provided with drain plugs.

3. Where radiators are designed for natural ventilation and natural liquid circulation, the external surfaces of the radiators shall be hot dipped galvanized before painting.

4. Temperature control equipment shall be installed in a weather tight NEMA 4X enclosure, complete with hinged doors and rain shield and located so as to be easily accessible from the ground. The equipment shall automatically start and stop the fans and/or pumps to maintain the transformer temperature within the rated temperature rise. A switch shall be provided to permit manual operation of the fans. A fan pump exercise circuit shall be provided to automatically operate the fans and/or pumps for one minute once every six days.

5. Where pumps and/or fans are not shown on the Contract Drawings, provisions shall be made for their future addition and control of same, in accordance with the requirements of 2.02 D.2 above.

6. All fans and pumps rated below 1HP shall operate on a 120 volts AC, single-phase system. Fans and pumps rated above 1HP shall operate on 480 volts AC, 3-phase system.

7. All current carrying parts shall be rated for the fan and pump cooling ratings.

E. Dielectric Fluid and Preservation System

1. Unless otherwise shown on the Contract Drawings, provide dielectric fluid preservation system on transformers 500 KVA and larger. The system shall be an inert gas pressure system, as defined in ANSI C 57.12.00, in which the transformer has a sealed tank with positive pressure nitrogen automatically maintained above the dielectric fluid and shall be factory-filled, complete with necessary accessories, alarms, valves and piping as defined below.

2. The dielectric fluid shall be as shown on the Contract Drawings, UL classified less-flammable liquid, in accordance with NFPA 70 for indoor use without a vault, and having a minimum fire point of 300 degrees C.

3. Transformer shall be shipped filled with the dielectric fluid and all fittings in place. Dielectric fluid shall not be shipped separately.

F. Surge Arrestors

1. Provide three surge arrestors mounted on the transformer high voltage side. Arrestors shall be of the types and ratings as shown on the Contract Drawings.

2. The arrestors shall be located in the transformer housing between the incoming feeder connector and the primary coil connection link. Connect both the line and ground sides of each arrestor.

3. The ground terminals of the three surge arrestors shall be connected together and a ground connection shall be made from the ground terminal of the lightning arrestors on each outside phase to a point approximately one foot above the transformer base. The ground connections shall be made with 1/4 inch x 2 inch copper bar or #4/0 AWG copper cable. Both ground risers shall be furnished with clamps and terminals for #4/0 copper cable ground connections.

G. Bushings and Insulators

1. All bushings shall be in accordance with NEMA standards. Bushings of higher than 15KV voltage classification shall be silicone or compound filled and shall have provisions for power factor testing.

2. Insulators and bushings shall be capable of withstanding the standard impulse test of 1.5 uSec x 40 full wave voltage in accordance with ANSI test standards.

3. Bushing locations shall be as shown on the Contract Drawings.

4. When surge arrestors are furnished, high voltage line bushings shall be connected to the surge arrestors by means of copper bus bar or tubing of suitable current carrying capacity, and with sufficient flexibility to prevent damage to the bushing or surge arrestor.

5. All bushings shall be furnished with terminals as shown on the Contract Drawings. Terminals for connection to incoming bus shall be for flexible copper connections.

6. Bushings shall be furnished with extended creepage characteristics.

H. Buses and Connectors

1. All buses shall be copper, hot dipped silver plated at all bolted areas, both internally and at incoming connections.

2. All buses shall be fully insulated, for the ungrounded system voltage supplied. Insulation shall terminate at the incoming line connection pads.

3. All buses and joints shall be insulated. Insulation shall be tape, sleeves, heat-shrink material, or any other approved material. Insulation installation shall be corona free. Painted coatings will not be accepted.

4. Provide two 2 inch x 3 1/2 inch stainless steel or copper faced ground pads mounted on diagonally opposite corners of the transformer. Each ground pad shall have two NEMA type threaded bolt holes and two pressure type ground lugs, each with two hole NEMA drilling, for 500 MCM cable.

I. Grounding Resistors

Grounding resistors, if shown on the Contract Drawings, shall be outdoor, punched stainless steel type, mounted in an expanded metal enclosure, on a separate rack, and shall have ratings in accordance with those shown on the Contract Drawings.

J. Tap Changers

1. No Load Tap Changer

a. Unless otherwise shown, a de-energized tap changer shall be in the winding shown on the Contract Drawings to give two 2.5 percent full capacity above and below the rated voltage. The tap changer shall be operated and shall have arrangements for padlocking in each tap position. The operating mechanism shall be covered with a removable metal enclosure. The contact shall be easily accessible through manholes in the transformer top cover without untanking.

b. Each tap changer, operating handle shall be brought down to a height of 4 feet above the base, for convenience of operation.

c. Indicators for tap changers shall be visible to a person standing on the ground.

2. Automatic Load Tap Changer

If specified on the Contract Drawings the Load Tap Changer (LTC) equipment shall conform to the requirements specified below.

a. Construction

(1) The winding shown on the Contract Drawings shall be furnished with automatic tap changing equipment providing a range of 12 percent boost and 12 percent buck in 32 steps (33 positions total) over normal rated voltage. Transformer shall be fully rated at all tap positions.

(2) All the necessary LTC equipment shall be mounted outside of the main transformer tank. There shall be no liquid communication between the transformer main tank and the LTC compartments. The LTC equipment (except vacuum type) shall have transfer switches housed in a compartment separated from the tap selector and reversing switches so that there will be no dielectric fluid interchange between these switches and the transformer tank. There shall be no arcing contacts in tap selector compartment.

(3) All contacts of the tap changer and associated equipment shall be readily accessible and designed to require minimum maintenance. The LTC equipment shall have, as a minimum, a contact life of 500,000 electrical operations. Hinged doors shall be provided for this purpose on the selector and transfer switch compartments. All arcing contacts shall be made of arc resisting material. If the contactor or diverter switch must be removed for inspection, a removable lifting device and a mounting provision shall be supplied on the top cover.

(4) For purposes of inspection or repair, it shall be possible to operate the tap changers electrically when the transformer is de-energized and the dielectric fluid has been removed from the tap changer compartments.

(5) The LTC equipment shall be arranged for remote and local control as specified herein. The operating mechanism shall be designed to provide at the transformer, electrical operation with the transformer carrying load and manual operations with the transformer de-energized; and it shall be designed so that it shall be impossible to operate the tap changer electrically during such manual operation. It shall also be impossible to operate the tap changers remotely during local operation. A visual position indicator shall be provided at the transformer to indicate each tap position.

(6) It shall be possible to change taps at any operating position with maximum loading on the transformer in compliance with ANSI C 57.92. It shall also be capable of transferring from one tap to another under short circuit limited only by the transformer impedance, without excessive contact damage.

(7) A tap change operation counter shall be provided and located in the mechanism housing.

(8) The LTC motor compartment shall be provided with a window for local observation of the tap changer position indicator.

(9) The load tap changing mechanism shall be designed so that in the event it should bind or jam, the linkage shall not break between phases; the motor drive shall stall, and the motor shall be positively protected from failure due to overheating. The use of shear pins, friction clutches and thermal sensitive elements as protective devices is not acceptable.

(10) The barrier between the main tank and the selector must be able to withstand a pressure difference of at least 14.7 psi. In addition, all compartments (main tanks, selector and contactors) shall be braced to withstand a full vacuum individually while the other compartments are maintained at atmospheric pressure (0 psi). One-inch diameter piping with a valve is required between the main tank top cover and selector compartments.

b. Control and Operation

(1) The voltage source for the automatic regulating control equipment shall be as shown on the Contract Drawings. Submit power requirements for control and indication equipment. Provide a current transformer for the compensators used for automatic regulation. The current circuit shall be designed for 0.2 ampere operation. Current transformer ratio shall be as required for the proper operation of LTC equipment.

(2) The automatic LTC equipment shall be suitable for stable operation without hunting when operating in parallel with other similar transformers, using circulating current compensation. Provide a lockout relay that prevents paralleled tap changers from runaway conditions.

(3) Selsyn or approved equal, electrical transmitting, receiving and indicating equipment shall be provided for remote indication of the tap changer position. The indicating units shall be a nominal 4-1/2 inch in diameter and will be mounted on remote control cabinet to be furnished by the transformer manufacturer. An output signal of -1,0,+1 mA DC shall be provided for transmitting tap position indication. Lights shall be provided in the LTC control housing for the following indications:

(a.) When passing from one tap to the adjacent tap.

(b.) When reaching each end limit position.

(c.) When the tap changer is operated on local-automatic control.

(d.) When the tap changer is operated on remote control.

In addition, provision shall be made for the remote indication of items a, b, c and d by means of lamps to be furnished by the transformer manufacturer.

(4) Parallel operation shall be designed such that any one or more transformer can be removed from automatic control while the remaining transformers continue in parallel operation.

(5) All control devices and wiring for each transformer shall be mounted in a local control cabinet except for remote control and indication devices. The local control cabinet shall be weatherproof for outdoor mounting on the transformer.

(6) An adjustable device shall be provided suitable for obtaining a time delay in the range from 15 to 60 seconds during automatic operation in both raise and lower directions between successive tap changes as well as to the initial step of a tap change. Unless otherwise shown on the Contract Drawings, this device shall be set for 60 seconds.

(7) The LTC equipment shall be arranged so that in the event power is lost during tap change operation, the LTC shall go back to the tap position before the power loss.

(8) Provision shall be made for the de-energization of the automatic LTC control circuit by means of an auxiliary contact, wired as shown on the Contract Drawings.

(9) A remote control cabinet shall be provided with control switches for remote operation and devices for remote indication as follows:

(a.) Remote operation shall include the following for each transformer:

i. Parallel Operation On-Off

ii. Manual - Automatic

iii. Tap Raise and Lower

(b.) Remote indication shall include the following for each transformer:

i. Tap position

ii. Indication lights as specified for 2.02 J.2.b.3)

iii. Tap changer hang-up alarm

iv. Tap changer extreme end position alarm

(c.) In addition to the above, two dry contacts shall be provided at the Remote Control Cabinet for alarm indication of tap changer hang-up at any one of the four transformers.

(10) All external wiring for LTC equipment at transformer shall be brought to a weatherproof terminal and control cabinet to be mounted on the transformer.

2.03 ACCESSORIES

Unless otherwise shown on the Contract Drawings, each transformer shall be furnished with the following ANSI C 57 required accessories and devices, as a minimum. Gauges and other instruments shall be installed so that they can be repaired without untanking.

A. Valves and Fittings

1. Main liquid drain valve, two-inch IPS at the bottom of the tank.
2. Upper and lower filter valves, 1-1/2 inch IPS. The upper valve shall be located on the same side as the drain valve while the lower valve shall be diametrically opposite to the upper valve to permit cross circulation for the removal of sludge.
3. Two sample valves, 3/8-inch minimum, one at the top and one at the bottom of the tank for sampling both top and bottom liquid.
4. A one-inch, removable threaded plug at the top of the transformer.
5. The lower valves shall be located so that the dielectric fluid can be drained to within one inch of the bottom of the tank, while the upper valves shall be located just below the 25 degree C liquid level of the fluid.
6. All valves shall be globe type.

B. Level Gauges

1. A dial type, magnetic liquid level gauge for each liquid filled compartment, with two sets of double pole, double throw contacts, one for operation on high level and the other for operation on low level. The contacts shall be rated 0.5 amperes inductive at 125 volts DC.
2. A level gauge or sight glass shall also be furnished for each liquid filled bushing.

C. Temperature Devices

In addition to the devices required for fan and pump cooling operation as shown on the Contract Drawings, the following shall be provided:

1. A dial type, liquid thermometer with a manual resettable maximum temperature indicator and double pole, double throw contacts, to operate on temperature rise above design normal. Contacts shall be rated 0.5 amperes inductive at 125 volts DC.

2. A dial type winding temperature thermometer with a manual resettable maximum temperature indicator and double pole, double throw contacts, to operate on temperature rise above design normal. Contacts shall be rated 0.5 amperes inductive at 125 volts DC.

3. Unless otherwise shown on the Contract Drawings, on 2,000 KVA transformers and larger, provide a resistance temperature detector or thermocouple and local indicator for measurement of the winding hot spot temperature. Provisions shall be made for remote indication.

D. Pressure Devices

1. A pressure-vacuum gauge.

2. A cover mounted mechanical pressure relief device with automatic resealing - resetting operation and mechanical signal for indication of device operation. The gas pressure relief device shall also be furnished with double pole, double throw contacts rated 0.5 amperes inductive at 125 volts DC.

3. A sudden pressure relay with double pole, double throw contacts rated 0.5 amperes inductive at 125 volts DC.

E. Current Transformers

When current transformers are shown on the Contract Drawings, they shall be of the multi-ratio, bushing type with ratings and accuracies in accordance with the requirements of ANSI C 57.13 and as shown on the Contract Drawings.

F. Wiring and Terminal Box

1. A NEMA 4 weatherproof terminal box with a hinged cover shall be provided for termination of all control, control power, alarm, and current transformer leads. Box shall be mounted so as to be conveniently accessible from ground or finished floor.

2. All wiring shall be brought to terminal blocks of appropriate size and rating. Terminal blocks shall be of the sliding link type with covers. Current transformer secondary terminal blocks shall have self-shorting links.

3. The minimum wiring size shall be #12 AWG for control and indication, and not less than #10 AWG for current transformer secondaries. Insulation shall be 600-volt type SIS.

4. Each end of each wire shall be tagged for ease of identification for maintenance and testing. Point-by-point schematic diagram shall be submitted for approval by the Engineer.

5. Unless otherwise shown on the Contract Drawings, all wiring from the various devices shall be brought to the terminal box in rigid galvanized steel conduit and shall terminate the liquid-tight conduit hubs.

   a. Provide a plugged, liquid-tight conduit hub on the underside of the box for a minimum 1-inch conduit, for power and control wiring.

   b. Provide a plugged, liquid-tight conduit hub on the underside of the box for a 2-inch conduit for remote wiring.

G. Signs and Nameplates

1. Provide a stainless steel diagrammatic nameplate with complete transformer data as required by ANSI C 57, including but not limited to ratings, polarity, angular displacement, temperature rise, weights, connection diagrams, lead markings and serial number.

2. Provide warning signs mounted on doors and removable panels that provide access or entrance to terminations, in accordance with OSHA requirements.

3. Provide a stainless steel nameplate with 1/4-inch high, minimum, black letter with name of facility and transformer designation as shown on the Contract Drawings.

2.04 FABRICATION

Each transformer shall be assembled, tested and shipped as a single complete unit.

2.05 PAINTING

A. Surfaces to be painted shall be prepared by the removal of all grease, oil, rust, scale or other foreign material.

B. A prime coat and two finish coats of ANSI-61 light gray paint shall be applied on indoor transformers or ANSI 70 dark gray paint shall be applied on outdoor transformers. Paint color shall be in accordance with ANSI 55.1.

C. The transformer base (underside) shall be coated with a bituminous paint.

D. Two one-quart cans of touch-up paint, for use after equipment is positioned, shall be supplied.

2.06 FACTORY INSPECTION AND TESTS

A. The transformer shall be completely assembled, wired and tested at the factory in accordance with ANSI standards. Tests shall be performed in the presence of the Engineer who shall be notified, in writing, a minimum of fourteen days prior to date of test. Transformer shall not be shipped until inspected and approved.

1. Submit a factory inspection and test plan, including all inspection and test procedures, their expected results and values, and their schedule, to the Engineer for review not less than 60 days prior to the planned start of testing.

2. No testing shall commence without prior approval of the test plan by the Engineer.

3. Any repairs or modifications required to make the equipment perform as specified shall be provided without cost to the Authority. After corrections have been made, the test shall continue until the results are satisfactory to the Engineer.

B. Tests shall include, but not be limited to the following:

1. Resistance measurement for each winding on the rated voltage connections prorated to the reference. Data sheets shall indicate resistance of the coils in series.

2. Turn ratio tests at nominal voltage tap and at all other tap connections.

3. Polarity, phase relation, and phase rotation (angular displacement) at nominal voltage tap.

4. No load loss at 100 and 110 percent rated voltage.

5. Excitation losses and current at rated 90 percent and 110 percent rated voltage.

6. Impedance and load loss at 25, 50, 75 and 100 percent rated current on rated voltage connections.

7. Temperature Rise Tests: Certified test results of previously built units of the type and size specified will be accepted in lieu of actual tests. For transformers with auxiliary cooling or more than one rating, test shall be performed for each KVA rating. One transformer of each rating shall be tested. The transformer(s) to be tested shall be selected by the Engineer at the time of the tests. Transformers exceeding the temperature rise will not be accepted.

8. Applied potential tests.

9. Induced potential tests.

10. Impulse test on all terminals, test may be conducted on one transformer of each type and rating. The transformer to be tested will be selected by the Engineer at the time of inspection and testing. Windings shall be designed and constructed so that there will be no corona discharge during any of the impulse tests. Should that unit fail the test, all other units shall be tested. In the event the selected transformer fails test, all transformers of same type and rating will be tested. Any transformer that fails the test will not be accepted.

    a. Tests shall be in accordance with ANSI test code C 57.12.90.

    b. One test shall be at reduced voltage, one at full wave and two at chopped wave.

    c. The reduced wave shall have a crest value between 50 and 70 percent of the full wave amplitude; the chopped wave shall be chopped no sooner than 1.5 microseconds from point of origin.

    d. Both voltage and current oscilloscope waveform photographs shall be taken during the test.

11. Audible Sound Level Test.

12. Radio influence voltage and corona tests.

13. Short circuit capability tests shall be performed in accordance with ANSI C 57.12.00 and ANSI C 57.12.90.

    a. Unless otherwise shown on the Contract Drawings, the duration of the test shall be limited to 2 seconds. When a transformer is subjected to successive short circuits as per the requirements shown on the Contract Drawings, the transformer shall be capable of withstanding successive short circuits, without cooling to normal operating temperatures between the successive occurrence of the short circuit, provided the accumulated duration of short circuit does not exceed the above specified limit.

    b. Acceptable test procedures shall include, as a minimum:

        (1) Visual inspection of external areas of the core and coil, removed from the tank, shall show no evidence of changes in the mechanical condition, between the before and after conditions.

        (2) Successful standard dielectric tests, with no change between before and after values.

(3) Leakage impedance testing in accordance of ANSI C 57.12.90, paragraph 12.5.4.

c. Certified test results on a previously built unit with similar characteristics and construction will be considered, subject to review and acceptance by the Engineer, in lieu of actual tests on the furnished transformer(s).

d. Where certified test results, as described in a. through c. above are not acceptable, perform the short circuit tests on a transformer constructed identically to the transformer(s) to be furnished.

e. The transformer subjected to short circuit testing will not be accepted for installation by the Authority.

14. Low-Frequency Test

C. Inspection and test certificates shall be furnished.

1. The Engineer or his appointed representatives shall be permitted to inspect any equipment, material or work to be furnished under this Section and shall have the right to reject any parts considered defective or unsuitable for the uses and purpose intended or not in accordance with this Section.

2. The manufacturer shall permit free entry of the inspector at all times to all parts of his works engaged in the manufacture of the equipment. The manufacturer shall provide without charge facilities for any reasonable tests that may be considered necessary in connection with inspection.

2.07 RUBBER MATTING

Conform to the requirements of ASTM D 178 for 1/4-inch thick, Type 2 matting.

PART 3. EXECUTION

3.01 TRANSPORTATION

The equipment shall be transported as a single complete unit to its final position as shown on the Contract Drawings in compliance with the manufacturer's written instructions.

3.02 PREPARATION

A. Concrete floors shall be level and concrete pads where required shall be installed in accordance with Division 3 Section on concrete.

B. Steel floor channels or angles shall be installed, leveled and grouted to support and anchor the equipment.

3.03 INSTALLATION

A. Transformer(s) shall be installed and connected in accordance with the Contract Drawings, manufacturer's recommendations, and in conformance with ANSI C2, NFPA 70, and local applicable codes.

B. Install rubber matting as shown on the Contract Drawings.

C. Prior to energization, the transformer(s) shall be field tested as described in 3.04 of this Section.

3.04 FIELD TEST

A. The transformer shall be completely assembled, wired and tested in the field in accordance with manufacturer's recommendations, International Electrical Association (NETA), UL and ANSI standards. Tests shall be performed in the presence of the Engineer who shall be notified, in writing, a minimum of 14 days prior to date of test. Transformer shall not be energized until inspected and approved.

1. Submit inspection and test plan, including all inspection and test procedures, their expected results and values, and their schedule, to the Engineer for review not less than 60 days prior to the planned start of testing.

2. No testing shall commence without prior approval of the test plan by the Engineer.

3. Any repairs or modifications required to make the equipment perform as specified shall be provided without cost to the Authority. After corrections have been made, the test shall continue until the results are satisfactory to the Engineer.

B. The Contractor shall perform all testing in the presence of the Engineer. The Contractor may have an approved testing organization perform the tests in lieu of the Contractor performing the tests. The Contractor shall notify the Engineer when the equipment is installed and ready for testing.

C. Testing shall be performed in the following manner:

1. Before any tests are performed, continuity and correctness of all windings shall be checked and all ground connections checked and tested.

2. Equipment ground resistance shall have a maximum acceptable ground resistance of 1 OHM when measured to the building ground bus or building steel. Each winding of the transformers shall be checked for freedom from ground as per the manufacturer's recommendations.

3. With primary disconnect switch open, the transformer secondary windings and switchgear cubicle grounded to the test ground, and any current transformers shorted, each transformer primary winding shall be given a megger test and high potential test immediately followed by a second megger test. The test shall include all taps for voltage adjustment.

4. With secondary breaker racked in, but in the open position, the neutral lead, if applicable, disconnected and switchgear bus grounded to the test ground, and any current transformer shorted, each transformer secondary winding rated greater than 600 volts shall be given a megger test and high potential test followed by a second megger test.

5. The sequence of megger and high potential test shall be as follows:

a. Megger test shall be applied to determine condition of insulation.

b. The high potential test shall be applied only if the megger test passes minimum requirements.

c. The successful high potential test shall be followed immediately by another megger test in order to detect any damage incurred by high voltage stresses.

6. Each transformer secondary winding operating at 600 volts or less shall be given megger test only. The test shall include any taps for voltage adjustment.

7. Megger and high potential test on each transformer winding shall be applied between all phases tied together and ground, all windings and adjacent cables or breaker contacts not included in the test shall be grounded.

8. Grounding resistors, when used, shall be given megger and high potential tests. With the neutral grounding resistor lead disconnected from the transformer neutral and the ground side of the resistor disconnected from ground, each neutral ground resistor and cable shall be given a megger test and high potential test followed by a second megger test. The resistor shall be tied to the test ground.

9. All control, alarm and metering circuits shall be checked.

10. Values of all results of all tests shall be in accordance with the manufacturer's recommendations.

END OF SECTION

SECTION 16327

MEDIUM VOLTAGE LIQUID FILLED POWER TRANSFORMERS 15MVA AND SMALLER-BASE RATING

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Outline dimensional drawings and weights (with and without dielectric fluid) shall be furnished which show overall dimensions, base details, location and arrangement of external features such as high and low voltage bushings and leads, radiators, disconnect switch compartment, control cabinets, resistors, jack pads and other essential equipment.
2. Nameplate drawing for each transformer.
3. Drawings showing location of all accessories.
4. Technical specifications for each transformer.
5. Schematic and Wiring diagram of fan cooling provisions.
6. Schematic and Wiring diagram of automatic tap changer controls.
7. Transformer foundation or pad drawing.

B. Catalog Cuts

1. Temperature gauges
2. Surge arrestors
3. Magnetization curves for current transformers
4. Fans
5. Relays
6. Tap changers
7. Bushings
8. Heat exchangers
9. Instrument transformers
10. Electrical Transmitting, Receiving and Indication Devices for remote indication of tap changer positions.
11. All other accessories specified in 2.03 of this Section.

C. Submit Cooling System Data as follows:

1. Number of heat exchangers

2. Number, horsepower, CFM, and voltage of fans per heat exchanger.

3. Number, horsepower, CFM, and voltage of pumps per heat exchanger.

4. Total power consumption at full load.

5. Percent of capability reduction from transformer rating with one heat exchanger assembly out of service.

6. Amount of time the transformer can carry full load at maximum OA temperature rating, without damage, with fans and pumps out of service when:

   a. Starting Cold

   b. After operating continuously at full load

7. Type of liquid preservation system.

D. Submit Equipment Manuals that include the following as a minimum:

1. Transformer maintenance instructions

2. Automatic Tap Changer Instructions

3. Schematic Diagrams

E. Submit the qualifications of the entity performing the field testing required by 3.04 of this Section.

END OF APPENDIX "A"

SECTION 16327

MEDIUM VOLTAGE LIQUID FILLED POWER TRANSFORMERS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(1.03)	Note indoor/outdoor locations of transformers.
(1.04 F)	Check seismic requirements.
(2.01 A)	Provide list of manufacturers

B. Acceptable manufacturers are:

ABB
General Electric – Prolec
Cooper Power Systems
MagneTeck Electric Co.
Rapid Power Technology, Inc.
Square "D" Co.
Virginia Transformer Corp.

Verify the acceptability and availability of the transformers from these manufacturers prior to inclusion in the Contract Drawings.

(2.01 B)	Note where prior approval of Utility Company is required.
(2.02 A.1)	Location, sizes, rating types, type of dielectric fluid and special features. Transformer configuration, if it varies from this paragraph.
(2.02 A.4)	Maximum core and coil losses.
(2.02 A.7)	Type and method of neutral grounding
(2.02 A.8)	Polarity, angular displacement and lead marking.
(2.02 B.8)	Bushing compartment size, terminations, and high voltage compartment surge arresters.
(2.02 C.3.a)	Transformer ratings.
(2.02 C.3.b)	Transformer insulation, BIL and NEMA voltage class.
(2.02 C.3.d)	Transformer X/R ratio.
(2.02 C.3.e)	Transformer impedance.
(2.02.D1)	Cooling system.
(2.02 D.2)	Cooling system variations regarding removal during operation.
(2.02 D.5)	Pumps and/or fans provisions
(2.02 E.1)	Dielectric fluid preservation system.
(2.02 E.2)	Dielectric fluid notation.
(2.02 F.2)	Surge arrestor types and ratings
(2.02 G.3)	Bushing locations.

(2.02 G.5)	Bushing terminals.
(2.02 I)	Grounding resistor ratings and location, if required.
(2.02 J.1.a)	No load tap changer. Check rating (2 x 2.5% above, 2 x 2.5% below) and requirements.
(2.02 J.2.a.1)	Automatic load tap changer equipment requirements.
(2.02 J.2.b.6)	Automatic LTC operation Time delay if different than 60 seconds.
(2.02 J.2.b.8)	Automatic LTC control circuit de-energization wiring.
(2.03)	Transformer accessories.
(2.03 C)	Temperature devices.
(2.03 C.3)	Resistance temperature detector.
(2.03 E)	Current transformer requirements.
(2.03 F.5)	Wiring to terminal box.
(2.03 G.3)	Nameplate
(2.06 B.13.a)	Factory short circuit test requirements.

C. Other Items

Ensure that the Specifications include the following Sections referenced in this Section.

(3.02 A) "CONCRETE"

D. If this specification is a part of purchase order, ensure that the Specifications include legal part that usually is included into Division 1 - General Provisions of Specifications.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16335

LOW VOLTAGE SWITCHGEAR

PART 1. GENERAL

1.01 SUMMARY

This Section specifies the requirements for metal-enclosed, low voltage draw-out type power circuit breaker switchgear.

1.02 REFERENCES

The following is a listing of publications referenced in this Section:

American National Standards Institute (ANSI)

ANSI C 37.13	Low-Voltage AC Power Circuit Breakers used in Enclosures
ANSI C 37.16	Standard for Switchgear - Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors - Preferred Ratings, Related Requirements, and Application Recommendations
ANSI C 37.20.1	Standard for Metal Enclosed Low Voltage Power Circuit Breaker Switchgear
ANSI C 37.27	Standard Application Guide for Low Voltage AC Non-integrally Fused Power Circuit Breakers (Using Separately Mounted Current-Limiting Fuses)
ANSI C 37.50	Test Procedures for Low-Voltage AC Power Circuit Breakers used in Enclosures
ANSI C 37.51	Standard for Switchgear - Metal Enclosed Low - Voltage AC Power - Circuit-Breaker Switchgear Assemblies - Conformance Test Procedures
ANSI C 37.90	Standard for Relays and Relay Systems Associated with Electric Power Apparatus
ANSI C 57.13	Standard Requirements for Instrument Transformers

National Electrical Manufacturers Association (NEMA)

NEMA AB 1	Molded Case Circuit Breakers
NEMA ICS 1	General Standard for Industrial Controls and System
NEMA ICS 2	Standards for Industrial Control Devices and Controllers and Assemblies
NEMA ICS 4	Terminal Blocks for Industrial Equipment and Systems
NEMA SG 3	Low Voltage Power Circuit Breakers
NEMA SG 5	Power Switchgear Assemblies

National Fire Protection Association (NFPA)

NFPA 70	National Electric Code

Underwriters Laboratories (UL)

UL 94	Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 489	Molded-Case Circuit Breakers and Circuit Breaker Enclosures
UL 1066	Low Voltage Power Circuit Breaker
UL 1558	Metal Enclosed, Low Voltage Power Circuit Breaker Switchgear

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

The switchgear shall be designed, manufactured, and tested in accordance with the latest revision of the applicable ANSI, NEMA, and UL Standards. Where a discrepancy exists between the various standards, the most stringent requirements shall apply.

1.04 QUALITY ASSURANCE

A. Switchgear and all components of types and sizes required shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

B. Entities manufacturing equipment shall have experience on at least two projects involving complexities similar to those required under this Contract.

C. When shown on the Contract Drawings, the switchgear shall be listed and labeled by a "Nationally Recognized Testing Laboratory" (NRTL), as defined by OSHA Regulations.

D. The switchgear and circuit breakers shall be suitable for and certified to meet all applicable seismic requirements of Uniform Building Code (UBC) for zone 4 application. Guidelines for the installation consistent with these requirements shall be provided by the switchgear manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, UBC: a peak of 0.75g, and a Zero Period Acceleration (ZPA) of 0.38g. The tests shall fully envelope this response spectrum for all equipment natural frequencies up to at least 35 Hz.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Prior to shipment, the switchgear assembly shall be cleaned by wiping with a clean, dry cloth. Oil and grease marks shall be removed and wiped dry. All insulation shall be cleaned thoroughly. Dirt, soot, grease or paint shall be removed from the circuit breaker contacts and surface of the entire current carrying structures.

B. All relays and instruments shall be firmly blocked to prevent damage during shipment.

C. The overall dimensions and weight of each shipping section shall be limited to the maximum allowable by applicable state and local codes governing shipment of materials over public roads or construction site handling limitations, whichever is less. Each shipping section shall have a label indicating dimensions and weight.

D. All equipment and materials shall be suitably wrapped, crated, boxed or otherwise prepared for shipment to prevent damage during handling and shipping. All openings shall be properly protected to prevent the entrance of any dirt or debris. All parts not constructed to be normally exposed to the weather shall be suitably weatherproofed.

E. Each box or crate shall be equipped with suitable lifting devices to facilitate unloading and shall contain a detailed packing list.

F. Packaging shall be labeled and numbered so that each section or assembly may be identified before being uncrated. Any items not fully assembled to the switchgear structure shall be packaged separately. Removable circuit breaker units shall be packaged and shipped separately.

G. Adequate means shall be provided for lifting by fork lifts and cranes and for moving the equipment on rollers. Lift points shall be marked on each crate.

H. Indoor switchgear that cannot be installed immediately shall be stored in a dry, clean location within a heated building. During storage, the switchgear shall be placed on a level surface.

I. Outdoor switchgear that cannot be installed immediately shall have its space heaters temporarily connected and energized so as to prevent condensation of moisture within the housing.

1.06 SPARE PARTS AND SPECIAL TOOLS

A. A minimum of six (6) spare fuses of each size and type used in the switchgear shall be furnished.

B. Furnish one set of all special tools required for the erection, operation, and maintenance of all equipment furnished.

C. Furnish a minimum of three (3) half-pint containers of paint matching the exterior finish of the enclosure.

D. Furnish six (6) spare indicating lamps of each type installed.

E. Furnish one (1) container of contact lubricant.

F. When shown on the Contract Drawings, furnish one (1) portable, breaker-lifting device.

1.07 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide metal-enclosed, low voltage power circuit breaker switchgear products of manufacturers listed on the Contract Drawings.

2.02 RATINGS

The switchgear shall have the following ratings, as shown on the Contract Drawings:

A. Nominal System Voltage.

B. Rated Maximum Voltage.

C. Rated Frequency.

D. Rated Insulation Level.

E. Rated Continuous Current.

F. Rated Short-Time Current.

G. Rated Short-Circuit Current.

H. Short Circuit Current Bus Bracing.

I. Control Voltage.

2.03 CONSTRUCTION FEATURES

A. General

1. Switchgear shall be factory assembled, suitable for indoor or outdoor use, as shown on the Contract Drawings, dead front, metal enclosed, free standing, and completely equipped with removable low voltage power circuit breakers, fuses, instrument transformers, relays, metering, switches, and associated devices as described herein and as shown on the Contract Drawings and conforming to ANSI C 37.13, C 37.16, C 37.20.1, C 37.27, C 37.50, C 37.51, NEMA SG 3, SG 5, NFPA 70, and UL 1066, 1558.

2. When shown on the Contract Drawings, the switchgear shall be arranged for close coupling to the transformer secondary through a transition compartment. Provisions shall be made for extension of the switchgear in both directions.

3. All breakers shall be arranged as shown on the Contract Drawings.

4. No polyvinyl chloride (PVC) materials, insulation or products shall be used in switchgear, except for removable insulating boots on bus work.

B. Assembly Features

1. The switchgear shall consist of rigid self-supporting vertical sections bolted together to form a rigid assembly. Each cubicle shall be completely enclosed with formed steel sheets adequately braced to prevent distortion under normal conditions as well as during interruption of short circuit currents.

2. The structural details of each cubicle for the same breaker rating shall be identical. The cubicles shall be uniform in height and depth, and built to form a continuous structure lining up in front and rear.

3. All louvers or other ventilating openings shall be protected against falling of dust, water, or other foreign material. No louvers or ventilation openings shall be located on top of the switchgear unless they are made drip-proof and approved by the Engineer prior to fabrication.

4. Sheet steel doors shall be provided for access to the circuit breaker compartments, instrument compartments, and cable compartments.

5. Doors shall be furnished with one or more handles, knurled steel screws, or a combination of these in order to firmly hold door closed. Doors shall be padlockable. Doors shall be reinforced with stiffeners to minimize vibration. Stops shall be provided to hold doors in the open position. Doors shall be furnished with galvanized, zinc plated or stainless steel hinges and hinge pins. Doors shall open at least 135 degrees.

6. An insulating flash shield shall be mounted above each circuit breaker to prevent flashover from the arc chutes to ground.

7. All insulating materials used for bus supports, barriers, or covers shall be of high dielectric strength, low moisture absorbing, flame retardant, arc resistant, and high impact strength material.

8. All combustible materials used for barriers, covers and the like shall meet the flammability test criteria of UL 94 for materials classed 94V-0.

9. Space heaters, with mechanical guards to prevent inadvertent contact of personnel with thermal element, shall be provided in each vertical section. Heaters shall be of the low temperature type, rated 240 volts and operated at 120 volts, each protected by an individual single pole molded case circuit breaker of suitable rating. The heaters shall be sized to keep the air inside the cubicle above its dew point. Heaters shall be thermostatically controlled. Thermostats shall be of the differential type and preset by the Contractor.

C. Circuit Breaker Compartment

1. The primary connection between the stationary units and the removable circuit breakers shall be made by means of a set of self-aligning, disconnecting devices mounted on the breaker studs or in the stationary structure, which shall positively engage with solid studs mounted in the stationary structure or on circuit the breaker, respectively. Firm contact pressure shall be maintained by means of steel coil springs. All primary contact surfaces shall be silver plated to prevent corrosion.

2. Each circuit breaker cubicle shall be equipped with an automatic safety shutter to close the entrances of the stationary primary disconnecting devices when the breaker is removed or in the test position.

3. The removable breaker element shall be connected to and disconnected from its operating position by a suitable engaging mechanism. Guides shall be provided to assure perfect alignment of all engaging parts of the removable breaker element with the corresponding parts in the stationary structure. A positive stop shall prevent over-travel of the removable breaker element when it is advanced to the connected and test positions.

4. Each breaker cubicle shall be equipped with a mechanical interlock which shall prevent the circuit breaker from being inserted or withdrawn from the connected position unless the breaker is opened. Another mechanical interlock shall prevent the breaker from being closed unless the primary disconnecting devices are in full contact or separated by a safe distance, such as in the test or disconnected position.

5. Each circuit breaker cubicle shall be furnished with provisions for locking the circuit breaker in the disconnected position

6. Cubicles containing current interrupting devices shall have ventilating provisions to minimize the movement of ionized gases between compartments or to the outside. Ventilating openings shall be rodent proofed by covering with a protective grill or wire mesh securely held in place.

D. Circuit Breaker Fuse Compartment

1. When shown on the Contract Drawings, non-integrally mounted Current Limiting Fuses for the protection of the removable circuit breaker, shall be mounted inside a switchgear cubicle or compartment on a drawout carriage similar to that used for the circuit breaker. The fuses shall be connected to the line side of the circuit breaker.

2. The fuse cubicle or compartment shall be equipped with an automatic safety shutter to cover the line and load disconnects when the carriage is removed from its compartment. A rejection feature shall be furnished so that only the correct carriage can be inserted in the compartment.

3. A hinged panel shall be positioned in front of the fuses so that they cannot be reached if the compartment door is open. The panel shall be interlocked to prevent it from being swung open unless the fuse carriage is fully withdrawn.

4. A key interlock or mechanical interlock system shall be installed in the associated circuit breaker compartment and fuse carriage compartment to prevent racking of the fuse carriage with circuit breaker in the closed position.

E. Cable Compartments

1. Size the cable compartment to accommodate all incoming and outgoing cables in compliance with NFPA 70. Cable compartments shall include cable supports. Where connections are to be made to busways, all necessary bus adapters, bolting, insulating supports, and metal flanges shall be provided. Ground sensing current transformers, when shown on the Contract Drawings, shall be mounted in the respective cable compartments.

2. All cables will enter the equipment as shown on the Contract Drawings. Compression crimp-type cable lugs shall be provided for power cables. Lugs shall have standard NEMA bolt hole spacing.

F. Barriers

1. Each individual vertical section shall be segregated from adjacent sections by means of steel barriers extending all the way to the rear of the section.

2. Each individual cable compartment shall be provided with a steel, or insulating barrier between the cable compartment and the main bus to protect against inadvertent contact with the main or vertical bus bars, and to ensure that no live connections are accessible in the rear of each section except the circuit breaker load connections.

G. Enclosures

1. Indoor switchgear shall be provided with a NEMA 1 enclosure.

2. When specified on the Contract Drawings, outdoor walk-in type switchgear shall be provided with the following features:

   a. Switchgear shall be enclosed in a NEMA 3R enclosure conforming to all applicable requirements of UL. The enclosure shall have a roof sloping toward the rear. Outer sections shall be the same widths as indoor structures, except the end sections of a walk-in enclosure shall be wider than the inner sections to permit opening the inner door. Each end of the outdoor structure shall have an end trim. Front aisle depth for walk-in structures shall be 42 inches, minimum.

   b. The enclosure shall be provided with rear hinged doors for each section. Aisle doors shall be supplied with provisions for padlocking. A steel floor shall be provided in walk-in aisle space and under each vertical section. Ventilating openings shall be provided complete with replaceable fiberglass air filters.

   c. Provide panic door hardware on aisle doors at each end of the line-up. External padlocking of the aisle doors shall not prevent operation of the panic hardware from the interior of the enclosure. The construction of the enclosure shall be modular so future sections can be added without affecting NEMA 3R integrity. Provide interior aisle lights, 3-way switches, and GFI protected receptacles.

   d. The enclosure shall be provided with undercoating applied to all members in contact with the foundation surface to retard corrosion.

   e. Power for the space heaters, lights, and receptacles shall be obtained from a control power transformer (CPT) within the switchgear, unless otherwise shown on the Contract Drawings. Supply voltage shall be 120 VAC.

   f. An overhead traveling hoist for handling circuit breakers shall be provided in the aisle of the enclosure.

3. When specified on the Contract Drawings, outdoor, non-walk-in type switchgear shall be provided with the same features as described above for the outdoor walk-in type switchgear, except for the aisle. In addition, the front of each vertical section shall have a weatherproof door.

H. Utility Metering Section

1. Where indicated on the Contract Drawings, provide a separate barriered-off utility metering compartment complete with hinge sealable door. Bus work shall include provisions for mounting utility company current transformers as required by the utility company.

2. Service entrance switchgear section shall comply with U.L. requirements that include Service Entrance Label, incoming line isolation barriers, neutral connection to switchgear ground for solidly grounded wye systems.

I. Pull Boxes

When shown on the Contract Drawings, provide pullbox with the width and depth of the cable compartment. Provide ventilation features to maintain air temperature in pullbox within same limits as in switchgear. Provide cable supports arranged to facilitate cabling and to support cables indicated on the Contract Drawings.

J. Traveling Hoist

Unless otherwise shown on the Contract Drawings, the switchgear shall be provided with an integral traveling hoist for breaker lifting. Traveling Hoist shall be rail mounted on top of the switchgear, movable and hand operated.

K. Buses

1. Buses shall be supported on isolated supports of high-impact, not-tracking, high quality insulation material and braced to withstand the magnetic stresses developed by currents equal to the largest circuit breaker interrupting ratings. Bus bars shall be high conductivity copper having silver-plated joints. All buses, taps and primary interconnections shall be insulated with an approved insulating material, when shown on the Contract Drawings. Tapes or rigid sleeving are not acceptable as an insulating material for bus.

2. Bolts and associated hardware used with current carrying buses shall be of nonmagnetic, corrosion resistant material.

3. Insulating barriers shall be provided where primary buses pass through from one vertical section to another.

4. Neutral bus shall have the same ampacity as the phase bus, unless otherwise shown on the Contract Drawings.

5. Vertical section bus shall be rated for the cumulative circuit breaker loading, conforming to ANSI C 37.20.1, and calculated assuming spaces for future circuit breakers are fully equipped with circuit breakers carrying current at 100 percent of their maximum frame size current ratings, and spare circuit breakers are loaded to the same degree.

6. A copper ground bus extending the entire length of the switchgear cable compartments shall be provided. All the metal parts of the structure shall be effectively connected to this bus. Ground bus shall be of rectangular cross section, not less than 1/4 inch by 2 inches.

L. Control and Auxiliary Power Wiring

1. Control wiring for each cubicle shall be enclosed in conduit or in compartments isolated from the primary circuits and shall conform to NEMA ICS 2.

2. Control and secondary cable shall be tinned copper, minimum class B stranded. Cable shall have insulation type SIS, rated 90 degrees C, 600 volt, heat resistant, and flame retardant. Wires crossing hinged joints and swing panels shall be flexible class K stranded.

3. All control wiring, leaving the switchgear, shall be wired to terminal blocks. Direct connections between devices located in different vertical sections are not acceptable. Connections made on terminal blocks and on internal devices shall be by means of flanged spade or ring type insulation gripping insulated terminals. On devices that do not permit flanged spade or ring type terminals, control wiring shall be held by screw type compression connectors. Internal wiring shall have no splices, nor shall more than two wires be terminated on one terminal point.

4. Control wire bundles shall be secured with nylon ties and anchored to the assembly with the use of pre-punched wire lances. All current transformer secondary leads shall first be connected to easily accessible short circuit terminal blocks, before connecting to any other device. All groups of control wires leaving the switchgear shall be provided terminal blocks with suitable numbering strips. Where feasible, provide plug-in terminal blocks for all shipping split wires.

5. Wire markers shall be provided at the end of all control wiring, identified by printing on wire sleeve with "origin" and "destination" markings.

6. Wiring shall be sized for the duty required. Control wiring shall be 14 AWG minimum; current transformer wiring shall be 10 AWG minimum. Wiring crossing hinged joints and swing panels shall be 12 AWG with extra flexible stranding.

7. The control circuit wiring between the stationary units and the removable circuit breakers shall be made by means of self-aligning, multi-contact, devices. Only the stationary contacts shall be energized when the circuit is disconnected. All contact surfaces shall be silver-plated.

   a. Suitable means shall be provided for completing the control circuits between the stationary unit and the removable circuit breaker when the circuit breaker is withdrawn from the connected position to the test position.

8. Unless otherwise shown on the Contract Drawings, auxiliary power circuits shall run the entire length of the switchgear. The circuits shall be one phase, 120 volt AC. The source of power shall be as shown on the Contract Drawings.

9. Protection for control and auxiliary power circuits shall be provided by pull-out-type fuse blocks and dual element time delay fuses.

M. Removable Low Voltage Power Air Circuit Breakers

1. Removable low voltage power circuit breakers shall be as shown on the Contract Drawings, as specified herein, and in Section 16475 of these Specifications entitled "OVERCURRENT PROTECTIVE DEVICES", conforming to ANSI C 37.13 C 37.16, C 37.27, C 37.50, NEMA SG3, and UL 1066.

2. All removable elements of the same type, ampere rating, and tripping characteristics shall be interchangeable to the extent that they can be used, will operate, and give complete relay protection in any stationary element with the same ampere rating.

3. An auxiliary switch (TOC) shall be mounted on the stationary housing (switchgear metal barrier) to indicate the connected position of the removable circuit breaker. In addition to the contacts required for the operation of the circuit breaker, the position switch shall consist of two (2) normally open and two (2) normally closed spare contacts.

4. When additional auxiliary switch contacts are needed than can be provided with circuit breaker auxiliary switches, such contacts shall be provided using auxiliary switches (MOC) mounted on the stationary housing. In addition to the contacts required for the operation of the circuit breaker, the position switch shall consist of two (2) normally open and two (2) normally closed spare contacts.

5. Auxiliary switch contacts shall be adjustable to either the normally open or normally closed position.

6. Mechanical interlocks shall be provided to prevent the removable circuit breaker from being moved to or from the operating position with the circuit breaker closed and to prevent the circuit breaker being closed unless primary disconnecting devices are fully engaged or separated a safe distance.

N. Instrument Transformers and Meters

1. Instrument transformers shall conform to ANSI C 57.13.

2. Voltage transformers shall have 120 volt secondary rating, ratio as shown on the Contract Drawings, accuracy classification 1.2Z at rated voltage for ANSI Standard burdens. Voltage transformers shall be capable of a burden at least double the connected load, to allow for portable instruments. Voltage transformers shall be provided with primary current limiting fuses.

3. Control Power Transformer (CPT) shall be designed for machine tool application and shall have voltage regulation and VA rating to limit the voltage drop to 5 percent, under maximum inrush conditions. The VA rating, along with supporting calculations, shall be submitted to the Engineer for approval. The primary and secondary windings of the transformer shall be protected with current limiting fuses, and shall be sized at 300 percent of the CPT rating. The interrupting rating of the primary fuse shall match the short circuit rating of the switchgear.

4. All current transformers shall be 5 amps secondary, ratio and accuracy class as shown on the Contract Drawings. Current transformers shall not saturate when operated at 20 times rated current. Current transformers shall be capable of a burden at least double the connected load. All current transformers shall be terminated in shorting blocks.

5. All current transformers shall be selected to withstand the thermal and mechanical stresses imposed by the maximum available system fault current. The current transformer rating and supporting calculations shall be submitted to the Engineer for approval.

6. Instrument transformer secondaries shall be grounded with a copper conductor not smaller than #10 AWG and connected to a ground bus located as closely as possible to the transformer.

7. Voltage and control power transformer primaries, where connected to ground, shall be grounded with a copper conductor not smaller than #6 AWG which is insulated for line-to-line voltage and terminates at the grounding bus in a lug. The connection to the bus shall be so designed that it can be easily disconnected and isolated for proof testing. Each ground wire shall be one continuous run without intervening splices or terminal blocks between the transformers and the ground point.

8. Metering system shall be as shown on the Contract Drawings and shall be one of the following:

a. Digital Metering System (DMS)

The Digital Meter System shall be compact, microprocessor based, all-in-one built, panel mounted, for measuring phase and neutral current, volts, KW, KVA, KVAR, HZ and power factor. The DMS shall be installed on each unit of the switchgear where metering is required. It shall be connected through current and potential transformers as shown on the Contract Drawings and in accordance with the manufacturer's instructions. The DMS shall be mounted on the front of the switchgear within reach of an observer near eye-level. The DMS shall be capable of being used as a stand-alone monitoring unit, or as one element of a larger SCADA (supervisory control and data acquisition) network. The DMS shall have the capability to communicate via an RS-232 or RS-485 port. A minimum of three output relays shall be provided in the DMS unit that can implement alarm, control, or protective trip functions. The DMS shall be supplied with the manufacturer's standard software, which shall be capable of adequately representing all of the functions described herein.

b. Conventional Metering System (CMS)

The CMS shall consist of current transformers, voltage transformers, meters, and switches as shown on the Contract Drawings, and as described below.

(1) Instruments and meters shall be of the semi-flush switchboard type, with rectangular dust-proof enclosing cases and anti-glare glass.

(2) Indicating instruments shall be 4-1/2 inches in diameter and have white dials with black marking, scales approximately 250 degrees and 7 inches in length, accuracy within plus or minus 1 percent of full scale, and external zero adjustment.

(3) Kilowatt-hour and kilowatt demand meters shall be of the integrating type and shall be draw-out type, with provision for testing, and shall be equipped with potential indicating lights.

O. Relays, Control Switches and Fuses

1. Protective relays, as shown on the Contract Drawings, shall conform to ANSI C 3 7.90 and be of the semi-flush mounted, removable type, with built-in test facilities. Current transformer secondaries shall be automatically short-circuited when the relay is removed from its case. Auxiliary relays shall be surface mounted and front connected, and shall be as specified on the Contract Drawings.

2. Protective relay ranges and types shall be as shown on the Contract Drawings.

3. Lockout relays shall be hand-resettable, panel mounted, with mechanical target on the escutcheon plate for indication of relay position. The contacts rating shall be 20 Ampere continuous. The relay shall be enclosed with a dust cover.

4. Control, transfer, and instrument switches shall be of the heavy duty rotary, multi-position, cam operated, multi-stage type, with dust cover, rated 600VAC, with silver to silver contacts rated for continuous current of 20 amperes. Each circuit breaker control switch shall have red and green target. Each switch shall be equipped with engraved plastic escutcheon or nameplate identifying its function and position. Handle styles shall be pistol grip for control, and oval for instrument or transfer switches.

5. Each Low Voltage Air Circuit Breaker shall be provided with a control switch on the door of each circuit breaker cubicle for performing breaker close and open operations. Mechanical red/green targets shall be incorporated in the switch to indicate breaker "Closed/Open" position. A spring-return mechanism shall return the switch handle to the normal vertical position.

P. Indicating Lamps

Indicating lamps shall be light emitting diodes (LED) of the low voltage, low burden series resistor type, with lens colors as approved by the Engineer. Lamps shall be replaceable from the front of the panel.

Q. Terminal Blocks

Terminal blocks for all external control connections shall be 600 volt, barrier type, having a minimum rating of 20 amperes with identifying marker strips. Terminal strips in each cubicle, shall have at least 20 percent spare terminals and shall be in accordance with NEMA ICS 4. Terminal blocks for current transformer secondary connections shall be of the short circuiting type.

R. Nameplates and Mimic Bus

1. Nameplates shall be provided for each switchgear, for each cubicle, and for all externally and internally mounted devices, including, but not limited to, instruments, meters, control switches, and relays to identify its function, and where applicable, its position.

2. Nameplates shall consist of letters and numbers back engraved on a laminated thermosetting plastic material, providing white letters and numbers on a black background. Size of letters and figures shall be approximately 1/8 inch for device nameplates and 7/16 inch for cubicle nameplates, and 1 inch for switchgear designations.

3. Nameplates shall be fastened with two oval-head stainless steel machine screws.

4. Number, location and designation of nameplates shall be as approved by the Engineer.

5. Mimic bus shall be provided on the face of the switchgear representing actual bus arrangements within the switchgear assembly. Circuit breaker control switches and indicating lights shall be located in the proper position on the mimic bus. The mimic bus shall be 1/8 x 3/4 inch, high strength thermosetting plastic material, secured every twelve (12) inches with self tapping screws.

2.04 SHOP PAINTING

A. Prior to assembly and before shop painting, all surfaces of the switchgear enclosure shall be thoroughly cleaned of rust, oil, grease, dirt and mill scale and receive a phosphatizing treatment, and then be primered with one coat of rust-inhibitor for a dry film thickness of 1-2 mils.

B. The exterior and interior of the switchgear shall be given two or more finish coats of corrosion resistant paint for a final dry film thickness of at least 2-4 mils. The color of the finish on the switchgear shall be ANSI number 61 light gray.

C. Alternative painting process, such as electrostatically applied paint, can be utilized, subject to the approval of the Engineer.

2.05 FACTORY TESTING

A. The switchgear shall be completely assembled, wired, adjusted, and tested at the factory. After assembly, the complete switchgear shall be tested to assure the accuracy of the wiring, and the functioning of all the equipment.

B. All switchgear components shall be tested in accordance with the Production Test outlined in ANSI C 37.20.1, C 37.50, and C 37.51 and shall include but not be limited to the following:

1. Dielectric Tests
2. Mechanical Operation Tests
3. Grounding of Instrument Transformer Cases Tests
4. Electrical Operation and Control Wiring Tests

C. Factory tests, shall be witnessed by the Engineer. The manufacturer shall notify the Engineer two (2) weeks prior to the date the tests are to be performed.

PART 3. EXECUTION

3.01 FIELD SUPERVISION

Provide the services of a qualified, factory-trained switchgear manufacturer's representative to provide technical field support in the installation and start-up of the equipment specified in this Section for a period shown on the Contract Drawings. The manufacturer's representative shall provide technical direction and assistance in general assembly of the equipment, connections, calibrations, adjustments, and testing of the assembly and components contained therein.

3.02 EXAMINATION

The Contractor is responsible for notifying the Engineer as soon as he finds conditions that prevent the proper installation of materials or methods specified in this Section.

3.03 INSTALLATION

A. Switchgear shall be transported within the construction site, unloaded, uncrated, installed, including assembly of all component parts, and wired in accordance with the manufacturer's instructions and recommendations and the requirements specified herein.

B. Provide all equipment, supervision, labor, rigging, tools, including, but not limited to, special equipment such as cranes.

C. Before setting the switchgear, the floor members and openings for conduits and bus entrances shall be checked for accuracy of position.

D. Switchgear shall be set on foundations at the locations shown on the Contract Drawings. Provide floor sills, and set level in concrete. Follow the manufacturer's recommendations for preparation of the mounting surface and the fastening of the equipment. The switchgear shall be set, aligned, and leveled in place using shims, where necessary, and shipping sections bolted together.

E. Bus splices shall be cleaned and bolted together and insulated either by taping or by use of insulating boots, if provided for that purpose.

F. The removable circuit breakers shall be installed in the housings and the rails adjusted, if required, for smooth travel of the circuit breakers. Main and secondary contacts on the removal and stationary sides shall be checked for tightness and adjusted if loose. Covers or enclosures shall be securely bolted in place.

G. After each item of equipment is installed and connected, the Contractor shall make a thorough inspection of the installation, cleaning all insulators that are exposed, and cleaning all cubicles and compartments of debris and foreign matter. Prior to final completion of the Work and field testing, the Contractor shall clean the equipment of all construction dust and dirt.

H. The Contractor shall complete all internal and external power and control connections.

I. All damaged paint areas shall be properly prepared by the Contractor for an application of primer and finish coats of paint, which shall be supplied by the manufacturer for this purpose. The Contractor shall apply the primer and finish paint coats.

3.04 FIELD TESTS

A. General

1. Field tests shall be performed in accordance with the manufacturer's recommendations, International Electrical Testing Association (NETA), NEMA, UL, ANSI, and as required in this Section and/or as directed by the Engineer.

2. All Work shall be performed with due regard for the protection of personnel and equipment. The Contractor shall provide protection to all personnel during performance of the tests.

3. Tests shall be performed only after equipment has been thoroughly cleaned.

4. All field tests shall be conducted in the presence of the Engineer for the purpose of demonstrating that the equipment and systems comply with the requirements of this Section to assure the Engineer that the entire installation meets applicable codes and standards requirements, and that all systems will function as designed.

5. All controls shall be checked individually by the Contractor prior to operational tests. Wiring diagrams and manufacturer's drawings shall be marked by the Contractor during checkout. Checked items shall be marked in yellow; discrepancies shall be corrected, and modifications shall be recorded in red. Marked wiring diagrams and manufacturer's drawings shall be submitted to the Engineer.

6. Record all test values, settings, and calibrations made by the Contractor and furnish the Engineer with copies of test reports after completion of each individual test. These reports shall include a description of the test procedures. The Contractor shall record all test data for each test required in this Section on test forms.

7. Advise the Engineer, in writing, upon failure of any equipment or material to pass the tests performed or to properly function as intended. The Contractor shall provide all necessary corrective action to render the equipment operational and acceptable.

B. Integrity Tests

The switchgear shall successfully complete the following tests as recommended by NETA and listed under the "Switchgear and Switchboard Assemblies" Section:

1. Visual and Mechanical Inspection

a. Inspect for physical, electrical, and mechanical condition.

b. Compare equipment nameplate information with latest one-line diagram and report discrepancies.

c. Check for proper anchorage, required clearances, physical damage, and proper alignment.

d. Inspect all doors, panels, and sections for paint, debris, scratches, fit, and missing hardware.

e. Verify that fuse and/or circuit breaker sizes and types correspond to the Contract Drawings.

f. Verify that current and voltage transformer ratios correspond to the Contract Drawings.

g. Inspect all bus connections for high resistance. Use low-resistance ohmmeter, or check tightness of bolted bus joints by using a calibrated torque wrench. Refer to manufacturer's instructions for proper torque levels.

h. Test all electrical and mechanical interlock systems for proper operation and sequencing.

(1) Closure attempt shall be made on locked open devices. Opening attempt shall be made on locked close devices.

(2) Key exchange shall be made with devices operating in off-normal positions.

i. Clean entire switchgear using manufacturer's approved methods and materials.

j. Inspect insulation for evidence of physical damage or contaminated surfaces.

k. Verify proper barrier and shutter installation and operation.

l. Lubrication

(1) Verify appropriate contact lubricant on moving current carrying parts.

(2) Verify appropriate lubrication on moving and sliding surfaces.

m. Exercise all active components.

n. Inspect all mechanical indicating devices for proper operation.

2. Electrical Tests

a. Perform tests on all instrument transformers in accordance with NETA published values.

b. Perform ground-resistance tests in accordance with NETA published values.

c. Perform insulation-resistance tests on each bus section, phase-to-phase, and phase-to-ground for one (1) minute. Test voltages and minimum resistances shall be in accordance with NETA published values.

d. Perform an overpotential test on each bus section, each phase-to-ground, for one (1) minute at values recommended by the manufacturer.

e. Perform insulation-resistance test on shipping split control wiring. Do not perform this test on wiring connected to solid-state components.

f. Perform control wiring performance test. Use the elementary diagrams of the switchgear to identify each remote control and protective device. Conduct tests to verify satisfactory performance of each control feature.

g. Perform secondary voltage energization test on all control power circuits and voltage tests as detailed below in paragraph k, and l. Check voltage levels at each point on terminal boards and at each terminal device.

h. Perform current injection test on entire current circuit in each section of switchgear.

(1) Perform current tests by primary injection, where possible, with magnitudes such that a minimum of 1.0 ampere flows in the secondary circuit.

(2) Where primary injection is impractical, utilize secondary injection with a minimum of 1.0 ampere.

(3) Test current at each device.

i. Determine accuracy of all meters and calibrate watt-hour meters per NETA recommendations. Verify multipliers.

j. Perform phasing check on double-ended switchgear to ensure proper bus phasing from each source.

k. Control Power Transformers - Dry Type

(1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.

(2) Verify proper primary and secondary fuse ratings or circuit breakers.

(3) Verify proper interlock function and contact operation.

(4) Perform insulation-resistance tests. Perform measurements from winding-to-winding and winding-to-ground. Test voltages and minimum resistances shall be in accordance with NETA published values. Results shall be temperature corrected in accordance with NETA published values.

(5) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to proper secondary voltage. Check voltage at all devices.

(6) Verify proper secondary voltage by energizing primary winding with system voltage. Measure secondary voltage with the secondary wiring disconnected.

l. Potential Transformer Circuits

(1) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to proper secondary voltage. Check voltage at all devices.

(2) Verify secondary voltage by energizing primary winding with system voltage. Measure secondary voltage with the secondary wiring disconnected.

C. Records of Tests

1. Types of Records

Maintain complete and accurate records of all tests. These records shall include the following:

a. Description of test equipment used, including serial numbers.

b. Equipment or circuit identification, description, and location.

c. Complete nameplate data, including serial number.

d. Readings and measurements taken, including temperature and humidity.

e. Description of test, including date and tester's signature.

f. Test results (written description as required).

g. Other observable data applicable to equipment tests.

h. Description of any necessary corrective actions.

i. Certification of satisfactory completion of wiring and installation in accordance with applicable items of this Section.

3.05 PROTECTION

Protect switchgear, equipment, and facilities against damage, mechanical or otherwise and provide maintenance until issuance of the Certificate of Final Completion. The switchgear and equipment shall be kept clean, dry, and protected at all times.

3.06 TRAINING

A. Provide at the construction site training sessions for the number of Authority personnel, as specified on the Contract Drawings, for two (2), eight (8)-hour days.

B. The training sessions shall be conducted by a manufacturer's qualified representative. The training program shall consist of the instruction on the operation of the assembly, circuit breakers and major components within the assembly.

C. For additional training time requirements, see Section 16000 of these specifications.

END OF SECTION

SECTION 16335

LOW VOLTAGE SWITCHGEAR

APPENDIX "A"

SUBMITTAL REQUIREMENTS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Legend, Abbreviations, General Notes, and Drawing List
2. Outline drawings indicating overall dimensions, shipping sections, weights, and aisle space requirement for removable equipment
3. Switchgear rigging and installation drawings including anchoring details, locations of sills, and anchor bolts
4. Elementary diagrams (terminal configuration) for removable circuit breakers, relays, control switches, and meters
5. Structural drawings showing available space for busway, conduit, and cable connections
6. Bus arrangement including dimensions and ampere rating of all bus bars
7. Bill of materials for all equipment including item description, rating, and location
8. One line diagram showing all ratings, main connections, and location of all instruments including relays, transformers, and meters
9. Three line diagrams showing all instrument connections including relays transformers and meters
10. Kirk key interlock diagram with functional description
11. Removable circuit breaker's elementary diagrams
12. Front view of each vertical section showing all panel mounted equipment
13. Front view of all internal panels of each cubicle showing all control devices such as relays
14. Complete point to point wiring diagrams or schedules indicating the internal wiring of each component and the interconnections between components
15. Nameplate schedule and details
16. List special tools required for operation and maintenance of all equipment

B. Catalog Cuts

1. Relays
2. Control switches
3. Indicating lamps

4. Control wiring
5. Wire markers
6. Terminal blocks
7. Switchgear space heaters
8. Thermostats
9. Bus insulation materials
10. All types of lugs
11. All types of fuses and circuit breakers
12. Family of time-current characteristics curves for all types of fuses, relays, and trip devices
13. Instrument transformer characteristic curves and burden
14. Conventional metering system (CMS) devices
15. Digital Metering System (DMS) hardware and software

C. Test Reports

1. Submit factory tests and field tests forms for approval prior to implementation of the tests.
2. Submit certified test reports for tests specified in 2.05 and 3.03 of this section.
3. Submit Seismic Certification.
4. Submit certified test report for paint qualification test performed per ANSI C 37.20.1.

D. Operation and Maintenance Manuals

1. Maintenance documentation, including manuals, shall include descriptive material that will enable the Authority to maintain a supplied equipment at the component level. The document shall provide guidelines for isolating the cause of malfunction and for the removal, repair, and replacement of all devices.
2. Each manual, in addition to the information described above, shall contain the following:
   a. Calibration data, curves, wiring diagrams, and other pertinent information for all components provided
   b. Operational procedure, both manual and automatic
   c. Recommended preventive maintenance schedules

E. Spare Parts List

Furnish a list of recommended spare parts, the list shall contain the prices and availability. Recommendation for spare parts shall not obligate the Authority to purchase any such parts.

END OF APPENDIX "A"

SECTION 16335

LOW VOLTAGE SWITCHGEAR

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in this Section:

(1.04.C)	Indicate if UL, or other third party listing and labeling is required. Ensure that such listing and labeling is available from specified manufacturers
(1.05.C)	Indicate dimensions and weight restrictions for shipping sections
(1.06.F)	Indicate if portable breaker lifting device shall be furnished
(2.01)	List of manufacturers of the switchgear assembly and the circuit breakers. List a minimum of two (2) manufacturers and include "or approved equal." If an item is unique of "sole source", then a "sole source" letter will be required.

B. Suggested list of Manufacturers

1. Switchgear Assembly

ABB Power Distribution, Inc.
C.G.I. Systems
Cutler-Hammer
General Electric Company
Control Power Corporation
Siemens Energy and Automation, Inc.
Square D Company

2. Circuit Breakers

ABB Power Distribution, Inc.
Cutler-Hammer
Federal Pioneer
Siemens Energy and Automation, Inc.
General Electric Company
Square D Company

(2.02) Show the following ratings for the low voltage switchgear:

a. Nominal system voltage (RMS sym) (e.g. 480/277V, 3 phase, 4 wire 60Hz)

b. Rated maximum voltage: Select one - 254V, 508V, or 635V

c. Rated Frequency

d. Rated Insulation Level: 2.2KV(rms) for AC system

e. Rated Continuous Current: Select one - 800A, 1600A, 2000A, 3000A, or 4000A

f. Rated Short Time Current

g. Rated Short Circuit Current

h. Bus Bracing: Specify Bracing requirements separately for riser bus and main cross bus.

i. Control Voltage

NOTE: Ratings for circuit breakers shall be shown separately on the Contract Drawings following the instructions associated with Section 16475.

(2.03.A.1)	Indicate whether the switchgear is indoor, outdoor walk-in or outdoor non-walk-in type
(2.03.A.2)	Indicate if transition section is required
(2.03.A.3)	Indicate breaker arrangement
(2.03.D.1)	Indicate if non-integrally mounted fused power circuit breaker shall be supplied
(2.03.E.1)	Show ground sensing CTS, if required
(2.03.E.2)	Indicate cable entry to cubicle - top, bottom, or both
(2.03.G.2.e)	If CPT is not required, state so. Also show power source for space heaters, lights, and receptacles
(2.03.H.1)	Show if utility metering section is required
(2.03.I)	Show pull boxes on top of switchgear vertical section, if required for cable pulling
(2.03.J)	Indicate if Traveling Hoist is not required
(2.03.K.1)	Indicate if buses, taps, and primary connections are to be insulated
(2.03.K.4)	Indicate if reduced size neutral shall be provided
(2.03.L.8)	Show source of power for control and auxiliary circuits
(2.03.N.2)	Show voltage transformer ratio, if any
(2.03.N.4)	Indicate current transformer ratio and accuracy class
(2.03.N.8)	If metering is required, indicate whether digital or conventional, analog, metering shall be provided
(2.03.N.8.b)	When conventional metering system is required, show functions and components on single line diagram
(2.03.O.1)	Specify auxiliary relay
(2.03.O.2)	Specify protective relay types and ranges.
(3.01)	Specify number of days, including hours per day, the manufacturer's service representative will be needed for field technical support during installation and start-up
(3.05)	Specify number of Authority personnel for which training session shall be arranged.

C. Other

1. Review submittal requirements to adjust to your particular requirements.

2. Insure that the following Sections are included in the Contract Booklet:

Section 16475, "OVERCURRENT PROTECTIVE DEVICES"

END OF INSTRUCTIONS

DIVISION 16

SECTION 16450

GROUNDING

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for grounding.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

	Administrative Code
	Electrical Code of the City of New York
	American National Standards Institute (ANSI)
ANSI C 2	National Electrical Safety Code
	Institute of Electrical and Electronics Engineers (IEEE)
IEEE Std 142-1991	Recommended Practice for Grounding of Industrial and Commercial Power Systems
IEEE Std 1100-1992	Recommended Practice for Powering and Grounding Sensitive Electronic Equipment
	National Fire Protection Agency (NFPA)
NFPA 70	National Electrical Code
	Underwriters Laboratories Inc. (UL)
UL 467	Grounding and Bonding Equipment

1.03 QUALITY ASSURANCE

A. Components and installation shall comply with NFPA 70, "National Electric Code."

B. Provide products specified in this Section that are listed and labeled. The terms "listed" and "labeled" shall be defined as they are in NFPA 70 Article 100.

1.04 SUBMITTALS

See Appendix A for Submittal Requirements.

PART 2. PRODUCTS

2.01 GENERAL

Furnish grounding elements for switchgear, transformers, cabinets panelboards, starters, and miscellaneous electrical equipment, for all non-current-carrying metallic portions of the entire electrical system and for exposed non-electrical systems located in electrical substations or switchgear rooms as required by ANSI C 2, NFPA 70, and building codes which would be applicable, if the Authority were a private corporation.

2.02 MANUFACTURERS

Subject to compliance with the requirements of this Section, provide grounding products of manufacturers as shown on the Contract Drawings.

2.03 GROUND RODS

Ground rods shall be copper clad steel. Unless otherwise shown on the Contract Drawings, the rods shall be 3/4-inch diameter by 10 feet long.

2.04 GROUNDING CONDUCTORS

A. Provide grounding conductors in accordance with the requirements of NFPA 70, Sections entitled "WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS)," "WIRES, CABLES, SPLICES, TERMINATIONS (MEDIUM VOLTAGE)," and "TAXIWAY/RUNWAY WIRES AND CABLES," as applicable, and as specified on the Contract Drawings.

B. Equipment grounding conductors shall be green insulated.

C. Isolated grounding conductors shall be green insulated with yellow striping.

2.05 ABOVE GRADE CONNECTIONS

Connectors to piping, fencing, and conduit systems shall be listed and labeled as grounding connectors for the materials used.

2.06 BELOW GRADE CONNECTIONS

Buried Cable and ground rod connections shall be exothermic welds. Welded connections shall be provided in kit form and selected for the specific types, sizes, and combinations of conductors shown on the Contract Drawings.

2.07 GROUNDING BUSHINGS

Grounding Bushing shall be insulated type.

2.08 LIGHTNING PROTECTION COMPONENTS

Lightning protection components shall be provided as specified in Section entitled "LIGHTNING PROTECTION SYSTEM."

PART 3. EXECUTION

3.01 INSTALLATION

A. General

Install grounding elements for switchgear, transformers, cabinets, panelboards, starters, and miscellaneous electrical equipment, for all metallic non-current carrying portions of the entire electrical system and for exposed non-electrical systems located in electrical substations or switchgear rooms as required by ANSI C 2, NFPA 70 and building codes which would be applicable, if the Authority were a private corporation.

B. Install grounding as shown on the Contract Drawings.

C. Grounding and bonding equipment for use in connection with interior wiring systems shall conform to UL 467.

D. Install separate insulated equipment grounding conductors with circuit conductors to maintain grounding system at equipotential. Raceway system shall not be utilized as the equipment ground.

E. Connect exposed metallic piping or ductwork of any non-electrical system that is located in an electric substation or switchgear room, to ground in the room. Where the run through the room exceeds 15 feet in length, make ground connections at both the entering and leaving points of the piping or ductwork.

F. Ground all non-current-carrying metallic enclosures of electrical conductors, or exposed non-current-carrying metallic parts of electrical equipment, or of power apparatus.

G. Connections:

1. General

   Make connections in such a manner as to minimize possibility of galvanic action or electrolysis. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

2. Use electroplated or hot-tin-coated materials to assure high conductivity and make contact points closer in order of galvanic series.

3. Make connections with clean bare metal at points of contact.

4. Make all connections of grounding connector cables to ground rods by exothermic welding method. Welds that are puffed up, or that show convex surfaces indicating improper cleaning are not acceptable.

5. Terminate insulated equipment grounding conductors for feeders and branch circuits with pressure-type grounding lugs. Where metallic raceways terminate at metallic housings without mechanical and electrical connection to the housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to the ground bus in the housing. Bond electrically non-continuous conduits at both entrances and exits with grounding bushings and bare grounding conductors.

6. Tighten grounding and bonding conductors and terminals, including screws and bolts, in accordance with manufacturer's published torque-tightening values for connectors and bolts.

7. Where insulated grounding conductors are connected to ground rods, or ground buses, insulate the entire area of the connection and seal against moisture penetration of the insulation and cable.

H. All sensitive electronic equipment including computers and other components specified on the Contract Drawings, shall be connected to an isolated grounding system. The isolated grounding system shall be installed as specified on the Contract Drawings. The isolated grounding system and the electrical power equipment grounding system must be connected together at a single point, as shown on the Contract Drawings and in accordance with the requirements of NFPA 70, and all applicable local codes. Utilization of a grounding electrode separate from, and not connected to, the electrical power equipment grounding system is not acceptable

I. All ground rods in grounding loops shall have less than 5 ohms resistance to ground. All individual or isolated ground rods shall have a maximum of 25 ohms resistance to ground. The maximum overall grounding system resistance to ground shall be as shown on the Contract Drawings.

3.02 FIELD TESTS

Make ground resistance tests at all ground rods to verify that grounding system is at equipotential and to ensure compliance with the requirements specified in 3.01 I above, in the presence of the Engineer, and prepare all test results in tabulated form indicating location and time of each test and soil resistivity measured. If ground resistance on a grounding resistance test is higher than the value specified in 3.01 I, either increase the length of the rod or add more rods to the grounding system until the required ground resistance is achieved.

END OF SECTION

SECTION 16450

GROUNDING

APPENDIX "A"

SUBMITTAL REQUIREMENTS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

A. Catalog Cuts for ground rods, connectors and connection materials, and grounding fittings.

B. Ground Resistance Test Results.

END OF APPENDIX "A"

SECTION 16450

GROUNDING

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.03)	Special length ground rods (other than 10 - foot)
(2.04 A)	Ground conductor sizes based on available short circuit current, overcurrent protection devices specified, and cable insulation melting point characteristics
(2.05)	Type of connectors to be used
(2.06)	Type of exothermic welding kit to be used
(3.01 B)	Grounding plans and details
(3.01 H)	Components and systems requiring isolated grounding, and details of computer grounding system such as the use of a signal reference ground.
(3.01 I)	Maximum overall grounding system resistance to ground

B. Other Items

Ensure that the Specifications include the following Sections referenced in this Section, as applicable.

(2.04 B)	"WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS)" "WIRES, CABLES, SPLICES, TERMINATIONS (MEDIUM VOLTAGE)" "TAXIWAY AND RUNWAY CABLES"
(2.07)	"LIGHTNING PROTECTION SYSTEM"

C. Submittals

Specify required submittals by editing Appendix A, "Submittal Requirements."

END OF INSTRUCTIONS

DIVISION 16

SECTION 16452

ELECTRICAL BONDING

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for furnishing, installing and testing an electrical bonding system for corrosion control/stray current mitigation on all underground structures.

1.02 REFERENCES

	American Society for Testing and Materials (ASTM)
ASTM B 3	Soft or Annealed Copper Wire
ASTM B 8	Concentric-Lay Stranded Copper Conductors, Hard, Medium-Hard, or Soft
	Military Specifications (MIL)
MIL A-18001	Anode, Corrosion Preventative Zinc, Slab, Disk and Rod Shapes
	National Association of Corrosion Engineers (NACE)
NACE RP 0169	Control of External Erosion on Underground or Submerged Metallic Pipe Systems

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

The Electrical Bonding System shall be designed, manufactured and installed in accordance with the latest revision of applicable standards ASTM, MIL and NACE. In case of conflict between various standards, the more stringent requirement shall apply.

1.04 QUALITY ASSURANCE

A. The Contractor shall provide the Electrical Bonding System design, certified by a NACE accredited Corrosion Engineer, licensed as a Professional Engineer in the state in which the work is to be performed, and experienced in corrosion control procedures. Submit the qualifications of the Corrosion Specialist, for review by the Engineer.

B. Electrical bonding devices, of type and sizes required, shall have been satisfactory used for the purposes similar to those herein, for not less than three years.

1.05 DELIVERY, STORAGE AND HANDLING

A. Store materials in original packaging in a manner to prevent soiling, damage, wetting or corrosion prior to installation.

B. Handle in a manner to prevent damage to finished surfaces.

C. Where possible, maintain protective coverings until installation is complete and remove such covers as part of final cleanup.

1.06 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide electrical bonding materials and equipment of the manufacturers listed on the Contract Drawings.

2.02 MATERIALS

A. Electrical Bonding Devices

Unless otherwise shown on the Contract Drawings, furnish materials and products in accordance with the following requirements:

1. Cables shall be stranded copper, #8 AWG minimum, conforming to ASTM B 3 and B 8, insulated with 0.11 inches of high molecular weight polyethylene.

2. Zinc Reference Electrode shall conform to the requirements of MIL A-18001, 1-1/4 inches by 1-1/4 inches by 9 inches long, 5 pound, 1/4" dia. steel core package electrode, and in accordance with the following requirements:

   a. Lead wire shall comply with 2.02.A.1, and shall be factory connected to the anode center with the connection sealed in cast epoxy resin encapsulation.

   b. Electrode shall be packaged in a permeable package cloth sack, total weight as recommended by the manufacturer, containing compacted backfill of mixture with the following requirements:

Material	Percent
Hydrated Gypsum	50
Bentonite	50

   c. Epoxy resin encapsulation shall be two-piece, snap-together molded bodies, sized for cable, with two-part low viscosity polyurethane insulating and sealing compound, rated for 600 volts.

B. Buried cable and ground rod connection shall be exothermic welded.

C. Junction boxes shall be in accordance with Section 16135, entitled "BOXES AND FITTINGS".

PART 3. EXECUTION

3.01 EXAMINATION

A. Verify that electrical installations, structural, mechanical and other related work satisfy the requirements for performance of the work for this Section in accordance with the Contract Documents.

B. Report immediately to the Engineer any electrical, structural or related construction defects in areas where bonding devices are to be installed, and do not attempt to rectify any defect unless specifically instructed to do so by the Engineer.

C. Provide control and inspection of all exothermic bonding connections before casting them in concrete and for proper electrical connections of all underground structural members.

3.02 PREPARATION

Before installation of electrical bonding devices, the Contractor shall investigate the site condition to determine, what preparatory work, if any, will be needed.

3.03 INSTALLATION

A. General

1. Install electrical bonding devices in accordance with approved printed manufacturer's installation procedures, and as specified.
2. Coordinate with other trades, to electrically bond all structural steel and reinforcing bars, embedded in the concrete below grade. Bonding shall be completed in closed circuit to minimize corrosion activity, and shall conform to the Corrosion Specialist design.

B. Bonding Connections

1. Bond bare or uncoated reinforcing steel using single insulated conductors or straps, exothermically welded to steel beams.
2. Cross bond all bare or reinforcing steel, using exothermic welds.
3. Make welds in accordance with manufacturer's requirements.

C. Conductors

1. Use continuous, insulated conductors, without splices, between welded connections.
2. At the end of line of bonded steel beams, connect the insulated header cable, using exothermic welds, and terminate this cable inside the test junction box as shown on Contract Drawings. Where structural beams or steel members are coated, clean and coat with coal tar epoxy after completion and cooling of welded area.

D. Test Electrode Wells and Junction Boxes

1. Bury electrodes of type and at locations shown on the Contract Drawings. Excavate and backfill holes in accordance with the manufacturer's written instructions and in accordance with the following requirements:

   a. Wet packaged electrode thoroughly before backfilling the hole.

   b. Use fine clay soil, free from stones and bricks, for backfilling.

2. Install header cables of size, and at location shown on the Contract Drawings.

3. Install test junction box of type, and at locations, shown on the Contract Drawings in accordance with Section 16135 entitled "BOXES AND FITTINGS".

4. Run electrode lead wires to test junction boxes as shown on the Contract Drawings.

5. Install size and type of conduit shown on the Contract Drawings, in accordance with the requirements of Section 16110 entitled "RACEWAYS".

6. Install cable, leaving slack in test junction boxes.

7. Use exothermic welds, sealed with cast epoxy resin encapsulation, for splices made in direct buried cable.

E. Identification

Identify all cables, in each test junction box, using fiber tags (1/16 inch thick and 3/4 inches wide) intended with letters and numbers 5/16 inch high, fastened to cables with #14 AWG weatherproof copper wire.

F. Field Tests

Test that materials are installed and connected as shown on the Contract Drawings, and as required by the Corrosion Specialist's certified design.

1. Test the complete Electrical Bonding System to ensure electrical continuity. The tests must show that the elements of the structure are electrically bonded and prepared for connection to the test box.

2. Testing shall be in accordance with NACE RP 0169 requirements.

3. All test data shall be included in a final report, prepared by the Corrosion Specialist, indicating the initial conditions, with a listing of further recommendations pertaining to the maintenance and periodic testing of the system(s).

4. The Contractor shall correct any deficiencies discovered during the tests.

END OF SECTION

SECTION 16452

ELECTRICAL BONDING

APPENDIX A

SUBMITTAL REQUIREMENTS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples", Division 1 - GENERAL PROVISIONS:

A. The Electrical Bonding System design, certified by a NACE accredited Corrosion Specialist, licensed as a Professional Engineer in the state in which the work to be performed.

B. Shop Drawings

1. Details of bonding of structural steel and reinforcing bars encased in concrete below grade.
2. Steel and concrete shop drawings, including all required welds, bonding connections and recoating or patching of protective coatings.
3. Layout drawings of test electrodes, cabling and test junction boxes.

C. Submit 12 copies of all test data, and the final report.

D. Submit qualifications of the Corrosion Specialist and a copy of NACE certificate.

END OF APPENDIX "A"

DIVISION 16

SECTION 16455

400 HZ OUTPUT SOLID STATE FREQUENCY CONVERTER FOR GROUND POWER SYSTEM

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for 60 Hz to 400 Hz frequency converter for aircraft ground power systems.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

	Air Transportation Association (ATA)
ATA-101	Ground Equipment Technical Data.
	American Society for Testing and Materials (ASTM)
ASTM A123	Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed and Forged Steel Shapes, Plats, Bars, and Strip.
ASTM B209	Aluminum-Alloy Sheet and Plate.
ASTM B580	Anodic Oxide Coatings on Aluminum.
	American National Standards Institute (ANSI)
ANSI C84.1	Voltage Rating for Electrical Power Equipment.
	American Welding Society (AWS)
AWS D1.1	Structural Welding Code, Steel.
Euro-Standard, 400 HZ	
DFS-400	400 Hz Aircraft Ground Power.
	International Electrical and Electronic Engineers (IEEE)
IEEE 127	Aerospace Equipment and Frequency Rating.
	International Electrical Congress (IEC)
IEC 146	Semiconductor Converters.
	International Organization for Standardization (ISO)
ISO-1540	Aerospace Characteristics of Aircraft Electrical Systems.
ISO-6858	Aircraft Ground Support Electrical Supplies.
	Military Specifications (MIL)
MIL I8500	Interchangeability and Replaceability of Component Parts of Aircraft and Missiles.
MIL W586A	Wire, Electrical, Polyvinyl Chloride Insulated, Copper or Alloy Copper.
MIL W168780	General Specification for Insulated Electrical Wire.

MIL S19500	Semi-conductor Devices.
	Military Standards (MIL STD)
MIL-STD-461D	Electromagnetic Interference Characteristics Requirement for Equipment.
MIL-STD-704D	Aircraft Electrical Power Characteristics.
	National Electrical Manufacturers Association (NEMA)
NEMA ICS 1	Safety Guidelines for the Application, Installation and Maintenance of Solid State Controls.
NEMA ICS 6	Enclosures Industrial Controls and Systems.
	National Fire Protection Association (NFPA)
NFPA 70	National Electrical Code.
	Society of Automotive Engineers (SAE)
ARP-1940	Solid State Frequency Converters.

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. General

The 400 Hz output solid state frequency converter shall be complete with components and accessories coordinated so that the complete unit shall function as specified. The frequency converter enclosure and accessories shall be manufacturer's standard design and shall comply with the requirements of DFS-400.

B. Input Characteristics

1. Input Voltage

Nominal voltage shall be 480v, 3 phase, 60 Hz. The frequency converter shall function properly with utility company voltage at -15% and + 10% of nominal voltage rating. Input current over the entire load range shall not differ more than 5% arithmetic average for the three input lines. All equipment voltage ratings shall adhere to ANSI C84.1.

2. Phase Rotation

Any with automatic phase lock for ABC (clockwise) or CBA (counter clockwise) output phase rotation.

3. Inrush Current

Shall not exceed 100% of rated full load current and unit shall be equipped with a fully automatic soft start circuit.

4. Protection

5. The frequency converter shall be equipped with the following input power protections:

a. Phase loss protection.

b. Phase sequence protection.

c. Over/Under voltage protection.

d. Thermal overload protection.

e. Overcurrent protection.

6. Voltage Operating Range

The frequency converter output voltage shall be capable of being adjusted over a range of ±10% from rated voltage.

C. Output Characteristics

1. Output Power Rating

Load capacity of the frequency converter shall be 90 KVA continuous at 0.8 power factor lagging.

2. Output Voltage

The output voltage shall be 115/200 volt, 3 phase, 4 wire, with grounded neutral in accordance with the international aircraft electrical power requirements. Output voltage shall not drift more than 1% for ambient temperature change up to 55 degrees Celsius.

3. Output Phase Rotation

Shall be 3-phase, 4-wire, wye, ABC (clockwise) rotation.

4. Output Frequency

Shall be 400 Hz +0.01%.

5. Voltage Regulation

Voltage regulation from no load to rated load and from rated load to no load shall be not more than 1% of rated voltage and shall be maintained with input line voltage variations of +10%.

6. Voltage Modulation

Voltage modulation shall not exceed 0.5% at any load from 0 to 100%.

7. Voltage Recovery

Transient voltage recovery shall meet or exceed MIL-STD-704D (not more than 50 mSec for 100% load change).

8. Voltage Phase Balance

With frequency changer operating at any load within the rated KVA the maximum difference in all line-to-neutral voltages shall not exceed 1% for balanced loads and within 2.5% for 25% unbalanced load.

9. Phase Voltage Displacement

Shall be 120% ±1.0% for balanced loads 120% ±2.0% for 33% unbalanced loads.

10. Voltage Trim Adjustment

The output voltage trim adjustment shall be +15% of nominal output span.

11. Crest Factor

Shall be 1.414 +5%.

12. Frequency Regulation

Shall be 400 Hz + 0.01% Hz and shall not be affected by load and shall conform to IEEE 127.

13. Harmonic Distortion

The maximum total harmonic distortion at any load shall not exceed 2.0% when measured line-to-line or line-to-neutral. The maximum single harmonic shall not exceed 1.5%.

14. Line Drop Compensation

Shall be 0 to 5% of voltage span and shall be adjustable.

15. Overload Capacity

After reaching stabilized temperature at full load, the frequency converter shall be capable of carrying the following overloads:

125% for 1 hour, 150% for 5 min., 200% for 10 sec., 250% for 1.0 sec., 300% for 0.50 sec.

The frequency converter shall be capable of sustaining a 300% overload without damage and shall be capable of start up into a sustained 300% minimum short circuit without damage.

16. Efficiency

The efficiency of the frequency converter shall be 95% or better at full load.

17. Over/Under Voltage Protection

An over/under voltage output protection shall be provided to automatically isolate the converter output power from the aircraft when it is exceeding limits of the MIL-STD-704D.

18. Overload/Short Circuit

The frequency converter shall be isolated from the aircraft load by overload/short circuit protection specifically rated for 400 Hz operation. The converter shall be equipped with an instantaneous electronic overload alarm circuit designed to operate at not less than 250% of rated capacity.

19. DC Content

The DC voltage component as measured at the output terminals shall not exceed 100 milli-volts for any load.

D. AC Input Protection Devices

1. Phase Loss

A circuit shall detect the loss of any phase and prevent unit from starting.

2. Phase Rotation

A circuit shall detect incorrect phase rotation and prevent unit from starting.

3. Isolation

A built-in circuit breaker of suitable size shall provide input isolation of the frequency/converter and protect from internal short circuits.

4. Control Circuit Transformers

Transformers with a fused primary shall be provided for operation of all control and indicating devices.

5. Fuses

All fuses shall be suitably marked as to circuit designation.

E. AC Output Protection Devices

1. Overvoltage Device

A circuit shall detect if overvoltage exceeds the voltage-time characteristic of MIL-STD-704D, and immediately shutdown.

2. Undervoltage Device

A circuit shall detect if undervoltage exceeds the voltage-time characteristics of MIL-STD-704D, and immediately shut down.

3. Overload and Short Circuit Devices

A circuit shall detect output overcurrent of 90% of component rating or short circuit and shut unit down without internal damage.

4. Internal Malfunction

A malfunction internal to the converter shall result in shutdown.

5. Internal Electrical Faults

Circuits shall be provided to detect internal faults and act to shutdown the converter in sufficient time to prevent secondary damage.

6. Cooling Loss/Overtemperature

Devices shall be provided for detection of cooling loss and overtemperature and actuate a shutdown of the converter.

7. Environmental Characteristics

F. The solid state frequency converter shall successfully operate under the following conditions:

1. Ambient Temperature Range: Minus 40 degrees C to 55 degrees C.
2. Relative Humidity: 10% TO 100% with condensation.
3. Altitude: 0 to 2000 meters w/o derating.
4. Wind: Up to 145 KM/hr.

5. Audible Noise Level: Shall be not more than 70 DBA at 1 meter (3 feet).

G. Control Circuit Characteristics

1. Controls

The frequency converter shall be designed to start and stop by means of depressing momentary push buttons, mounted on the converter control panel. Provisions for remote operations shall be provided. The frequency converter shall be equipped with a fused, isolated 28 vdc power supply for operation of all control and indication devices. All fuses shall be suitably marked as to the circuit designation.

2. Output Contactor

The frequency converter output shall be connected to an output contactor of sufficient capacity to handle rated load and overload specified. The output contactor shall be electrically interlocked with input circuitry so that frequency converter will be immediately isolated when converter is being shutdown. The operating push-button and associated light indicators shall be mounted on the door mounted control panel.

3. Line Drop Compensation

The voltage regulation means shall include an electronic line drop compensation circuit for maintaining the voltage regulation at a single point distance from the converter and shall be adjustable at full load to at least of 5% of rated output voltage.

4. Aircraft Interlock Circuit

The E and F interlock circuit shall instantaneously isolate the converter output in the absence of a 28 vdc signal from the aircraft. The E and F interlock circuit indicator shall be provided to display the status of E and F interlock.

5. Aircraft Bypass Switch

For testing purposes an aircraft bypass switch shall be provided inside the converter to allow the unit to deliver the output power without the 28 vdc power from the aircraft. An indicator shall be provided to indicate that the BYPASS circuit has been selected.

6. Output Voltage Adjust

A voltage adjusting potentiometer located on the back of the primary access panel shall be provided to permit adjustment of the converter output voltage.

7. Bridge Control Interlock

For frequency converters installed on passenger loading bridges, the converter shall be interlocked with the bridge control circuit so that the bridge cannot be moved away from the aircraft while frequency converter is plugged to the aircraft.

8. Alarm Indicator Reset

A reset push-button shall be provided to reset all indicators from cleared alarm signals.

H. Meters and Indicators

1. External Instruments

a. Voltmeter

The output voltmeter shall have a single 0 to 300 vac scale in order to read line-to-line and line-to-neutral voltages. The voltmeter shall be calibrated for 400 Hz and shall have an accuracy of ±2% full scale.

b. Voltmeter Selector Switch

Seven position selector switch with "OFF" position shall be provided to monitor line-to-line and line-to-neutral voltages.

c. Ammeter

The output Ammeter shall have a single 0 to 300 A RMS scale in order to read output phase currents. The Ammeter shall be calibrated for 400 Hz and shall have an accuracy of ±2% full scale.

d. Ammeter Selector Switch

A four position selector switch shall be provided to monitor output phase currents "A", "B", "C" with "OFF" position.

e. Frequency Meter

Output frequency meter with a range of 360 Hz to 440 Hz and accuracy ±0.5% full scale.

f. Elapsed Time Meter

Shall be non-resettable type with 0 to 99,999 hrs.

g. Status Indicators

The following status indicators shall be provided: "Power On", "Module Fault", "Input Voltage Fault", "Output Voltage Fault", "Converter On", "Interlock System Not Available".

h. Lamp Test

The lamp test push-button when depressed shall test all door mounted light indicators.

2. Internal Instruments

a. Diagnostic System

The solid state frequency converter shall be equipped with a complete diagnostic system including alarm message system. All of the converter's vital function shall be continuously monitored by the diagnostic system.

b. System Indicators

The frequency converter shall be equipped with a light emitting diode (led) status package to provide monitoring of the proper system modules operation.

I. Physical Characteristics

1. Design and Construction

a. The frequency converter shall be designed and constructed so that parts will not work loose in service. It shall be designed to withstand the strains, jars, vibration and other conditions incident to shipping, storage, installation and service.

b. The converter and inverter sections of the frequency changer shall be modularized solid state components. The standard construction shall have no moving parts and shall require a minimum service or maintenance. All cards shall be equipped with vibration resistant latching mechanism. All solid state components shall meet MIL Specifications S19500.

c. Transistorized inverters shall be utilized throughout the frequency converter to eliminate the need for forced commutation reactors and controlled rectifiers for enhanced reliability. The inverters shall comply with the requirements of IEC 146 and ARP-1940.

d. Components shall be cooled by convection, natural draft cooling, use of heat sinks, or by forced draft cooling provided the overall efficiency of the unit is not reduced by the use of fans. All fans shall be equipped with permanent, washable aluminum mesh air filters.

e. The power transformers shall be mounted in separate compartments from the solid state equipment.

f. For outdoor locations, the electronics shall be completely sealed from the environment and the system cooling fans. The electronic compartments shall be equipped with environmentally safe, vapor-type corrosion inhibitors.

g. The frequency converter shall be equipped with approved weather tight fittings for all wiring that pass through the weather tight compartments to preclude the entrance of moisture and dust into isolated electronic compartments.

h. All printed circuit boards shall be conformably coated to protect against the effects of humidity, corrosion and salt fog. All integrated circuits shall be installed in plug-in sockets to simplify repair and prevent disturbing the conformable coating during repair or maintenance.

i. The frequency converter shall be so constructed that adjustments and repairs can be easily made by maintenance personnel.

j. All major components and sub-assemblies shall be stenciled or labeled with identification number or letter code on or near the device. The code shall be readily visible when servicing the frequency converter.

2. Cabinet

a. The cabinet enclosure shall be designed to be suitable for the intended environmental conditions. The cabinet shall be mounted in such manner that no damage will occur as a result of transportation. The complete frequency changer shall be designed for lifting and transporting by forklift. Means shall be provided for easy access to all components and sub-assemblies.

b. A door interlock switch shall be provided to shut down the unit, suitable warning labels or covers shall be provided where internal voltages decay slowly after shutdown.

c. The control panel shall be mounted in, or be part of the converter cabinet. Provisions shall be included for attaching remote controls to operate the frequency converter from remote position.

3. Finishes

a. Steel surfaces shall be zinc coated (hot galvanized) per ASTM A 123, and then finished with a tough 2 part polyurethane top coat with a heavy texture surface.

b. Aluminum surfaces shall be anodized per ASTM B 580 or coated with manufacturer's standard coating.

c. Unless otherwise specified, color finishes shall be manufacturer's standard.

d. Color of exposed surfaces of frequency converters installed on passenger loading bridges shall match the adjacent surfaces of such bridges.

4. Workmanship

The frequency converter, including all parts and accessories shall be fabricated and finished in a workmanlike manner. Particular attention shall be given to freedom from, not limited to, defects, burrs, sharp edges, quality of soldering, welding, brazing, painting, wiring, riveting, alignment of parts and tightness of assembly screws, bolts. Wiring harness shall conform to MIL Specification W586A and MIL Specification W168780.

1.04 QUALITY ASSURANCE

A. The manufacturer of the 400Hz Frequency Converter System shall have manufactured equipment for 400Hz at 115/200 volts, alternating current, 3-phase, 4-wire, and the equipment of the cited manufacturer shall have been satisfactorily used for purposes similar to those intended herein, in at least 3 locations, each for a minimum of three years. When directed by the Engineer, the Contractor shall have the manufacturer submit a list of installations and contracts for which he has produced such materials, to substantiate the required experience.

B. The 400Hz Ground Power System shall be designed, manufactured, and tested in accordance with the requirements of these Specifications, and shall achieve the following minimum levels of performance for service availability:

1. Overall availability of not less than 98% in the first year of operation

2. Mean-Time-Between-Failure (MTBF) of not less than 24,000 hours

3. Mean-Time-Between-Repair (MTTR) of less than 1 hour.

C. All Work of this Section shall be performed and completed in a thorough, workmanlike manner and shall follow the best modern practice in the manufacture of high-grade equipment. All Work of this Section shall be performed by workmen skilled in their respective trades and shall meet ISO 1540 and ISO 6858.

D. All parts shall be made accurately to standard gauge, where applicable, for ease of replacement and repairs.

E. All material selected for the manufacture of the 400Hz Frequency Converter System shall be the best available for the purpose for which they are intended to be used, considering strength, ductility and the best engineering practice. All parts shall conform to the applicable requirements of MIL Specification I8500, so that the converter or its components will not damage aircraft system.

F. All parts shall be readily accessible and like parts shall be interchangeable insofar as possible.

G. Surfaces to be welded shall be clean and free from dirt, rust or other foreign matter. The welding processes shall be in accordance with the requirements of AWS D1.1.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Each 400 Hz Frequency Converter System shall be delivered complete, in the manufacturer's original, unopened protective packaging. All accessories shall be in place and wired. Packing materials shall be such as to prevent damage to components due to vibration, jarring, or the like during transportation and handling.

B. Accessories or spare parts shipped loose shall be delivered in the manufacturer's original unopened protective packaging and shall be identified with a non-corrosive tag.

C. The 400Hz Frequency Converter System shall be handled in a manner to prevent damage to finished surfaces.

D. Where possible, maintain protective coverings until installation is complete and remove such coverings as part of final cleanup.

E. Touch up any damage to finishes to match adjacent surfaces.

1.06 SPARE PARTS

A. Prior to issuance of the Certificate of Final Completion, furnish the required spare parts to meet the specified availability MTBF and MTTR, and an index of the parts, to the Engineer. The spare parts shall be protectively packaged and provided with containers for indoor storage. Each container shall be provided with legibly printed identification of the part designation and number, which shall match the index of supplied parts.

B. Submit a complete listing of recommended spare parts necessary to be retained on-site, other than power magnetics, to maintain the specified availability, Mean Time Between Failures (MTBF), and Mean Time To Replace (MTTR).

C. Equipment requiring a full replacement unit or the equivalent thereof in component parts, in order to meet the specified availability, MTBF or MTTR will not be considered acceptable.

1.07 SPECIAL TOOLS OR EQUIPMENT

A. Provide all special tools or test equipment necessary to maintain the equipment, and meet the specified availability, MTFB and MTTR.

B. Special tools shall mean any tool not available from the current Sears or Jensen Handtool catalogs.

C. Special testing equipment shall mean any test equipment other than an industrial, 4-1/2-digit, multi-range volt-ohm-amperes meter, Fluke No. 83, or approved equal.

D. Provide unity power factor load test bank per manufacturer's recommendations.

1.08 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURER

Subject to compliance with requirements of this Section, provide 400 Hz frequency converter system(s) of one of the following manufacturers, or approved equal:

Jetway Systems, an IC Industries Company
MagneTek Airport Systems
FCX Systems
AeroTech Systems
Unitron
Hobart

2.02 CONSTRUCTION FEATURES

A. Controls and Indicators

1. Terminals for external remote mounted power on-off pushbuttons.
2. Voltage adjustment: ±15%.
3. Internal Diagnostic Digital meter: 0.25% accuracy.
4. 28 Volt DC Interlock Switch: On and Off.
5. Line Drop Compensation Selector: Selectable for load cable compensation - 0 to 150 ft.
6. External Indication
   a. Solid Red: Internal fault.
   b. Flashing Red: Phase loss/rotation.
   c. Solid Yellow: Utility power OK.
   d. Flashing Yellow: 28 Volt In By-pass.
   e. Solid Green: 400Hz power applied.
   f. Flashing Green: 28 Volt not available.
7. Internal Fault Indication - Alpha-numeric read out for:
   a. Normal Condition.
   b. Problems with any Inverter/Module.
   c. Over/Under Voltage.

d. Over Temperature.

8. Internal Operation Monitor: Provide LED indicators to indicate correct operation of:

a. Input 60 Hz - Phase A.

b. Input 60 Hz - Phase B.

c. Input 60 Hz - Phase C.

d. Plus (+) 15VDC.

e. Minus (-) 15 VDC.

f. Plus (+) 5 VDC.

B. Built In Test Equipment shall permit monitoring and testing of critical circuits during normal operation. Testing selection shall be through internally mounted keypad with monitoring through the Digital Meter.

C. Provide sustained memory function with 5-day duration on absence of external power.

D. Provide phase synchronization circuitry to allow "no-break" transfers required, but not limited to 747-400 aircraft.

E. Physical Characteristics:

1. Dimensions shall generally be:

Width:	60 inches, ±6 inches
Height:	18 inches, ±6 inches
Depth:	48 inches, ±6 inches

2. Weight shall not exceed the following limits:

a. 90 kVA Rating: 2,000 lbs., ±100 lbs.

b. 120 kVA Rating: 2,300 lbs., ±100 lbs.

F. Enclosures

1. Unit access shall be provided by bottom hinged, exterior access door(s) and the front panel of the unit, allowing access to all major components and circuits. Panel shall be accessed via a minimum of six (6) type AN or MS locking screws.

2. Housing shall be completely sealed, with no air transfer from external sources to internal components. Case materials shall be aluminum sheet and structural members, conforming to the requirements of ASTM B209. Internal framing shall be galvanized steel, conforming to the requirements of ASTM A123. Enclosure shall conform to the requirements of NEMA ICS1 and ICS6 for Type 3R enclosures.

3. Housing finish shall be fully alodine treated. External surfaces shall be painted Silver Gray, or other color as selected at the time of shop drawing approval. Custom colors shall be available to match the loading bridge finishes.

G. Operational life shall be not less than 20 years when operated within system specifications. Equipment shall conform to the requirements of MIL STD 461D for electromagnetic compatibility.

H. Unit shall operate to full capacity in the environmental conditions of -40 degrees C to +55 degrees C, 0 to 100% relative humidity, including condensing.

I. Components shall be modular, conforming to the applicable requirements of MIL Specification I8500.

J. Wiring shall be insulated, stranded copper, conforming to the requirements of MIL Specification W586A, MIL Specification W168780 and NFPA 70.

2.03 MANUALS

A. Provide complete Operation, Installation and Maintenance Manuals with each 400Hz Frequency Converter System. The Manuals shall conform to the requirements of ATA 101 and shall consist of the following:

1. Converter description, theory of operation and specification.
2. Installation and maintenance procedures.
3. Starting, Operation, Maintenance and Trouble-shooting instructions.
4. Schematics and Connection wiring diagrams.
5. Recommended Spare Parts list.

2.04 SHOP TESTS

A. Provide certified test results of all shop or factory testing to verify proper operation and unit capacity prior to shipping equipment to the site.

1. Submit the intended test plan to the Engineer for approval, a minimum of 30 calendar days prior to the scheduled commencement of testing. Testing shall not proceed until the plan and any necessary modifications to the plan are approved by the Engineer.
2. Test results shall be certified by a factory representative, and shall be submitted to the Engineer for approval.

B. Should the tests reveal any defects in the function, operation or capacity of the equipment, promptly correct such defects and rerun the tests until the results are satisfactory to the Engineer.

1. Should the equipment not be ready for testing at the time of the scheduled and approved test date, or should the equipment fail testing and require the Engineer to return to the shop or factory to rerun the tests, the manufacturer shall bear the cost of all travel, accommodations, and expenses related to a second and any subsequent trips.

C. Factory Test Shall Consist of:

1. Each converter shall be tested at no load and full load conditions and shall be given a "burn-in" test for at least 24 continuous hours.
2. In addition to load tests the following tests shall be performed:
   a. Output Voltage Waveform.
   b. Transient Voltage Recovery Time (for 50% and 100% load shocks).
   c. Output Voltage Regulation.

d. Efficiency Test at 100% load.

2.05 TRAINING

Provide not less than sixteen hours of on-site classroom operator and maintenance training under the direction of the manufacturer's representative. Training shall demonstrate the routine operations of the equipment and means to identify malfunctions, and customer serviceable troubleshooting and maintenance to preserve the warranty and maintain the specified availability, MTBF and MTTR.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install 400 Hz Frequency Converter System as shown on the Contract Drawings, in accordance with the manufacturer's instructions and in compliance with the requirements of NFPA 70.

B. All conduit and bus connections to the enclosure shall be made with liquid-tight, flexible metal conduit and vibrationless connectors.

3.02 FIELD TESTS

A. General

1. Provide all labor and materials for functional tests required. Power for the tests will be furnished by the Authority.
2. Should the tests reveal any defects in the installation under this Contract, promptly correct such defects and rerun the tests until the entire installation is satisfactory to the Engineer in all respects.

B. Perform the following field tests in the presence of the Engineer to demonstrate the proper phasing of each 400 Hz Frequency Converter System installation:

1. Verify that the proper phase sequence is maintained using a phase sequence meter.
2. Verify the ability to operate the aircraft as available on site.

END OF SECTION

SECTION 16455

400 HZ OUTPUT SOLID STATE FREQUENCY CONVERTER FOR GROUND POWER SYSTEM

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Submit shop drawings showing physical dimensions.
2. Layout drawings showing the locations of all accessories, mounting provisions, required clearances and conduit entries and sizes. Technical equipment specifications. Wiring diagrams, including block, schematic logic diagrams and interconnection wiring diagrams.

B. Catalog Cuts

Catalog cuts for all controls and components, down to the smallest replaceable component, and for all recommended spare parts.

C. Product Data

Submit a complete listing and description of required special tools or testing equipment.

D. Test Reports

Submit certified factory test results and reports.

E. Maintenance Manuals

Submit complete operations and maintenance manuals and equipment manuals.

F. Spare Parts List

Submit a complete listing of all recommended spare parts.

G. Site Inspection Reports

Submit certified copies of all field tests performed.

END OF APPENDIX "A"

DIVISION 16

SECTION 16470

PANELBOARDS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for electrical panelboards and cabinets.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

	National Electrical Manufacturers Association (NEMA)
NEMA PB 1	Panelboard
NEMA PB 1.1	General instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less
NEMA PB 250	Enclosures for Electrical Equipment (1000 Volts maximum)
NEMA AB 1	Molded Case Circuit Breakers and Molded Case Switches
NEMA AB 3	Molded case Circuit Breakers and Their Application
NEMA 280	Application Guide for Ground Fault Circuit Interrupters
NEMA AB 4	Guidelines for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications
NEMA Z535.4	Product Safety Signs and Labels
	National Fire Protection Association (NFPA)
NFPA 70	National Electric Code
	Underwriters Laboratories Inc. (UL)
ANSI/UL 67	Panelboards
ANSI/ UL 50	Cabinets and Boxes
UL 1059	Electrical Terminal Blocks
ANSI/UL 65	Electric Wired Cabinets
ANSI/ UL 486E	Equipment Wiring Terminals for Use With Aluminum and/or Copper Conductors
ANSI/UL 486A	Wire Connectors and Soldering Lugs for Use With Copper Conductors

ANSI/UL 969	Marking and Labeling systems
ANSI/UL 467	Electrical Grounding and Bonding Equipment
ANSI/UL 437	Key Locks

Federal Specifications

Panelboards, W-P-115a,c

Type 1 - Circuit Breaker Equipped

Class 1- Panelboards

Class 2 - Load Centers

Molded Case Circuit Breakers, W-C-375a,b

Fusible Switches, W-S-865c

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. Panelboards shall be designed in accordance with applicable standards of ANSI, NEMA, NFPA and UL. A list of acceptable manufacturers is shown on the Contract Drawings.

B. Unless otherwise shown on the Contract Drawings, Panelboard cabinets shall meet the following environmental requirements:

1. Cabinets located in heated areas shall be NEMA Type 1.
2. Cabinets located in unheated areas or in areas subject to dust or oil, shall be NEMA Type 12.
3. Cabinets located in exterior areas or locations subject to rain, dripping liquid, or hosing shall be NEMA Type 4X, stainless steel.

C. ANSI design test shall have been made on a prototype of each type of panelboard.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Panelboards shall be delivered to the construction site complete. All circuit breakers, other electrical devices, and accessories, shall be in place and wired.

B. Panelboards and accessories shall be packaged to prevent damage due to vibration, jarring and the like during transportation and handling.

C. If any electrical devices or accessories must be shipped loose they shall be delivered in the manufacturer's original unopened protective packaging and shall be identified with suitable non-corrosive tag.

D. Store components and devices in clean and dry space, protected from weather.

E. Where possible, maintain protective covering until installation is complete and remove such covering as part of final cleanup.

F. Touch up any damage to finishes to match adjacent surfaces.

1.05 SPARE PARTS AND TOOLS

A. One set of all special tools and wrenches required for assembly or disassembly of the panelboard and the installation of breakers shall be furnished.

B. Furnish a list of recommended spare parts for each panelboard. This list shall contain the prices and availability of the spare parts recommended.

1.06 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 GENERAL

A. List of acceptable manufacturers is shown on contract drawings.

B. The size, rating, and number of circuit breaker in the panelboard shall be as shown on the Contract Drawings.

C. All panelboards, for which there are established UL standards, shall bear the UL label.

D. Location of panelboards and their approximate dimensions shall be as shown on the Contract Drawings.

E. Each panelboard shall be factory assembled, tested and shipped as a single complete unit, with all circuit breakers and buses installed, unless written permission is given by the Engineer to disassemble any parts for shipment.

2.02 CONSTRUCTION FEATURES

A. Panelboard interior

1. Panelboard interiors shall be designed and assembled so that individual breakers may be added, removed, or replaced without disturbing adjacent units and without removing main bus or brunch circuit connectors.
2. All parts shall be readily accessible and like parts shall be interchangeable insofar as possible.
3. Modifications and optional features such as silver plated copper bus, subfeed lugs, shunt trips, meters, etc., shall be as shown on the Contract Drawings.

B. Panelboard Enclosures (Cabinets)

1. The panelboard assembly shall be mounted in a galvanized steel or stainless steel enclosure (cabinets) as shown on the Contract Drawings. Cabinets and trims shall be surface-mounted or recessed installation as shown on the Contract Drawings.

2. Cabinets shall be arranged to provide side gutters 6 inches wide. Cabinets shall be provided with top and bottom gutters not less than 6 inches wide. For 400A or 600A mains, top and bottom gutters shall be 8 inches. Where feeder cables supplying the mains of a panelboard are carried through its box to other panelboards, the cabinet shall be provided with adequate additional side gutters space for the riser cable and taps.

3. The cabinet shall have a galvanized sheet-steel one-piece frame with a hinged door.

4. Recessed or flush-mounted cover frames shall extend 3/4 inch beyond each side of the cabinets and shall be set with their backs flush with the finished wall. Covers shall have adjustable trim clamps to compensate for misalignment and shall be completely concealed when door is closed.

5. Surface-mounted cover frames shall be sized to match the overall dimensions of the cabinet or flanged around to cover the edge of the cabinet.

6. Breakers and interior bus shall be covered by a removable framed trim, mounted inside the cabinet.

7. Doors shall close against a rabbet placed all around the inside edge of the frame, with a close-fitting joint between the door and frame

8. Doors shall be fitted with concealed, continuous, flush piano hinges.

9. Fastening screws on front panel shall be stainless steel and shall be of the captive, tamper proof type. Front panels shall not be removable with door in locked position.

10. Provide a metal frame with clear impact resistant plastic cover, mounted inside of each panelboard door to hold circuit directory.

C. Overcurrent protective devices and buses

1. Overcurrent protective devices shall be circuit breakers, fully rated, bolt on, thermal magnetic, inverse time delay, molded case. Breakers shall be 1, 2 or 3 pole with an integral crossbar or an internal common trip element, to assure simultaneous opening of all poles of a multi-pole circuit breaker. All circuit breakers shall meet requirements specified in the section of these Specifications entitled "OVERCURRENT PROTECTIVE DEVICES"

2. Connections of the branch circuits to the main bus shall be of the phase sequence type, that is, adjacent poles shall be of unlike polarity and rotated in sequence. This shall allow complete flexibility of circuit arrangement (1, 2 or 3 poles) to evenly balance the electrical load on each phase.

3. Main bus bars, including full capacity isolated neutral, shall have an ampere rating not less than that of the main breaker or lugs, and shall be braced for a momentary short circuit as specified on the Contract Drawings. The minimum short circuit rating shall be equal or be greater than the rating of the panelboard integrated equipment.

4. Buses shall be designed in such a manner that no machining, drilling, or tapping shall be required to change circuits or add new breakers.

5. All main and branch circuit bus shall be copper with a 1000 Amperes per square inch current density, and contact surfaces shall be silver plated and shall have no more than 200 Amperes per square inch current density.

6. A copper ground bus shall be furnished and installed by the panelboard manufacturer for equipment grounding. When shown on the Contract Drawings the Manufacturer shall install an isolated type grounding bus.

7. Main lugs shall be solderless, mechanical type and shall be secured in line with UL standards to prevent lugs from turning or loosening when incoming cables are installed.

8. Where circuit breakers with ground fault protection are shown on Contract Drawings, they shall be UL class A type and shall be identified on the panelboard.

9. Lighting fixture circuits controlled only by a circuit breaker shall each be identified by a 1 inch long by 3/4-inch high black laminated plastic nameplate with white letters.

10. Circuit breakers used for switching fluorescent lighting shall be rated and identified with a SWD tag.

2.03 ACCESSORIES

A. Nameplates

1. Provide approved nameplates on the front cover of each cabinet, indicating the panel name and number.

2. Unless otherwise shown on the Contract Drawings, fabricate nameplates from an approved type of lamacoid plastic with letters engraved on the plate in white on black background. Where letter sizes are not shown on the Contract drawings, use 1/2-inch high letters. Nomenclature shall comply with a schedule approved by the Engineer.

3. Secure nameplates on equipment with brass or stainless steel screws with locking hardware.

B. Panelboard cabinet locks

Each locked cabinet shall be furnished with a combination catch and flat lock with spring loaded type door pull. Locks shall be fitted to separate keying for each system. Furnish one key for each cabinet installed and a maximum of 20 keys per system.

C. Provide a typewritten directory identifying each brunch circuit as to the load which it serves, and install the directory in metal frame inside the panelboard door.

2.04 PAINTING

A. Surfaces to be painted shall be prepared by the removal of all grease, oil, rust, scale or other foreign material.

B. A prime coat of zinc chromate paint and two (2) finish coats of enamel paint conforming to ANSI Z 55.1 shall be applied. The gray prime and finish paints shall be a compatible finish system. In public areas the cabinets shall be painted as above, unless otherwise shown on Contract Drawings.

C. Furnish a can of touch-up paint for use after equipment is positioned.

D. Stainless steel panels shall not be painted. Galvanized panels shall be painted if shown on the Contract Drawings.

2.05 SHOP TESTS

A. Shop tests shall be in accordance with NEMA, ANSI and IEEE specifications.

B. During the period of shop drawing submission complete information outlining the test methods and procedures to be followed shall be submitted to the Engineer for approval. A copy of test forms and a set of sample computations to be used shall be furnished at the time.

C. The Engineer shall be permitted to inspect any equipment, material or work to be furnished under this specification and shall have the right to reject any parts considered defective, unsuitable for the purposes or not in accordance with these specifications.

D. The Engineer shall be notified at least two weeks before testing. This notification shall list type and number of units to be tested. The Engineer reserves the right to require additional testing or to waive factory inspection or witnessing of tests.

E. Five (5) certified copies of all test results shall be furnished to the Engineer. Certification shall be by a Professional Engineer licensed in the State in which the tests are performed, and stamped.

F. Circuit breakers shall be tested individually in the following sequence:

1. Calibration test
2. Overload performance test
3. Continuous current test
4. Endurance performance test
5. Calibration test (repeated)
6. Determination of interrupting rating
7. Dielectric test

Results of tests on prototype circuit breakers of each size and type will be acceptable.

G. Panelboards shall be marked with their maximum short circuit rating at the supply voltage. The short circuit rating of each panelboard shall be determined after complete assembly. The short circuit tests on the breakers and panelboard structure shall be made simultaneously by connecting the fault to each overcurrent device with the panelboard connected to its rated voltage source. The method of testing shall be in accordance with UL 67. The source shall be capable of supplying specified panelboard short circuit current or grater.

H. Release of equipment shall not relieve the Contractor of the responsibility of furnishing equipment conforming to all specification requirements.

PART 3. EXECUTION

3.01 EXAMINATION

A. Verify that electrical installations, structural, mechanical and other related Work satisfy the requirements for performance of the work of this Section in accordance with the Contract Documents.

B. Before delivering the equipment to the site, the Contractor shall investigate the site conditions to determine the best method of shipment, what preparatory work, if any, will be needed to bring the equipment onto the site, and what will be the best and quickest method of unloading the equipment and setting it in place.

C. Report immediately to the Engineer any electrical, structural or related construction defects in areas where control panels or cabinets are to be installed, and do not attempt to rectify any defect unless specifically instructed to do so by the Engineer.

D. Before unloading the equipment it shall be inspected for damage during shipment. Any damage shall immediately be brought to the attention of the Engineer for resolution.

3.02 PREPARATION

A. Install any channels, angles or other supports that are required to support or mount the panelboards.

B. Use supports and fasteners as specified in the Section of the Specifications entitled "SUPPORTING DEVICES" or as shown on the Contract Drawings.

3.03 INSTALLATION

A. Surface and flush mounted panelboards shall be installed with tops 6 feet-6 inches above the floor, unless otherwise shown on the Contract Drawings.

B. Panelboards shall be installed true and plumb on supporting struts and shall not be mounted directly on concrete, concrete block walls, or any other walls subject to moisture. Leave a minimum gap of 1/2 inch between the back of the enclosure/cabinet and the wall, using stainless steel hardware.

C. Where mounting directly on the wall is unavoidable the back of the enclosure shall be painted with two coats, minimum, of a bituminous paint.

D. Cables shall be neatly racked and bundled with nonflammable nylon ties, routed and supported within the enclosures/cabinets or gutters. Minimum bending radii as recommended by cable manufacturers shall not be reduced.

E. After conduits and cables are installed, the enclosures/cabinets shall be inspected for foreign materials and shall be vacuumed clean. Prior to energization the panels shall be tested as described below.

F. A typewritten directory shall be furnished and installed in the frame inside the panelboard.

3.04 FIELD TESTS

A. Visually inspect each breaker in the panelboard and operate manually.

B. Check all connections for tightness

C. Check current rating of all circuit breakers. To each pole of the circuit breakers apply current 3 times its rating, recording currents and breaker trip times. Apply rapidly increasing currents and record the value that consistently causes instantaneous tripping of the breaker. Compare these recorded times with manufacturer's time current curves.

D. Perform megger and hi-pot test on each pole.

E. All discrepancies found by the contractor shall be brought to the attention of the Engineer

F. All testing shall be performed in the presence of and as directed by the Engineer. The Contractor shall notify the Engineer when the equipment is installed and ready for testing.

END OF SECTION

SECTION 16470

PANELBOARDS

APPENDIX "A"

SUBMITTALS

Submit for approval the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

Shop drawings for each enclosure/cabinet shall include:

1. Data sheet for each panelboard with the following information
   - a. Job name
   - b. Item number
   - c. Panelboard nameplate(s) in accordance with the design drawings
   - d. Quantity of this panelboard configuration
   - e. Phase, wire and voltage
   - f. Main and neutral Bus material, continuous current, current density, and momentary capacity.
   - g. Short- circuit rating
   - h. Main connection information:
     - (1) Circuit Breaker - rating, interrupting rating, number of poles, type, manufacturer, and catalog number
     - (2) Lugs per phase, Cables per phase, Cable size range
     - (3) Location (top, bottom)
   - i. Thru feed lugs, subfeed
   - j. Ground bar with main lug on frame
   - k. Branch connection information:
     - (1) Circuit breakers rating, number of poles, type, manufacturer, and catalog number
     - (2) Lugs and cables per phase, Cable size range
   - l. Panelboard circuits breaker's arrangement for left and right side-top to bottom.
   - m. Panelboard overall dimensions H x W x D
   - n. Panelboard NEMA rating
2. Panelboard dimensional drawing. Indicate conduit entrance space at the top and bottom, knockout diagram and mounting details
3. Panelboard directory

B. Catalog cuts

1. Panelboards and Cabinets
2. Circuit breakers
3. Family of time current characteristic curves for all types and sizes of circuit breakers

C. As-built Documentation acceptable to the Engineer, with typewritten copy of completed panelboard directories.

END OF APPENDIX "A"

SECTION 16470

PANELBOARDS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in this Section:

1.03 B	Environmental requirements if other than that specified
2.01 A	List of manufacturers (min. - three)

1. Suggested list:

   General Electric Company
   Square D Company
   Westinghouse Electric Corporation
   Siemens Energy and Automation, Inc.

2. Make a note that manufacturers of equal qualifications to those listed on the drawings will be acceptable if approved by the Engineer.

3. Before recommending specific manufacturer check that the specified equipment is currently produced by the vendor and the nonstandard requirements and modifications (if any) can be made.

4. Provide clear indication if any equipment or materials shall be furnished by one particular manufacturer with no substitution.

2.01 B	Size, rating, and number of circuit breakers in each panelboard. Prepare a panel schedule with this information. Indicate on panel schedule number of poles and desired location of each circuit breaker in the cabinet. Indicate spaces for future breakers. Indicate on panel schedule where ground fault breakers or switching breakers are located.
2.01 D	Location of panelboard and their approximate dimensions.
2.02 A.3	Optional features, other than specified.
2.02 B.1	Indicate material of the enclosure/cabinet. Indicate surface-mounting or recessed installation of cabinets and trims.
2.02 C.3	Rating of main bus and neutral bus. Indicate short circuit rating for each panelboard.
2.02 C.6	Size of ground bus and where required isolated ground bus.
2.02 C.8	Indicate on schedule where any ground fault breakers or switching breakers are located.
2.03 A	Fabrication of nameplates and letter sizes if other than that specified.
2.04 B	Paint color of public area cabinets if other than specified.
2.04 D	Indicate if galvanized steel cabinets are to be painted.
3.03	Installation if other than specified.

B. Other

1. Review submittal requirements to adjust to your particular requirements.
2. Ensure that the following Sections are included in the Contract bucket:

   Section 16475 "OVERCURRENT PROTECTIVE DEVICES"
   Section 16190 "SUPPORTING DEVICES"

END OF INSTRUCTIONS

DIVISION 16

SECTION 16475

OVERCURRENT PROTECTIVE DEVICES (600 VOLTS OR LESS)

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies requirements for overcurrent protective devices.

B. The types of overcurrent protective devices specified in this Section are:

1. Low Voltage Power Air Circuit Breakers
2. Molded Case Circuit Breakers
3. Safety Switches
4. Fuses

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

	American National Standards Institute (ANSI)
ANSI C 37.13	Low Voltage AC Power Circuit Breakers used in enclosures
ANSI C 37.16	Related Requirements and application recommendation for Low Voltage Power Circuit Breakers
ANSI C 37.50	Test Procedures for Low Voltage AC Power Circuit Breakers
ANSI C 97.1	Low Voltage Cartridge Fuses 600 Volts or Less
	National Electrical Manufacturers Association (NEMA)
NEMA AB-1	Molded Case Circuit Breakers and Molded Case Switches
NEMA KS-1	Enclosed Switches
	National Fire Protection Association (NFPA)
NFPA 70	National Electrical Code
	Underwriters Laboratories Inc. (UL)
UL 98	Enclosed and Dead Front Switches
UL 198	Safety Standard for Fuses
UL 489	Molded Case Circuit Breakers and Circuit Breaker Enclosures
UL 943	Standard for Ground Fault Circuit Interrupters

Federal Specifications (FS)

W-C-375B/Gen	Circuit Breakers, Molded Case; Branch Circuit and Service
FSW –S-865	Covers Surface-mounted, Air-break, Box or Enclosed Switches for Ratings through 500 Volts, 1200 Amperes and 50 Horsepower

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

The overcurrent protective devices and associated materials shall conform to all applicable standards, and shall also conform to the requirements specified herein and shown on the Contract Drawings.

1.04 QUALITY ASSURANCE

Overcurrent protective devices of types and ratings required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Overcurrent protective devices to be installed in an assembly, as shown on the Contract Drawings, shall be mounted in the assembly and delivered in accordance with the manufacturer's specifications for such assembly.

B. Overcurrent protective devices to be installed in their own enclosures, as shown on the Contract Drawings, shall conform to the following requirements:

1. Enclosures shall be packaged with material to prevent damage to components due to vibration, jarring and the like during transportation and handling.

2. Enclosures shall be delivered in the manufacturer's original, unopened, protective packaging and shall be identified with suitable non-corrosive tags.

C. Where possible, maintain protective coverings until installation is complete and remove such coverings as part of the final cleanup.

1.06 SUBMITTALS

See Appendix "A" for submittal requirements.

1.07 SPARE PARTS

Furnish a minimum of three but not less than 10% spare fuses of each type and rating required and shown on the Contract Drawings.

PART 2. PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with the requirements of this Section, provide low voltage power circuit breakers, molded case circuit breakers, safety switches and fuses of one of the manufacturers specified on the Contract Drawings.

2.02 MATERIALS

A. General

1. Location, types, sizes, ratings and enclosures for overcurrent protective devices are shown on the Contract Drawings.

2. Overcurrent protective devices mounted in their own enclosures as shown on the Contract Drawings shall conform to the requirements of NEMA, UL, and NFPA. Enclosures shall be as specified in the Section of these Specifications entitled "PANELBOARDS ".

3. Overcurrent protective devices, to be installed as part of an assembly unit, shall be installed in accordance with the manufacturer's requirements for the specified assembly or as shown on the Contract Drawings.

4. Overcurrent protective devices and enclosures for which there are established UL standards, shall bear the UL label.

B. Low Voltage Power Air Circuit Breakers

1. General

a. All circuit breakers shall be 3 pole, single throw, 600V AC class, 60 Hz, trip free, with stored energy closing. Controls shall be as shown on the Contract Drawings.

b. Circuit breakers shall be of the draw-out type with self-aligning fingers to engage the line and load primary terminals.

c. The draw-out mechanism shall firmly support the breaker from the fully connected to the fully disconnected positions and shall be so designed as to permit racking the breaker without opening the door in all three positions: connected, test, and disconnected.

d. Interlocks shall be provided to prevent racking the breaker from the connected position to the test or disconnected position, or moving the breaker into the connected position while the breaker is closed.

e. Required circuit breaker sizes and ratings shall be as shown on the Contract Drawings.

f. In addition to all contract requirements to achieve the operation indicated on the Contract Drawings and specifications, provide the following spare contacts rated 125 VDC, 20 amperes continuous.

(1) A minimum of two normally open and two normally closed contacts, which shall operate when the breaker is in the fully connected position.

(2) A minimum of one normally open and one normally closed contacts, which shall operate when the breaker is withdrawn from the fully connected position. Contacts shall be rated 125V DC, 20 amperes continuous.

g. Provide a position indicator visible from the front of the switchgear for each breaker to indicate whether the breaker is open, tripped or closed.

h. Tripping shall be through integrally mounted solid state overcurrent and short circuit trip units with adjustable settings for long time, short time and instantaneous trip unless otherwise shown on the Contract Drawings.

2. Manually Operated Breakers

a. Provide manually operated circuit breakers with a front mounted handle to manually charge the stored energy closing mechanism.

b. Breakers shall be mechanically trip free and shall be furnished with provisions for the future addition of a control solenoid for remote closing.

c. Provide a mechanical trip and close button on the front of each breaker.

d. Provide a maintenance handle for slow closing during contact adjustment.

3. Electrically Operated Breakers

a. Provide electrically operated breakers with a motor- operated, stored-energy, closing mechanism. Motor voltage shall be as shown on the Contract Drawings.

b. Breakers shall be electrically and mechanically trip-free and each shall be provided with an electrically operated spring release to close the breaker.

c. Provide a mechanical trip button on the front of each breaker.

d. Provided an electrical close button or control switch on the front of each breaker.

e. Provide a maintenance handle for slow closing during contact adjustment.

f. Provide breakers with a shunt trip device for remote operation, arranged for both local and remote control of the closing and tripping functions.

4. Fused Circuit Breakers

a. Where shown on the Contract Drawings, fused circuit breakers shall be provided.

b. The fuses shall be current limiting type and shall be integrally or separately mounted units coordinated with overcurrent trip devices so as to avoid unnecessary blowing of the fuses.

c. Fused breakers shall have a blown fuse indicator and lockout device. The lockout device shall trip all phases upon blowing and prevent the breaker from being closed with any fuse element blown. Operation of the breaker shall not be permitted by this device until the fuse is replaced and the lockout reset.

d. The blown fuse indicator shall be visible from the front of the breaker and shall indicate which fuse has blown.

e. When a Protective Device Coordination Study is performed, the fuse rating shall be in accordance with the requirements of the protective study.

C. Molded Case Circuit Breakers

1. General

a. Molded case circuit breakers for panel or individual mounting shall be molded-case type, quick-make and quick-break on manual or automatic operation. The handle mechanism shall be trip-free to prevent holding contacts closed on a fault. Tripping shall be indicated by the handle automatically assuming a position between the manual "off" and "on" positions.

b. Molded case circuit breaker contacts shall be of the high-pressure type and shall be made of a silver composition material. Arc shields shall be provided to confine, cool, and quench the arc drawn at interruption.

c. Continuous ampere ratings and number of poles shall be as shown on the Contract Drawings.

d. Molded case circuit breakers shall be bolt-on type. Unless otherwise shown on the Contract Drawings or as required by the system interrupting rating, all 120V or 208V circuit breakers shall have a minimum short circuit interrupting rating of not less than 10,000 amperes (RMS symmetrical) and all 277V or 480V breakers shall have a minimum short circuit interrupting rating of not less than 18,000 amperes (RMS symmetrical).

e. All molded case circuit breakers feeding 120V or 277V lighting circuits that are not controlled by local wall switches shall be UL approved type "SWD" circuit breakers.

f. Each molded case circuit breaker shall be suitable for the circuit on which it is applied and the load that it controls.

g. Accessories including, but not limited to, auxiliary switches, shunt trips, undervoltage trips, ground fault sensing and tripping shall be as shown on the Contract Drawings.

2. Thermal-Magnetic Circuit Breakers

a. Circuit breakers up to, but not including 400 amperes shall be thermal magnetic trip. Electronic trip circuit breakers rated 100 amperes or higher may be provided in lieu of thermal magnetic type.

b. Automatic operation of the molded case circuit breaker shall be obtained by means of calibrated thermal and magnetic tripping devices for each pole of the breaker. The thermal device shall provide time-delay tripping on overloads, and the magnetic device shall provide instantaneous tripping on short circuits. The instantaneous magnetic trip shall be adjustable and accessible from the front of the breaker on frame sizes above 100 amperes.

3. Electronic Trip Circuit Breakers

a. Circuit breakers rated 400 amperes and higher shall be electronic trip.

b. The integral trip system shall be independent of any external power source and shall contain industrial grade electronic components as a minimum.

c. Circuit breakers shall be equipped with back-up thermal magnetic trip system unless otherwise indicated on the Contract Drawings.

d. Circuit breaker trip system shall be a microprocessor based true rms sensing design.

e. The sensor size rating plug and adjustment positions shall be clearly marked on the face of the circuit breaker.

f. The following time/current adjustments shall be provided. Each adjustment shall have discrete settings and shall be independent of all other adjustments.

Long time pick up
Long time delay
Short time pick up
Short time delay
Instantaneous pick up
Ground fault pick up
Ground fault delay

g. A means to seal the trip unit adjustments in accordance with NEC shall be provided.

h. Local visual trip indication for overload short circuit and ground fault trip occurrences shall be provided.

D. Safety Switches

1. Safety switches shall conform to NEMA KS-1, UL 98 and FSW-S-865.

2. Safety switches shall conform to the NEMA classification and shall be rated, as shown on the Contract Drawings.

3. Safety switches utilized for service entrance shall include a groundable insulated neutral.

4. Safety switches shall be of the quick-make, quick-break type with terminals suitable for copper conductors, shall be padlockable in the "off" position and shall be equipped with defeatable door interlocks.

E. Fuses

1. Fuses shall be of the class, size and ratings (current, voltage, interrupting capacity, type, NEMA class) as shown on the Contract Drawings.

2. Fuses shall conform to UL 198 and ANSI C97.1 for low voltage fuses.

3. Unless otherwise shown on the Contract Drawings, fuses used in conjunction with motor protection shall be current limiting, dual element, time-delay type.

PART 3. EXECUTION

3.01 INSTALLATION

A. General

Unless otherwise shown on the Contract Drawings, overcurrent protective devices shall be installed in conformance with NFPA 70, and UL 98, in accordance with the manufacturer's instructions and in accordance with the requirements of this Section.

B. Fuses

1. All fuses rendered inoperative during the Work shall be replaced before the issuance of the Certificate of Final Completion.

2. All replacement fuses shall be provided in addition to the spare fuses specified in 1.07 herein.

END OF SECTION

SECTION 16475

OVERCURRENT PROTECTIVE DEVICES (600 VOLTS OR LESS)

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Fuses; time-current and current-limiting curves for both melting and clearing.
2. Circuit breakers; time-current curves.
3. Fused circuit breakers - time current curves.

B. Catalog Cuts

1. Low Voltage Power Air Circuit Breakers
2. Molded case circuit breakers
3. Safety Switches
4. Fuses

END OF APPENDIX "A"

SECTION 16475

OVERCURRENT PROTECTIVE DEVICES (600 VOLTS OR LESS)

INSTRUCTIONS TO SPECIFIER

A. General

Ensure that the Contract Drawings show the following items specified in this Section:

1.03	Design and performance requirements which are not included in
1.06	Each type and rating of spare fuses
2.01 A	A list of acceptable manufacturers must be added to the Contract Drawings. The following is a suggested list: <u>Circuit Breakers and Safety Switches</u> Square 'D' Company General Electric Company Siemens Energy Automation, Inc. Cutler – Hammer <u>Fuses</u> Commercial Enclosed Fuse Company (CEFCO) Cooper Industries Inc./Bussman Division Gould Incorporated/Circuit Protection Division
2.02 A.1	Location, types, sizes, rating and enclosures.
2.02 A.2	Indicate whether overcurrent protective devices are to be installed via assembly or enclosure
2.02 B.1.a	Controls for low voltage power air circuit breakers
2.02 B.1.e	Required sizes and ratings of circuit breakers
2.02 B.1.h	If electro-mechanical tripping is required
2.02 B.3.a	Motor voltage
2.02 B.4.a	Location of fused circuit breakers
2.02 C.1.c	Continuous ampere rating and number of poles for molded case circuit breakers
2.02 C.1.d	Minimum short circuit interrupting rating if other than that specified.
2.02 C.1.g	Accessories for molded case circuit breakers
2.02 D.2	Safety switch rating
2.02 E.1	Class, size and ratings of fuses, and type of enclosures
2.02 E.3	Fuses used in conjunction with motor protection if other than that specified
3.01 A	Installation if other than that specified in this Section and the manufacturer's instructions

B. Other

Ensure that the following Sections are included in the Contract booklet:

Section 16470	PANELBOARDS AND CABINETS"
Section 16477	"PROTECTIVE DEVICE COORDINATION STUDY"
Section 16450	"GROUNDING"

END OF INSTRUCTIONS

DIVISION 16

SECTION 16477

PROTECTIVE DEVICE COORDINATION STUDY

PART 1. GENERAL

1.01 REFERENCES

The following is a listing of publications referenced in this Section.

	American National Standards Institute (ANSI)
ANSI C 37.91	Protective Relay Applications of Power Transformers
	Institute of Electrical and Electronics Engineers Inc. (IEEE)
IEEE 242	Protection and Coordination of Industrial and Commercial Power Systems
	National Fire Protection Association (NFPA)
NFPA 70	National Electrical Code

1.02 QUALITY ASSURANCE

A. The PDCS shall be certified by a Professional Engineer licensed in the State where the installation will take place. The qualifications of the Professional Engineer shall be submitted for review and approval by the Engineer.

B. Entities performing the Work of this Section shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.03 SUBMITTALS

For submittals see Appendix "A".

PART 2. PRODUCTS

2.01 COORDINATION STUDY

Unless otherwise shown on the Contract Drawings, the PDCS shall start from the designated connection point and shall include all protective devices and circuit elements shown on the Contract Drawings. In general, such devices and elements shall include, but not be limited to conductors, high voltage fuses or circuit breakers, transformers, low voltage switch-gear, fuses, circuit breakers, panel boards, motor control centers, transfer switches, and all or switching devices within the distribution system. This requirement shall apply to both AC and DC systems. The PDCS shall conform to the requirements of ANSI C37.91, IEEE 242, NFPA 70, and this Section.

A. Short Circuit Analysis

The Short Circuit Study will be considered a part of the PDCS. The Short Circuit Study shall be performed by using a computer software DAPPER or A_FAULT by SKM Systems Analysis. Results of such a study shall be provided on hard copy as well as on a floppy disk.

1. The short circuit analysis shall study the distribution protective and switching devices and conductors, for both continuous and fault current capabilities. This shall include the ability of the devices and conductors to withstand fault current until the protective devices operate.
2. The short -circuit analysis shall analyze the electrical system, to identify the maximum short circuit values available at each protective device and on the conductors within the system.
3. The short circuit analysis shall be based on the characteristics of the equipment, conductors, raceways and routings actually used in the construction.
4. The short circuit analysis shall be based on the actual available short circuit from the utility at the designated connection point.

B. Protective Device Coordination Analysis

The Protective Device Coordination Analysis shall be performed by using the latest version of the computer software called CAPTOR by SKM Systems Analysis. Results of such a study shall be provided on hard copy as well as on a floppy disk.

1. The analysis shall clearly define the proposed coordination among the devices which include, circuit breakers, overcurrent relays, fuses, transformers, motor sand cable damage curves, magnetizing inrush currents, fault currents and currents related to each device's proposed ratings and settings.
2. The analysis shall establish the settings necessary to selectively isolate faults or failures from the remainder of the electrical system with minimum power interruption.

C. Coordination Plots

The coordination plots shall graphically demonstrate the proposed coordination for the electrical system, plotted on ANSI standard, full-sized, log-log forms such as Time-Current Characteristic forms by Keuffel & Esser Co. The coordination plots shall be plotted on a plotter. No hand drawn plots shall be accepted.

1. The plots shall define the types of protective devices selected, together with the CT ratio selected, proposed taps, time-dial and instantaneous settings.

2. All the coordination plots shall be submitted on hard copies as described above, as well as on computer floppy disks suitable for the approved protective device coordination software as defined section "B" above. In addition, the individual Time-Current Characteristic curves of all the protective devices used in the study shall be provided on a computer floppy disk in the proper format as well as original manufacturer's curves for future reference by the Authority.

3. The coordination plots shall include complete titles, representative one-line diagrams, associated system characteristics, complete parameters for transformers and complete operating bands for distribution circuit breaker trip devices and fuses.

   a. The long-time region of the plots shall designate the pickups required for the circuit breakers.

   b. The short -time region shall indicate the magnetizing inrush, and ANSI transformer withstand parameters, the circuit breaker ground -fault, short -time and instantaneous trip settings, fuse minimum melting and total clearing time, tolerance bands and symmetrical fault currents.

   c. Molded case circuit breakers shall be separated from each other and the associated upstream and downstream protective devices by a current or time margin for coordination and protection in the event of secondary faults.

   d. The protective device characteristics or operating bands shall be suitably terminated to reflect the actual symmetrical fault currents sensed by the device.

   e. Each primary protective device required for delta-to-wye connected transformers shall be selected so that the characteristics or operating bands are within the transformer parameters, which shall include a parameter equivalent to 58 percent of the withstand point to afford protection for secondary line -to-ground faults. The transformer damage curve shall be included for the transformer when the selected protective device is not within the associated parameters.

   f. The coordination plots shall include the damage curves for the transformers, cables and rectifiers. Actual curves provided by the manufacturers of the respective equipment shall be where ever possible.

4. The Authority will furnish settings and fault impedances up to the first level of the upstream protective devices owned by the Authority.

5. The PDCS shall take into account the general characteristics and requirements for the wires, cables, motors, transformers, circuit breakers, rectifiers and any other high and low voltage equipment.

6. All specific equipment characteristics shall be determined in accordance with the results of the PDCS. Report to the Engineer any conditions within the Work, or within equipment not installed under this Contract, where the study recommendations, as approved by the Engineer, require equipment types or sizes other than the requirements of the Specifications, or as shown on the Contract Drawings. The Contractor's compensation for completing such changes, at the direction of the Engineer, will be determined in accordance with the clause of the Contract providing compensation for Extra Work.

7. The study shall include verification of equipment ratings and settings. The results of the study shall be coordinated with the shop drawings required by various other Sections of the Specifications. The Contractor shall maintain the PDCS up-to-date with any Contract changes that affect the study recommendations, and shall submit the revised PDCS for approval by the Engineer.

END OF SECTION

SECTION 16477

PROTECTIVE DEVICE COORDINATION STUDY

APPENDIX "A"

SUBMITTALS

A. Submit in advance, to the Engineer, for approval, the qualifications of the Professional Engineer specified in 1.02 A.

B. Submit six bound copies of an initial protective device coordination analysis and short circuit study. Submit revised copies of the study in accordance with the requirements of 2.01.

END OF APPENDIX "A"

SECTION 16477

PROTECTIVE DEVICE COORDINATION STUDY

INSTRUCTIONS TO SPECIFIER

A. Define the scope of the coordination study on the Contract Drawings.

B. If all of the distribution system included in the Protective Device Coordination Study does not appear on the Contract Drawings, provide reference drawings or list available drawings as required.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16480

MOTOR CONTROL CENTERS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for motor control centers.

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

A. Motor control centers shall be designed and manufactured in accordance with the applicable requirements of ANSI, NEMA, NFPA and UL.

B. Unless otherwise shown on the Contract Drawings, the enclosure shall be NEMA 1B.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Motor control centers shall be delivered complete and in shipping sections that are as large as practical. All electrical devices, including but not limited to circuit breakers, starters, meters, pilot lamp, control power transformers, switches and relays shall be in place and wired. Packaging materials shall be such to prevent damage to components due to vibration, jarring and the like during transportation and handling.

B. Electrical devices shipped loose shall be delivered in the manufacturer's original unopened protective packaging and shall be identified with suitable, non-corrosive tags.

C. Where possible, maintain protective coverings until installation is complete and remove such coverings as part of the final cleaning up.

D. Touch up any damage to finishes to match adjacent surfaces.

1.04 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section of the Specifications, provide motor control centers of one of the following manufacturers:

General Electric Company
Siemens Energy and Automation, Incorporated
Westinghouse Electric Corporation

2.02 GENERAL

A. Locations, size, number of cells and the requirements for the devices mounted on each drawout unit and its relationship to the entire motor control center shall be as shown on the Contract Drawings.

B. The exterior of the motor control center shall be light gray ANSI 61 and the interior including the drawout units shall be white.

C. The following products or materials shall not be used in any part of the motor control center:

1. Asbestos.
2. Polyvinylchloride.

2.03 CONSTRUCTION FEATURES

A. Enclosure

1. Unless otherwise shown on the Contract Drawings, motor control centers shall be indoor, totally enclosed, dead-front and dead-back, freestanding, consisting of unitized sections, bolted and bussed together to form a mechanically sound and electrically coordinated assembly, with provisions for future additions or rearrangement of control units. Each vertical section shall be divided into compartments which shall contain a combination starter unit, a circuit breaker or other overcurrent protective device, or other control assemblies, all as shown on the Contract Drawings.
2. Removable lifting angles shall be provided on top of each motor control center shipping section.
3. Each section shall be 90 inches high, 20 inches deep and shall contain a minimum of a 72 square inch horizontal wireway at the bottom and the top. The top wireway shall be isolated from the horizontal bus and readily accessible by means of a bolted, removable cover plate. The bottom of each structure shall be provided with a minimum 17" x 14" rectangular area for termination of bottom entrance conduits, unless obstructed by bottom mounted devices such as transformers or capacitors. Adequate space for conduit and wiring to enter top or bottom shall be provided without structural interference and safely accessible without disrupting service. All openings shall be closed to prevent rodents from entering the enclosure.
   a. Openings shall be provided in the sides of each vertical section at the top and bottom to permit a continuous horizontal wiring trough from end to end of the motor control center.
   b. End vertical sections shall have cover plates that can be easily removed to allow addition of future vertical sections and extensions of horizontal wiring troughs and horizontal bus.

4. Compartments for housing control units shall be incremented to allow six NEMA, size 1, starter units to be mounted in each section and arranged for easy unit removal. Unit heights shall be of modular dimensions to allow for unit layout, in any combination without structural interference. A vertical wireway with a minimum of 50 square inches of cross sectional area, free of all live parts and containing cable supports, shall be adjacent to each compartment.

5. Vertical steel barriers with insulating inserts shall completely isolate the horizontal and vertical bus compartments from the motor starter unit area. Rear access shall not be necessary for inspection and maintenance of motor control centers. On front accessible only motor control centers, removable rear covers shall be provided.

6. Each vertical section shall have a minimum of 40 square inch vertical wireway extending the full height of the structure (72 inches). This wireway shall be completely barriered from the controller area, from the vertical bus area, and from adjacent vertical sections. It shall have its own separate hinged door. Wire hangers shall be provided in each vertical trough for wire tie-down. The vertical wire troughs shall intersect the top and bottom horizontal wire troughs for easy cable routing.

7. Doors shall be formed of 16-gauge steel or heavier, with all edges flanged 5/8-inch deep minimum. Doors shall be mounted on adjustable and removable pin type concealed hinges and so arranged that unit doors may be removed without disturbing unit doors above or below.

8. All buses shall be hard drawn copper. Main horizontal buses shall have a minimum rating of 600 amperes, but not less than that of the incoming feeder.

   a. Vertical buses feeding unit compartments shall be securely bolted to the main bus, each rated to carry the full connected loads as shown on the Contract Drawings, but not less than 300 amperes. Bus assemblies shall be braced to withstand short circuit current not less than 25,000 amperes symmetrical.

   b. Where shown on the Contract Drawings, provide a neutral copper bus rated 600 amperes minimum. A continuous copper equipment ground bus shall be provided in all sections. This bus shall have a minimum current rating of 300 amperes, and shall be located in the bottom of the structure, with cable lugs at each end of the line-up.

   c. All buses shall be copper, sized on the basis of not more than 1000 amperes per square inch current density.

9. Control units shall be drawout-type, with tin-plated stab assemblies for connection to the vertical bus. No wiring to stab assemblies shall extend into the bus compartments. Unit guides shall be provided to properly align stabs with the bus without the possibility of misalignment.

10. Unless otherwise shown on the Contract Drawings, construction shall be NEMA Class I, Type B, with factory wired terminal blocks mounted within the unit. No disconnection of factory wiring shall be necessary for unit withdrawal.

B. Drawout Units

Unless otherwise shown on the Contract Drawings, drawout units shall be provided with equipment specified herein.

1. Provide thermal magnetic circuit breakers with minimum interrupting capacity of 22,000 amperes, RMS symmetrical for feeding other equipment from the motor control center.

2. Capacitors, where shown on the Contract Drawings, shall be provided for each motor. The capacitors shall be mounted in separate motor control center compartments and shall be properly pre-wired at the factory to the related motor starter.

3. All interlock wiring shall be furnished and installed as shown on the Contract Drawings, various other Sections of the Specifications and in accordance with the manufacturer's instructions.

4. Each motor control unit shall be provided with a laminated phenolic nameplate, identifying the motor or devices fed as shown on the Contract Drawings.

5. Unless otherwise shown on the Contract Drawings, combination motor starters shall be full voltage non-reversing combination-type, with arc-extinguishing characteristics and silver to silver renewable contacts.

   a. Starters shall be provided with magnetic only-type circuit breakers. Starters and circuit breakers shall have a coordinated minimum short circuit interrupting capacity equal to or greater than the maximum available fault current specified for each motor control center, but not less than 22,000 amperes symmetrical.

   b. The manufacturer shall select and provide motor control center the proper starter overload elements and the circuit breaker settings. All overload elements shall be of the bi-metallic manual reset type, NEMA Class 10, equipped with one normally open alarm contact.

   c. Unless otherwise shown on the Contract Drawings, each starter unit shall be provided with not less than two normally open and two normally closed auxiliary contacts.

   d. Each disconnect shall have provisions for padlocking in the "on" and "off" positions. Size of starters and circuit breakers shall be as shown on the Contract Drawings.

   e. The minimum contactor shall be NEMA Size 1.

   f. Trip, auxiliary and alarm contacts shall be rated NEMA B600.

6. Each starter shall be complete with primary and secondary fused control transformer, with hand-off-automatic selector switch and running light mounted on the hinged front cover of each compartment.

   a. Control transformers shall be sized to adequately provide power to the connected control devices. Each ungrounded leg of the primary circuit shall be fused, using a 600-volt rated fuse, Bussmann KTK or approved equal. One leg of each 120-volt secondary circuit shall be fused using a standard 250-volt fuse. The other secondary leg shall be solidly grounded. Minimum transformer size shall be as follows:

Starter Size	Transformer VA
1	100
2	150
3, 4	200

b. Pushbuttons, selector switches, and indicating lights shall be heavy-duty oil-tight type.

c. Indicating lights shall be transformer type, with push-to-test lens assembly.

7. Combination motor control units, Size 1 through Size 4, as well as other electrical assemblies including feeder tap units through 225 amps shall be provided with appropriately rated stab assemblies for drawout type construction. Starter units Size 5 and larger, as well as feeder tap units above 225 amps, shall be bolt-in construction and will be cabled directly to the horizontal bus.

C. Painting

The motor control center shall be thoroughly cleaned and degreased before painting, then given a prime coat of zinc chromate paint. The finish shall consist of electrostatically applied paint. The finish thickness shall be between 1-1/2 and 3 mils and shall provide a highly durable, attractive surface appearance.

PART 3. EXECUTION

3.01 EXAMINATION

Verify that the electrical installation, structural, and related Work performed under other Sections of the Specifications, satisfy the requirements for the performance of the Work in accordance with the Contract Drawings and as specified in this Section.

3.02 INSTALLATION

A. The Contractor shall obtain from the manufacturer written Certificates that the circuit breakers have been properly adjusted and that the proper overloads have been installed. Prior to start up of equipment, submit the manufacturer's certification to the Engineer for approval.

B. Motor control center(s) shall be installed in accordance with details and locations shown on the Contract Drawings and in accordance with the manufacturer's instructions.

C. Cables shall be neatly racked and bundled with nonflammable nylon ties, routed and supported within the enclosure gutters, and compartments. Minimum bending radii as recommended by cable manufacturers shall not be reduced.

D. Furnish the motor control center manufacturer the actual nameplate data from all motors fed from the motor control center.

3.03 FIELD TESTS

A. In addition to other tests that may be required, perform operational tests, in the presence of the Engineer.

1. Demonstrate proper interlock and control circuit operation.

2. Demonstrate manual trip operation of overload relay, and other safety circuitry.

3. Demonstrate specified alarm and indication circuitry.

B. Provide all labor, materials and power required for the above tests other than power for the operational tests that will be furnished by the Authority.

C. Should the tests reveal defects, immediately correct such defects and rerun the tests until the entire installation is satisfactory to the Engineer in all respects.

END OF SECTION

SECTION 16480

MOTOR CONTROL CENTERS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Overall arrangement of the motor control center, including:
   - a. Overall dimensions.
   - b. Shipping sections and splits.
   - c. Identification of units.
   - d. Unit locations.
   - e. Locations of incoming line terminals.
   - f. Mounting dimensions.
   - g. Available conduit entrance areas.
   - h. Location of the master terminal board, if required.
2. Schematic and elementary diagrams for individual unit, and master terminal boards consisting of drawings which identify:
   - a. Electrical devices.
   - b. Electrical connections.
   - c. Terminal numbering designations.

B. Catalog Cuts

1. Terminal blocks.
2. Nameplates.
3. Relays.
4. Meters.
5. Circuit breakers.
6. Starters.
7. Contactors.
8. Other factory or field mounted devices shown on the Contract Drawings.

C. Manufacturer's Certifications.

END OF APPENDIX "A"

DIVISION 16

SECTION 16510

LIGHTING SYSTEMS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for Lighting Systems.

1.02 REFERENCES

American National Standards Institute (ANSI)

ANSI C 78.379	Electric Lamps - Incandescent and High-Intensity Discharge Reflector Lamps - Classification of Beam Patterns
ANSI C 82.1	Ballasts for Fluorescent Lamps – Specifications
ANSI C 82.4	Ballasts for High-Intensity Discharge and Low Pressure Sodium Lamps

Illuminating Engineering Society of North America (IESNA)

National Equipment Manufacturers Association (NEMA)

NEMA WD6	Wiring Devices - Dimensional Requirements

National Fire Protection Association (NFPA)

NFPA 70	National Electrical Code
NFPA 101	Life Safety Code

Administrative Code

NYCEC	Electrical Code of the City of New York

Underwriters Laboratories (UL)

UL 57	Electric Lighting Fixtures
UL 844	Electric Lighting Fixtures for Use in Hazardous (Classified) Locations
UL 924	Emergency Lighting and Power Equipment
UL 935	Fluorescent Lamp Ballasts
UL 1029	High-Intensity-Discharge Lamp Ballasts
UL 1570	Fluorescent Lighting Fixtures
UL 1571	Incandescent Lighting Fixtures
UL 1572	High Intensity Discharge Lighting Fixtures

OSHA Occupation Safety and Health Administration

The Energy Policy Act of 1992

Lamp Efficiency Labeling and Standards

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. Lighting System shall be furnished, supplied, installed and adjusted in accordance with this Section and as specified on the Contract Documents.

B. Components of the Lighting System manufactured, supplied, and installed shall comply with the requirements of NFPA 70, NFPA 101, all local codes, and the requirements of OSHA.

1.04 QUALITY ASSURANCE

A. Entities manufacturing lighting fixtures, equipment, and components specified herein, and as shown on the Contract Drawings, shall have a minimum of five years of manufacturing experience and shall demonstrate prior experience on at least two projects involving complexities similar to those required under this Contract.

B. Lighting equipment for which there is a nationally recognized standard shall be safety tested and bear the conformance labeling of the third party inspection authority, such as Underwriters Laboratories Inc. (UL), ETL, Factory Mutual, or approved equal, certifying that the lighting fixtures and equipment are listed as suitable for the purpose specified and shown on the Contract Drawings.

C. Lighting equipment shall be manufactured and installed in compliance with applicable articles of NFPA 70, NFPA 101 and NYCEC.

1.05 DELIVERY, STORAGE AND HANDLING

A. Lighting fixtures shall be wrapped for protection during delivery, storage, and handling. Wet or damp wrapping shall be removed, and disposed of, to prevent staining finish.

B. Deliver materials in manufacturer's original, unopened, protective packaging.

C. Store materials in original packaging in a manner to prevent soiling and physical damage, prior to installation.

D. Handle in a manner to prevent damage to finished surfaces.

E. Where possible, maintain protective covering until installation is complete and remove such coverings as part of final cleanup.

1.06 SPARE PARTS

A. Unless otherwise noted on the Contract Document, provide 10% (or minimum of 12) replacement lamps for each type of lamp installed.

B. Unless otherwise noted on the Contract Document, provide 5% (or minimum of 2) replacement ballasts for each type of ballast installed.

1.07 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

A. General

All components of the lighting system shall be manufactured by the companies shown on the Contract Drawings.

2.02 MATERIALS

A. General

The location, number, size, and type of all lighting fixtures and accessories to be installed shall be as shown on the Contract Drawings.

B. Lighting Fixtures

Lighting fixtures shall be furnished with lamps, which comply with the requirements of this Section, and as shown on the Contract Drawings. All fluorescent and high intensity discharge lighting fixtures supplied shall come with factory installed ballasts, which comply with the requirements of this Section, and as specified on the Contract Drawings.

Unless otherwise shown on the Contract Drawings lighting fixtures shall comply with the following requirements:

1. Housing

   a. Lighting fixtures shall be of rigid construction and built in accordance with NEMA WD6.

   b. Ferrous components shall be protected from corrosion by plating or finished with white baked enamel unless another color is shown on the Contract Drawings. All paint shall be spray-applied and baked at 350°F, for at least 20 minutes. Interior surfaces of all fluorescent fixtures shall be white enamel of minimum 87% reflectance.

   c. Exposed parts of the lighting fixture housing shall be free from spinning lines, ripples, or other visible marks and manufacturer's stickers.

   d. Outdoor lighting fixture housings shall be constructed of copper-free cast aluminum (copper content less than 0.4%, Alloy 360.4) or stainless steel. Housings shall be properly gasketed to be watertight. All hardware shall be stainless steel.

   e. Recessed lighting fixture housings shall be constructed of a minimum 20-gauge cold-rolled steel and painted with a white, baked enamel finish.

   f. Pendant and surface-mounted, continuous lighting fixture housings shall be constructed of extruded aluminum and treated with the finish specified on the Contract Drawings.

g. Ballast compartment shall be so designed that ballast temperature shall not exceed the UL limit of 105°C at 40°C ambient temperature.

2. Optical System

a. Reflectors

(1) Unless otherwise shown on the Contract Drawings, fluorescent, parabolic louvers shall be constructed of non-iridescent, semi-specular aluminum with a minimum reflectance of 85%.

(2) Diffuser reflectors shall be finished with high-reflectance, baked white enamel with a non-yellowing binder.

(3) Clear reflector inserts for fluorescent lighting fixtures shall be fabricated of aluminum or steel backing with a silver film laminate which shall be guaranteed by the entity manufacturing the lighting fixtures against separation and peeling for a minimum of five years. Minimum reflectance shall be 92%.

(4) The visible clear Alzak reflectors shall be of non-iridescent finish with a minimum reflectance of 90%.

b. Lenses, Diffusers, and Shielding Devices

(1) Lenses, diffusers, and shielding devices shall be properly and securely mounted within the lighting fixture housing. Lay-in lenses, diffusers, or shielding devices shall not be acceptable.

(2) Glass lenses or diffusers shall be constructed of tempered, borosilicate glass.

(3) Plastic lenses or diffusers shall be white opal or clear, prismatic, 100% ultraviolet-stabilized acrylic or high-impact polycarbonate. Plastic lenses shall be installed with the smooth side out.

(4) The shielding and optical materials shall be tightly fitted with no loose parts and shall show no visible leaks of unintentional light.

3. Exit Signs

a. Furnish single and double face Exit Signs with hardware suitable for wall or ceiling mounting as shown on the Contract Drawings.

b. Exit Signs shall be guaranteed by the manufacturer for a minimum of five years.

c. Surface mounted Exit Signs shall be of die-cast aluminum construction with aluminum faceplates and invisible universal arrows and mounting knockouts for field adjustment. Finish of the housing and faceplates shall be as shown on the Contract Drawings. Exit Signs shall be single or double face, and shall be suitable for ceiling, back, or end mounting.

d. Edge-lit Exit Signs shall be of UV stabilized acrylic construction with inbeded, laminated legend and arrows.

e. Exit Signs shall be energized from either 120 VAC or 277 VAC. Exit Signs shall operate on Light Emitting Diode (LED) light sources and shall consume a maximum of six watts per Sign face.

f. Average luminance of the legend "EXIT" shall be no less than 15 cd/m^2 (5 Fl) with uniformity ratio (max/min) no greater than 3/1.

4. Emergency Battery Operated Lights

a. Emergency Battery Operated Lights specified herein shall be:

(1) Fluorescent Fixture with internal or external battery pack

(2) Battery Operated Exit Sign

(3) Incandescent Emergency Lighting Fixture

b. Emergency Battery Operated Lights shall automatically switch "ON" when normal or emergency power supply fails and provide a minimum of 90 minutes of reduced illumination.

c. The fluorescent batteries of fixtures used for both, normal and emergency lighting, shall be of the nickel-cadmium or the lead-calcium type and shall have sufficient electrical capacity to energize the connected lamps at a minimum of 50% of normal light output. The battery shall be guaranteed by the manufacturer for a minimum of five years.

d. The battery charger shall be the dual-rated type and shall have sufficient capacity to recharge the discharged battery to full charge within twelve hours, maximum.

e. Emergency Battery Operated Lights shall be equipped with a test switch and an LED lamp indicating AC power is on.

C. Lamps

1. General

Lamps shall comply with the requirements of the Energy Policy Act of 1992 or it's latest editions.

2. Fluorescent Lamps

Unless otherwise shown on the Contract Document, lamps shall comply with the following requirements:

a. Tubular Type

(1) Lamp tube diameter shall be T8, T10, or T12

(2) Lamps shall have triphosphor coating with a minimum Color Rendering Index (CRI) of 70

(3) Minimum average lamp life at 3 hours per start shall be 20,000 hours

(4) Minimum efficiency shall be 80 lm/W (lumens per Watt).

(5) Maximum lamp lumen depreciation at the end of rated life shall be 20%

b. High Output (HO) and Slimline Type

(1) Lamp tube diameter shall be T8 or T12

(2) Lamps shall have triphosphor coating with a minimum Color Rendering Index (CRI) of 70

(3) Minimum average lamp life at 3 hours per start shall be 12,000 hours

(4) Maximum lamp lumen depreciation at the end of rated life shall be 20%

c. Compact Fluorescent Lamps

(1) Minimum average lamp life at 3 hours per start shall be 10,000 hours

(2) Lamp shall have a triphosphor coating with a minimum Color Rendering Index (CRI) of 82

(3) Minimum efficiency shall be 65 lm/W

(4) Maximum lamp lumen depreciation at the end of rated life shall be 15%

3. Incandescent and Tungsten Halogen Lamps

Unless otherwise shown on the Contract Document, lamps shall comply with the following requirements:

a. Incandescent and tungsten halogen lamps shall have a minimum average lamp life of 2500 hours.

b. Incandescent reflector type lamps shall have beam patterns as shown on the Contract Drawings and conforming to ANSI C 78.379.

4. High Intensity Discharge Lamps

Unless otherwise shown on the Contract Documents, lamps shall comply with the following requirements:

a. High Pressure Sodium (HPS) Lamps

(1) Minimum average lamp life at 10 hours per start: 24,000 hours

(2) Minimum efficiency: 75 lm/W

(3) Maximum lamp lumen depreciation at the end of rated life: 20%

(4) Maximum color shift: ±250 degrees Kelvin

b. Metal Halide (MH) Lamps

(1) MH lamp fixtures shall be connected only to circuits that are turned off for at least 15 minutes a week. Use of MH lamps in uninterrupted 24-hour operation circuits is not permitted.

(2) Minimum average lamp life at 10 hours per start shall be 15,000 hours for lamp burning in a vertical position. For lamps burning in a horizontal position, as follows:

Lamps < 400 W:	10,000 hours
400 W lamps:	20,000 hours
1000 W lamps:	12,000 hours
1500 W lamps:	6,000 hours

(3) Minimum efficiency: 75 lm/W

(4) Maximum lamp lumen depreciation at the end of rated life: 30%

(5) Maximum color shift: ±250 degrees Kelvin.

(6) Minimum Color Rendering Index (CRI): 65

c. Mercury Vapor (MV) Lamps

Unless otherwise shown on the Contract Drawings, MV lamps shall not be permitted for general illumination purposes.

D. Ballasts

1. Fluorescent Lamp Ballasts

a. Fluorescent lamp ballasts shall comply with ANSI C 82.1 and shall be Class 'A' sound rated Class 'P' listed by ETL and UL.

b. Fluorescent lamp ballasts shall be certified for the appropriate for the application minimum starting temperature.

c. Unless otherwise shown on the Contract Drawings, fluorescent lamp ballasts for indoor applications shall be high-frequency, electronic type, suitable for operation in rapid start circuitry and comply with the following requirements:

(1) Minimum Power Factor: 0.950

(2) Total Harmonic Distortion: less than 20%

(3) Lamp Current Crest Factor: less than 1.7

(4) Lamp Current Frequency: greater than 20 kHz

(5) In-rush current: less than 20x normal current

d. Fluorescent lamp ballasts shall be wired and grounded in accordance with NFPA 70 and the manufacturer's written instructions.

2. High Intensity Discharge (HID) Ballasts

a. HID lamp ballasts shall comply with ANSI C 82.4, and shall be the high-power factor, constant wattage auto-transformer (CWA), or similar, type of automatic wattage regulation.

b. The power loss of HID lamp ballasts, as a percentage of lamp wattage, shall not exceed 20%.

c. HID lamp ballasts for indoor applications in public spaces shall be encased and potted for the purpose of noise reduction.

d. HID lamp ballasts shall be wired and grounded in accordance with NFPA 70 and the manufacturer's written instructions.

e. Remote HID lamp ballasts shall be installed in accordance the manufacturer's written instructions.

f. Unless otherwise noted on the Contract Drawings all HPS ballasts, which are not used in 24 hours operations, shall be furnished with automatic protective starters. An automatic protective starter shall apply pulses for no more than 15 minutes and then deactivate if a lamp arc cannot be initiated.

E. Fuses

Fuses and fuse assemblies shall be as shown on the Contract Drawings.

F. Lighting Control

1. Lighting Management System

a. The lighting management system shall automatically switch lights on and off according to a time clock schedule, amount of daylight present, and in accordance with the requirements of this section and as shown on the Contract Documents.

b. A factory-trained field service engineer shall be to functionally test each hardware and software component in lighting management system after installation, and to provide on-site training for Authority personnel. The minimum of 16 hours training session shall consist of the following parts:

(1) general description of the system and operational functions of it's components

(2) hands on training for each of the hardware components (performance, maintenance, repair, parts replacement)

(3) hands on software training (programming, operation, modem connection)

At least two representatives from the facility where the system is being installed, two representatives from the electrical maintenance group and two representatives from the Authority engineering department shall be present for the training.

Manufacturer shall provide a minimum of 6 complete operation manuals.

c. Remote Power Switching Panelboards

(1) The remote power switching lighting panelboards shall be mounted in electrical closets and shall comply with Section 16470 of these Specifications and as specified on the Contract Documents.

(2) The remote power switching panelboards shall consist of a microprocessor-based control module, interface module, control busses, remote-controlled breakers, and Class 2 barriers.

(3) The remote power switching panelboards shall meet or exceed the following capabilities:

(a.) Individual control for up to 42 remotely controllable circuit breakers.

(b.) Eight dry-contact inputs for connection to either 2-wire maintained or 3-wire momentary external control devices.

(c.) Zone creation and control of individual circuit breakers or zones.

(d.) Run/Halt/Hold/All-On operational modes.

(e.) Individual circuit breaker and zone manual override.

(f.) Circuit breaker status monitoring.

(g.) Security access codes.

(h.) Telephone override.

(i.) Diagnostic testing of memory, keyboard, screen, com ports, and circuit breaker.

(j.) Expansion port to connect additional inputs via expansion cabinet.

(k.) RS-232 port for connection to personal computer.

(l.) Non-violable EEPROM memory.

(4) All electronic modules and circuit breakers in the panelboards shall be mounted in the positions and control the loads as indicated on the panel wiring schedules indicated on the Contract Drawings.

(5) Emergency panelboards shall respond to the loss of normal power in the associated normal panel by automatically switching on all emergency circuits.

d. Addressable Relay Panels

(1) Addressable relays shall provide inputs and outputs directly compatible with the existing remote power switching panelboard system.

(2) Each remotely controlled relay panel shall be furnished with at least one manual on/off override.

(3) The addressable relay panels shall meet or exceed the following capabilities:

(a.) Protocol shall be based on a modified ANSI 3.28.

(b.) Run length without repeaters shall be 10,000 feet at 9,600 Baud, full duplex.

(c.) Up to 16 analog inputs and digital inputs. These inputs shall except directly, occupancy sensors and variable output ambient light sensors.

(d.) All information shall be stored internally in register locations and be readable/writeable from any device on the high-speed network.

(e.) Addressable in the range of up to 32 panels.

2. Photoelectric Control Devices

a. The location, number, size, and type of all ambient light sensors, timers, and occupancy sensors to be installed shall be as shown on the Contract Drawings.

b. The ambient light sensor shall have a cadmium sulphide, hermetically sealed photocell, shall be fully temperature-compensated, and shall provide for a time delay of at least 15 seconds to prevent false switching. The ambient light sensors shall be remotely mounted where shown on the Contract Drawings.

c. The ambient light sensor shall meet or exceed the following capabilities:

(1) There shall be different lighting sensors for different tasks (i.e. atrium, skylight and outdoor).

(2) Separately mounted resolution enhancement adjustment.

(3) The photoelectric device shall be a class 2, low voltage type.

(4) Output shall be directly proportional to light measured.

(5) Fully adjustable response in the range between 0 and 10,000 foot-candles with +/-1% accuracy at 21C.

(6) The housing shall be constructed from flame-retardant material, and meet UL984 HB standards.

(7) Outputs shall be 4-20mA or 0-10Volt.

(8) Power supplies shall be available in a range of voltages.

d. The time switch shall function to prevent lighting from being energized at pre-set periods each day. The time switch shall permit different "ON-OFF" settings for each day of the week, with provision for omitting selected days. The time switch shall have at least 4 inputs. Unit shall be capable of retaining memory for no less than 90 days. When permitted by the time switch, photoelectric controls shall operate to energize lighting whenever natural lighting falls below 2,5 lux (25 FC).

3. Occupancy sensors

a. The occupancy (motion) sensors shall be designed to control lighting automatically based on the presence or absence of people.

b. The ultrasonic occupancy sensors shall produce a low intensity, inaudible sound (above 22KHz) and detect changes in the acoustic waves caused by motion. The sensors shall not respond to audible sound. If the sensors detect motion, the internal or external relays shall close the contacts and turn on the connected lighting loads. If no motion occurs within a pre-set period of time, the lights shall be automatically turned off.

c. Ultrasonic detectors shall be precision crystal-controlled. Sensors shall not interfere with each other when two or more sensors are placed in the same room.

d. The passive infrared occupancy sensors shall maintain a detection when the person of average size and weight moves within a maximum distance of 8 inches at the speed of 12 inches per second.

e. The occupancy sensors shall be equipped with LED walk indicator, which shall be visible from any area in the room.

f. The occupancy sensors shall be furnished with an adjustable timer for delayed turn-off. The time delay shall be adjustable from 30 seconds to 15 minutes.

g. The occupancy sensors shall be furnished with adjustable sensitivity control. Although, sensitivity shall be high, false triggering by random noises or motions other than human movement shall not be permitted.

h. The occupancy sensors shall be furnished with manual override switch that will enable a bypass of the sensor in the event of failure.

i. The sensors shall be connected to power modules. The power module consumption shall not exceed 2VA in any mode of operation. The power modules shall combine a Class 2 (120V/277V) transformer and heavy duty relay with form A isolated contacts in a single housing. The relay shall be rated for 20A operation.

j. The sensors shall be suitable for ceiling-mounted installation and shall not protrude more than 1-1/2 inches from the ceiling surface.

k. All sensors or equipment supplied shall be accompanied by electronic circuit diagram, component layout, circuit description and installation instructions.

l. All devices shall have a minimum three-year factory warranty for materials and labor.

m. All sensors shall be properly masked and adjusted for required sensitivity and time delay. Coordinate adjustments with manufacturer.

4. Dimmers

a. Wallbox dimmers shall be of linear sliding type and shall be rated for operation with the specified connected load. Dimmer shall be designed to smoothly change light output of the lamps without visible flicker. Rotary type dimmers are not permitted.

b. Wallbox dimmers shall be equipped with built in on/off switch and preset control button.

c. Furnish an appropriate wallbox dimmer for each individual type of load:

(1) Incandescent

(2) Electronic low voltage

(3) Magnetic low voltage

(4) Fluorescent

d. Preset dimming control system shall be as shown on Contract Drawings and shall meet or exceed the following capabilities:

(1) System shall have four preset scenes and off for up to 8 control zones.

(2) System shall be mountable in a standard 2, 3 or 4 gang metal wallbox. Wallbox shall be as specified in Section 16135 of this Specification.

(3) One raise/lower switch with visual display shall be available for each zone.

(4) A temporary master raise/lower switch shall move all light levels up or down.

(5) System shall have smooth fade mode. Switching time between scenes shall be adjustable from 1 second to 90 minutes.

(6) A temporary zone override shall be provided.

(7) Multiple controls and remote wallstations shall be capable of activating each of the preset scenes and shall not interfere with each other.

G. Contactors

1. Contactors shall be of the single coil, electrically operated, mechanically held type. Positive locking shall be obtained without the use of hooks, latches, or semi-permanent magnets. Contactors shall be required to make, but not break, the operating coil current.

2. The contactor's main contacts shall be the double break, silver-to-silver type protected by arcing contacts. Contacts shall be self-aligning and renewable from the front of the panel.

3. The contactor's control connections shall be clearly marked "L" for line wire, "C" for closing wire, and "O" for opening wire. A manual operating lever shall be included with the contactor.

4. Each contactor shall be equipped with a control line fuse, a coverplate to conceal contacts, and one normally open auxiliary contact.

5. Unless otherwise shown on the Contract Drawings, contactors shall be mounted separately in a sheet steel, NEMA 12 enclosure. Grouped contactors shall be installed in a common sheet steel, NEMA 12 enclosure.

6. Unless otherwise shown on the Contract Drawings, relays for two-wire control shall be provided, where required, for the operation specified on the Contract Drawings.

PART 3. EXECUTION

3.01 EXAMINATION

A. Inspect all lighting fixtures, equipment, and accessories prior to installation. Replace any damaged items.

3.02 PREPARATION

A. The Contractor shall be responsible for field verification of dimensions and coordination of conduit entry and all other mounting conditions with the entity manufacturing lighting fixtures.

B. Unless otherwise shown on the Contract Drawings, all lighting outlets shall have lighting fixtures. In instances where a specific lighting fixture has not been assigned to a lighting outlet, furnish and install a complete lighting fixture of the type and wattage designated for outlets of similar function and/or type as directed by the Engineer.

C. Unless otherwise shown on the Contract Drawings, lighting fixtures and/or fixture outlet boxes shall be provided with hangers to adequately support the complete weight of the lighting fixture. The design of hangers and the method of fastening other than what is shown on the Contract Drawings, or herein specified, shall be submitted to the Engineer for approval.

3.03 INSTALLATION

A. Install all lighting equipment and accessories, as well as all lighting fixtures, complete with lamps, in the locations shown on the Contract Drawings in accordance with the manufacturer's written instructions. All lighting fixtures shall be properly secured to structural elements.

B. Lighting fixtures shall be carefully supported and aligned with necessary hangers, supporting members, and plaster frames for proper installation, all as shown in the Contract Drawings and the Specifications, and as approved by the Engineer. No rivets, springs, or other hardware shall be visible after installation.

C. Lighting fixtures shall be supported to satisfy seismic requirements described in applicable local codes.

D. All lighting fixtures shall be properly wired and connected to branch circuits, tested, and left ready for operation. Bond all lighting fixtures and metal accessories to the branch circuit-grounding conductor.

E. Where a continuous string of lighting fixture is specified to be installed, the lighting equipment shall be installed so as to produce a continuous, straight, unbroken band of light, free of visual imperfections, socket shadows, light gaps, etc.

F. All pendant-mounted lighting fixtures within the same room or area shall be installed plumb, and at a uniform height from the finished floor. Adjustment of a height shall be made during the installation. Unless otherwise shown on the Contract Drawings, stems and canopies shall be matched to the associated lighting fixtures.

G. Install recessed lighting fixtures to permit removal from below. Use accessories and firestopping materials to meet regulatory requirements for fire rating.

3.04 ADJUSTMENTS

A. Prior to final inspection, relamp all fixtures which have failed lamps, or lamps where visible color shift has occurred, and leave all lighting fixtures, equipment, and accessories in good, uniform operating condition. The Contractor shall replace any burned-out lamp during the first 100 days after the completion of the Contract.

B. Aim and adjust all lighting fixtures as shown on the Contract Drawings.

C. Adjust exit sign arrows as shown on the Contract Drawings.

D. Cleaning

1. Clean all components of the lighting system to remove conductive and deleterious materials.
2. Remove dirt and debris from all enclosures.
3. Clean finishes and touch up damage.

END OF SECTION

SECTION 16510

LIGHTING SYSTEMS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. For each lighting fixture type: Clearly illustrate assembly methods, detailed dimensions, mounting details, materials, finishes, electrical components, and light sources.
2. For each lighting fixture type: Submit independent testing laboratory photometric report, and performance data in IESNA format
   a. Luminaire, ballast and lamp description and manufacturer's complete catalog number
   b. Luminaire drawing with basic dimensions
   c. Candela Distribution Table and Curve
   d. Coefficient of Utilization Table
   e. Visual Comfort Probability Table
   f. Zonal Lumen Summary Table
   g. Luminance Summary Table
   h. Input Watts
   i. Luminaire Efficiency
3. For each lighting fixture type support: Submit verification of compliance with seismic requirements of applicable codes.
4. For each ballast type: Submit manufacturer's data with ballast description, catalog number, lamp type, input voltage, in-rush current, line current, input wattage, ballast factor, power factor, crest factor, minimum starting temperature, total harmonic distortion and wiring diagram.
5. Lighting management system: Submit shematic wiring diagrams, component specifications, enclosure dimensions, installation details, operation manual, and approvals of respective standards.
6. Dimmer system components: Submit schematic diagrams, component specifications, enclosure dimensions, installation details, and approvals of respective standards.
7. Photoelectric Control Devices: Submit manufacturer's data for ambient light sensors, timers, infrared and ultrasonic occupance sensors.

B. Samples

For items indicated on the Contract Drawings submit working samples for review and approval upon request by the Engineer. Install and energize samples as shown on the Contract Drawings or as directed by the Engineer.

C. Mock-up

1. If requested on the Contract Drawings, provide mock-up installation for review and approval by the Engineer. The mock-up shall simulate specified lighting system conditions as shown on the Contract Drawings.

2. For each substitution item which is not specified on the Contract Drawings provide mock-up installation at no cost to the Authority if requested, and as directed by the Engineer.

END OF APPENDIX "A"

SECTION 16510

LIGHTING SYSTEMS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.02) 1.02 SHOW LIGHTING FIXTURES LAYOUT INDICATING LOCATION, TYPE, ELECTRIC PANEL AND CIRCUIT NUMBER FOR EACH LIGHTING FIXTURE. INDICATE MEANS OF LIGHTING CONTROL. SHOW LIGHTING LEGEND WITH LIGHTING FIXTURE CHARACTERS AND SHORT LIGHTING FIXTURE DESCRIPTIONS.

(2.02.F) 1.03 SHOW LIGHTING FIXTURE SCHEDULE WITH PRECISE FIXTURE DESCRIPTION AND MANUFACTURER'S CATALOG NUMBER. SPECIFY HOUSING DIMENSIONS, CONSTRUCTION, MATERIAL, AND FINISH. SPECIFY OPTICAL ASSEMBLY. SPECIFY LAMP, BALLAST, OPERATING VOLTAGE AND MOUNTING CONDITION. SPECIFY SPECIAL FEATURES. SPECIFY FIXTURE MANUFACTURERS AND CATALOG NUMBERS.

(1.04.B) Specify UL listing application, Damp, Wet, Marin or Hazardous environment.

(2.02.G) Specify means of lighting control:

Switches, wall box dimmers, preset dimming systems, photoelectric control devices, occupancy sensors, lighting contactors.

If a lighting management system is used, verify compatibility with existing lighting management system and specify the following:

Operational requirements of the lighting management system and interface requirements with other building systems such as existing lighting management system, fire alarm, HVAC, baggage motor centers, central time synchronization, security, etc.

Personal Computer hardware and software capacity, monitor size, and software graphical interface capability.

Block wiring diagram with panelboard numbers and locations, auxiliary controls, conduit and wiring. On-site service and personnel training requirements, Specify number of sessions, hours and topics to be covered during the training

A. Other Items

Ensure that the specifications include the following Sections referenced in this Section:

(2.02.G.1.c.1) "PANELBOARDS AND CABINETS"

(2.02.G.4.d.7) "BOXES AND FITTINGS"

END OF INSTRUCTIONS

DIVISION 16

SECTION 16527

HIGH MAST FLOODLIGHT SYSTEMS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for high mast floodlight systems.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

National Fire Protection Association (NFPA)

NFPA 70	National Electrical Code
NFPA 101	Life Safety Code

American Association of State Highway and Transportation Officials (AASHTO)

AASHTO LTS-2	Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals

American Society for Testing and Materials (ASTM)

ASTM A 36	Structural Steel
ASTM A 123	Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 143	Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
ASTM A 153	Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 615	Deformed and Billet-Steel Bars for Concrete Reinforcement
ASTM A 572	High-Strength Low-Alloy Columbium-Vanadium Steel of Structural Quality
ASTM A 595	Steel Tubes, Low-Carbon, Tapered for Structural Use

American Institute of Steel Construction (AISC)

AISC	Specification for the Design, Fabrication and Erection of Structural Steel for Buildings

American Welding Society (AWS)

AWS D 1.1, D 1.5 Structural Welding Code, Steel

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. The high mast floodlight systems shall be furnished, supplied, installed, adjusted and tested in accordance with this Section and as specified on the Contract Drawings.

B. The high mast floodlight poles shall be designed in accordance with AASHTO LTS-2, the local Building Code and the provisions of the AISC Specifications. In case of conflict, the more stringent requirement shall govern. The poles shall be designed for vibration and fatigue using two million vibration cycles. All structural details shall be checked for fatigue resistance by applying governing fatigue loading, computing nominal stress ranges at the details and assuring that the stress ranges are less than the constant-amplitude fatigue limits for the particular details.

C. The design windload shall be the pressure of the wind based on a wind velocity of 90 m.p.h. (and shall include a 30 percent gust factor) on the pole with all appurtenances installed as shown on the Contract Drawings, including but not limited to lowering ring, luminaries, pole and base.

D. Physical properties of poles shall be such that horizontal linear displacement due to the transverse load application is not greater than 5% of the structure height or the limitations set by vibration or fatigue analysis.

E. Structural design calculations of floodlight poles assemblies, including anchor bolts, bases, and lowering devices shall be signed and sealed by a Professional Engineer licensed in the State where the installation will take place.

1.04 QUALITY ASSURANCE

A. Entities manufacturing high mast floodlight equipment, and components specified herein, and as shown on the Contract Drawings, shall have a minimum of five years of manufacturing experience and shall demonstrate prior experience on at least two projects involving complexities similar to those required under this Contract.

B. Electrical equipment for which there are a nationally recognized standards shall be safety tested and bear the conformance labeling of the third party inspection authority, such as Underwriters Laboratories Inc. (UL), Electrical Testing Laboratory (ETL), Factory Mutual, or approved equal, certifying that the electrical equipment is listed as suitable for the purpose specified and shown on the Contract Drawings.

C. Electrical equipment shall be manufactured and installed in compliance with applicable articles of NFPA 70, NFPA 101 and all local codes.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in the manufacturer's original, unopened, protective packaging. Wet or damp wrapping shall be removed, and disposed of, to prevent staining finish.

B. Store materials in manufacturer's original protective packaging in a manner to prevent soiling and physical damage, prior to installation.

C. Maintain protective covering until installation is complete and remove such coverings as part of final cleanup.

D. Handle in a manner to prevent damage to finished surfaces. Touch up any damage to finishes to match adjacent surfaces.

1.06 SPARE PARTS

A. Unless otherwise noted on the Contract Drawings, provide 10% (or minimum of one) spare winch assemblies.

B. Unless otherwise noted on the Contract Drawings, provide 10% (or minimum of 12) replacement lamps for each type of lamp installed.

C. Unless otherwise noted on the Contract Drawings, provide 5% (or minimum of 2) replacement ballasts for each type of ballast installed.

1.07 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide high mast floodlight systems of manufacturers listed on the Contract Drawings.

2.02 MATERIALS

Unless otherwise noted on the Contract Drawings, materials for high mast floodlight systems shall be as specified below:

A. Pole

Pole shaft shall consist of round and multi-sided tapered steel tubes. Pole sections over 12.5 inches in diameter shall be fabricated of ASTM A 572, Grade 65 material with minimum yield strength of Fy = 65ksi. Sections 12.5 inches and under in diameter shall be fabricated of ATSM A 595, Grade A steel modified to 55,000 psi minimum yield strength. Shaft shall be hot-dip galvanized after fabrication in accordance with ASTM A 123 and A 143.

B. Anchor Base Plate

Steel plate fabricated from hot rolled weldable, low carbon steel conforming to ASTM A 572, Grade 42 shall be circumferentially welded to the pole top and bottom. The material shall possess a minimum yield strength of Fy = 42 ksi. Base Plate shall be hot-dip galvanized after fabrication in accordance with ASTM A 123 and A 143.

C. Anchor Bolt Assemblies

Fabricated from low carbon high strength steel alloy conforming to ASTM A 615 possessing a minimum yield strength of Fy = 75 ksi. Each anchor bolt shall be provided with two (2) hex nuts and two (2) flat washers and two (2) leveling shims. The threaded end of each anchor bolt and each hex nut and washer shall be hot-dip galvanized in accordance with ASTM A 153 without hydrogen embrittlement.

D. Bracket Arms

Fabricated from 2" schedule 40 pipe shall conform to ASTM A 513.

E. Lighting Fixture Housings

Fabricated from copper-free aluminum Alloy 360.1 with 0.4% copper content.

2.03 CONSTRUCTION FEATURES

A. General

The locations, sizes and types of high mast floodlight pole assemblies are shown on the Contract Drawings.

B. Pole

1. Shaft shall be tapered steel tubing. All shaft steel shall be full gauge without laminations. All sections of the shaft shall have a uniform taper from top to bottom and shall be full length longitudinally welded. Weld shall be as per AASHTO LTS-2, AWS D1.1 & D1.5, whichever will govern. All welds shall be inspected by methods described in AASTO LTS-2. The Authority shall perform additional testing as directed by the Engineer.
2. The overall height dimension as shown on the Contract Drawings shall be achieved by a combination of shop welding and/or field telescoping of one section onto another.
3. Pole shaft shall be secured to the ground by base plate with anchor bolts.
4. All transverse welds and all base plate welds shall be 100 percent penetration. Longitudinal welds shall be 60 percent minimum penetration. The longitudinal weld in slip joint area shall be reinforced. Inspection shall consist of ultrasonic testing for all 100 percent penetration welds, visual and magnetic particle for all others.
5. Overall pole height shall not deviate from the specified height plus or minus 1 percent. Sweep and camber shall be maximum of 1/8 inch per 5 feet. Twist shall be a maximum of 10 degrees overall.
6. The handhole shall be located 6 inches above the base plate and shall be approximately 14 inches by 36 inches outside dimensions and shall have a suitable hinged door and quarter turn lock.

7. Welded splices or connections shall be in accordance with AWS D 1.1. In material where the yield point is increased by cold working or other physical means, the strength of the welds themselves shall be based upon the properties of the base metal prior to working.

8. A grounding lug shall be welded adjacent to the equipment handhole inside the pole, and shall be suitable for connection with #4/0 AWG bare copper cable as shown on the Contract Drawings.

9. Resistance of all joints in pole shall not exceed that of parent material.

10. Lightning rod assembly shall be bronze and mounted on top of pole. Rod shall be 2-inch diameter, lead coated solid copper and shall have a terminal as shown on the Contract Drawings.

11. Each anchor bolt shall be threaded as required, and have a 90 degree hook. Anchorage shall be based on the more stringent of AISC and AASHTO codes. Anchor bolts shall be provided with a full-size bolt circle template.

12. The foundation and anchorage system shall be designed for loads equal to, or greater than, the maximum loads that the pole is designed for. The geotechnical criteria shall be stated in order to determine the type of footing to be used (i.e. spread footing).

C. Lowering Device

1. Power Unit

a. The power unit shall be a drill type tool with a heavy duty reversing motor with the stalled torque at least twice that required to operate the device. The motor shall drive the winch through the torque limiter coupling to limit the lifting force exerted on the cables. The torque limit shall be factory pre-set. There shall be a back-up shear pin designed to shear at torque level between 50% and 100% over the torque limiter setting. Provide five extra pins with each power unit. The motor shall be controlled by the switch connected by a 20-foot remote cord.

b. The motor shall be provided with a support frame that can be mechanically connected to the winch assembly.

c. The portable power unit shall be provided with a portable, enclosed and encapsulated transformer to step down the voltage from the value specified on the Contract Drawings to 120V to operate the power unit. The transformer shall be provided with carrying handle. All electrical connections shall be pre-wired outdoor type twist-lock caps and plugs.

d. Utilize the unit in the erection of the floodlight pole assemblies and upon completion of said work deliver the unit, in good operating condition, to a location designated by the Engineer.

e. Unless otherwise indicated on the Contract Drawings, provide one power unit per each ten poles installed.

2. Winch and Gear Reducer Assembly

a. The winch shall be designed for power operation. The winch shall have a strength at least five (5) times the lifted load with the number of layers of cable with which it will be used. The winch shall be supported from both ends and stainless steel keepers shall be provided to ensure the uncoiled cable will properly rewrap onto the drum.

b. The worm gear reducer shall have a minimum of 30 to 1 reduction ratio and include an internal drag brake on the worm shaft to prevent free spooling of the winch drum.

c. The drum shall be capable of winding 150 feet of cable and shall be factory pre-wound with stainless steel 7x19 aircraft cord of 1/4-inch diameter and sufficient length to maintain at least eight (8) complete wraps on the drum after the device has been lowered to its lowest position.

d. A disconnecting type clevis assembly shall be crimped on the end of the drive cable at the factory, and an adapter plate for connecting the reducer onto the drive mounting plate shall be provided with each reducer assembly.

e. The winch shall be welded to a removable mounting plate connected to the pole structure with four (4) stainless steel bolts and with welded bottom lip to release stress from the bolt connections.

f. All hardware shall be hot-dip galvanized according to ASTM A 153.

3. Transition Clevis Assembly

a. The transition clevis assembly shall be fabricated of A 36, quality steel and shall be hot-dipped galvanized.

b. A transition clevis assembly shall be used to properly attach winch cable to the three (3) hoisting cables and the main electrical power cord. To prevent the cables from untwisting while loaded, which would result in a reduction of tensile strength of the cable, the clevis shall not allow either the winch cable or any of the hoisting cables to independently rotate.

c. The underside of the transition plate shall contain three compression springs Type S54. The springs shall be internally supported by a galvanized eye-bolt assembly for connection to the main drive cable. Each spring loaded eye-bolt shall have its corresponding 7x19 stainless steel woven aircraft hoisting cable of 3/16" diameter attached to it by means of factory installed crimps.

4. Headframe Assembly

a. The headframe shall be attached to the pole by means of a steel slip fitter and secured by stainless steel screws. The assembly shall be made of a minimum A36 quality steel and hot-dip galvanized per ASTM A 123.

b. The headframe shall encompass six (6) hoisting cable sheaves with the minimum diameter of six (6) inches. The cable grooves shall be machined to eliminate any rough surface on which cable shall ride. Oil impregnated sintered bronze bushing shall be pressed into the steel sheave hub and shall ride on stainless steel shafts.

c. Sheaves shall be housed inside side plates with stainless steel cable keepers. Each sheave shall utilize a keeper bolt arrangement to prevent cables from jumping the sheave.

d. The headframe shall include three (3) symmetrically located latching devices. The latches shall contain no moving parts and shall remove all loading from the suspension and drive cables. The latches and hardware shall be A36 quality steel and shall be galvanized. Each latch shall be strong enough to support three (3) times the weight of the entire ring and the maximum number of luminaires.

e. Indicator flags shall turn automatically during locking process, providing a signal visible from the ground that the latch is securely locked.

f. The power cable shall ride over a roller assembly. The assembly shall consist of multiple rollers installed between two (2) vertical side plates. To prevent abrasion of the cable as it travels through the headframe, the rollers shall be made of resin. The rollers shall be located on a radius on both ends of the assembly to support power cable in at least a seven (7)-inch, bending radius. A keeper bar shall be positioned at both ends of the assembly to keep the cord in its track during pole erection and normal operation.

g. All suspension cables shall be pre-strung in the factory through the head assembly.

h. The entire headframe assembly shall be covered by the bird-proof, aluminum-free, cover hood. The hood shall fit the cable sheaves in such a manner as to prevent the cables from jumping the sheave. The hood shall be attached to the frame by means of stainless steel screws and self-locking nuts.

5. Luminaire Ring Assembly

a. The ring shall be made of a minimum seven (7)-gauge A36 quality steel channel and shall be hot-dip galvanized. The ring shall have welded to it a sufficient quantity of 2" diameter galvanized steel pipe tenons for attachment of the luminaires.

b. The luminaire tenon shall be pre-wired, with power cord running from the tenon to the junction box. The ring shall contain three stainless steel locating pins, each with a stainless steel sleeve.

c. The ring assembly shall be furnished with spring loaded iris guide arms or other centering device that will center the luminaire ring while ascending or descending the pole. The centering device shall be capable of keeping the ring concentric about the pole in winds up to 30 mph.

6. Wiring

a. Each ring shall be furnished with the necessary length of 4#10 Type "SO" electrical power cords. All cables shall be attached to the ring assembly at a NEMA Type IV weather-tight copper-free aluminum wiring compartment through watertight cable connectors. A factory prewired 600V terminal block shall be provided in the wiring chamber. A weather-tight twist-lock power inlet shall be provided on the chamber to allow the testing of the luminaires while in the lowered position.

b. A circuit breaker assembly shall be mounted to the winch plate to serve as disconnecting means for the lowering device. Prewired to the breaker assembly shall be a weather-tight twist-lock connector to alternately supply the power to the portable power unit and to the test inlet on the lowered luminaire ring.

c. Strain relief shall be provided at both ends of the main power cable with the use of the properly sized cable clamps. The hole in the headframe plate through which the power cable passes shall be dressed with a stainless steel bushing.

D. Luminaires

Each high mast floodlight pole shall be furnished with the luminaires appropriate for the floodlight application. Provide luminaires as specified on the Contract Drawings and in accordance with the requirements of Section 16510 "LIGHTING SYSTEMS".

E. Paint

Each pole shall be primed and painted in accordance with the requirements specified in the Section entitled "PAINTING".

PART 3. EXECUTION

3.01 INSTALLATION

A. Foundation

Foundations shall be as shown on the Contract Drawings. Concrete shall be in accordance with the Section entitled "CONCRETE".

B. Excavation and Backfill

Excavation and backfill for foundation shall be in accordance with the Section entitled "EXCAVATION, BACKFILLING AND FILLING".

C. Install anchoring hardware in accordance with the manufacturer's instructions and the specified anchor bolt template.

D. Dissimilar Metals

1. "Dissimilar metals" shall mean those metals which are incompatible with one another in the presence of moisture, as determined from their relative positions in the Electrochemical Series, or from test data.
2. Where dissimilar metals come in contact, paint the joint both inside and out with approved coating to exclude moisture from the joint, or provide a suitable insulating barrier separating the metals.

E. Assemblies

1. Assemble luminaires, furnished under the Section 16510 "LIGHTING SYSTEMS", in accordance with the manufacturer's instructions and as shown on the Contract Drawings. Provide and install any additional boxes, brackets, required for a complete installation.
2. Provide stainless steel safety tether for each luminaire. Connect safety tether to the luminaire and the ring assembly.

3.02 INSPECTION

Upon completion of the installation, the lighting fixtures and lighting equipment shall be in operating order and condition and wiring shall be neatly arranged and the finish free from defects. At the time of final inspection, all fixtures shall be fully lamped and be complete with the required lenses, reflectors, and other components necessary for the specified functioning of the fixtures. All fixtures and equipment shall be clean and free from dust or paint spots. Any reflectors, glassware, or other parts broken prior to the final inspection shall be replaced.

3.03 ADJUSTMENTS

Luminaires shall be carefully aimed in accordance with an approved computer-generated plot so as to provide a required footcandle distribution. Adjust floodlights during the hours of darkness under the supervision of the Engineer. Notify the Engineer at least 48 hours before the aiming.

END OF SECTION

SECTION 16527

HIGH MAST FLOODLIGHT SYSTEMS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Manufacturer's established installation procedure manuals for each type of specified high mast floodlight pole, lowering device and lighting fixture.
2. For each high mast type: Clearly illustrate assembly methods, luminaire mounting hardware, detailed dimensions, anchor bolt size and templates, lowering device details, materials, finishes and electrical components.
3. For each lighting fixture type: Submit independent testing laboratory photometric report, and performance data in IESNA format.
   a. Luminaire, ballast and lamp and optical assembly description and manufacturer's complete catalog number
   b. Luminaire schematic drawing with basic dimensions
   c. Isolux (isofootcandle) Curves for street and house sides
   d. Lumen Utilization Curves for street and house sides
   e. Zonal Lumen Summary Table
   f. Input Watts
   g. Luminaire Efficiency
4. For each ballast type: Submit manufacturer's data with ballast description, catalog number, lamp type, input voltage, input wattage, ballast factor, power factor, minimum starting temperature, operating temperature and wiring diagram.
5. Photoelectric Control Devices: Submit manufacturer's data for ambient light sensors and contactors.

B. Calculations

1. For each high mast floodlight system type specified on the Contract Drawings submit calculations verifying that total weight and Effective Projected Area (EPA) of the selected high mast with accessories and appurtenances do not exceed manufacturers Maximum Recommended Total Load. Structural design calculations of floodlight poles assemblies, including anchor bolts, bases, and lowering devices shall be signed and sealed by a Professional Engineer licensed in the State where the installation will take place.

2. Submit:

   a. Test results of the welds.

   b. Results of vibration and fatigue analysis.

   c. Structural computation of lowering device.

   d. If the splice design is based on the results of an independent outside entity, the complete test design shall be submitted.

   e. The design computations and drawings for any necessary dampers.

   f. Structural steel, reinforcing steel and concrete.

3. Submit computer generated lighting calculations.

END OF APPENDIX "A"

SECTION 16510

LIGHTING SYSTEMS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.02) 1.02 SHOW LIGHTING FIXTURES LAYOUT INDICATING LOCATION, TYPE, ELECTRIC PANEL AND CIRCUIT NUMBER FOR EACH LIGHTING FIXTURE. INDICATE MEANS OF LIGHTING CONTROL. SHOW LIGHTING LEGEND WITH LIGHTING FIXTURE CHARACTERS AND SHORT LIGHTING FIXTURE DESCRIPTIONS.

(2.02.F) 1.03 SHOW LIGHTING FIXTURE SCHEDULE WITH PRECISE FIXTURE DESCRIPTION AND MANUFACTURER'S CATALOG NUMBER. SPECIFY HOUSING DIMENSIONS, CONSTRUCTION, MATERIAL, AND FINISH. SPECIFY OPTICAL ASSEMBLY. SPECIFY LAMP, BALLAST, OPERATING VOLTAGE AND MOUNTING CONDITION. SPECIFY SPECIAL FEATURES. SPECIFY FIXTURE MANUFACTURERS AND CATALOG NUMBERS.

(1.04.B) Specify UL listing application, Damp, Wet, Marin or Hazardous environment.

(2.02.G) Specify means of lighting control:

Switches, wall box dimmers, preset dimming systems, photoelectric control devices, occupancy sensors, lighting contactors.

If a lighting management system is used, verify compatibility with existing lighting management system and specify the following:

Operational requirements of the lighting management system and interface requirements with other building systems such as existing lighting management system, fire alarm, HVAC, baggage motor centers, central time synchronization, security, etc.

Personal Computer hardware and software capacity, monitor size, and software graphical interface capability.

Block wiring diagram with panelboard numbers and locations, auxiliary controls, conduit and wiring. On-site service and personnel training requirements, Specify number of sessions, hours and topics to be covered during the training

A. Other Items

Ensure that the specifications include the following Sections referenced in this Section:

(2.02.G.1.c.1) "PANELBOARDS AND CABINETS"

(2.02.G.4.d.7) "BOXES AND FITTINGS"

END OF INSTRUCTIONS

DIVISION 16

SECTION 16541

AIRPORT ELEVATED RETROREFLECTIVE TAXIWAY EDGE MARKERS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for airport elevated retroreflective taxiway edge markers.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

Federal Aviation Administration, Advisory Circular (FAA-AC)

FAA-AC 150/5345-39	Runway and Taxiway Retroreflective Markers FAA Specification (L-853).

1.03 QUALITY ASSURANCE

A. Entities performing the Work of this Section shall have experience on at least two projects involving complexities similar to those required under this Contract.

B. Before markers are installed, they shall meet the requirement of a successful one-year test installation at an Authority airport.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in manufacturer's original, unopened, protective packaging.

B. Store materials in original packaging in a manner to prevent soiling and physical damage, prior to installation.

C. Handle in a manner to prevent damage to finished surfaces.

D. Where possible, maintain protective coverings until installation is complete and remove such coverings as part of final cleanup.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 CONSTRUCTION FEATURES

A. Elevated Retroreflective Taxiway Edge Markers

1. Elevated retroreflective taxiway edge markers shall consist of a cylindrical plastic tube, 30 inches long by 2-3/4 inches in diameter and shall be equipped with four plastic, reflective bands, 4 inches high, spaced at 1-1/2-inch intervals beginning 1-1/2 inches from the top end of the tube. The marker shall comply with FAA-AC 150/5345-39 and shall be approved under FAA Specification L-853. Edge markers shall be the following types, as shown on the Contract Drawings.

   a. Type 'A': For socket mounting in a 3 inch core drilled hole or pipe.

   b. Type 'B': For flange mounting, by nailing or adhesive bonding to paved surfaces.

2. Elevated retroreflective taxiway edge markers shall consist of blue colored tubes with yellow bands, unless otherwise shown on the Contract Drawings.

B. Vinyl tape shall be 1-1/2 inches wide, 8.5-mils thick, black polyvinyl chloride, Scotch (3M) No. 88, or approved equal.

2.02 SHOP TESTS

Qualification tests shall be run on markers in accordance with the requirements of FAA-AC 150/5345-39.

PART 3. EXECUTION

3.01 INSTALLATION

A. Employ the services of a Land Surveyor licensed in the State where the Work is to be performed to establish the exact locations of the markers whose general locations are shown on the Contract Drawings.

B. Install markers in accordance with FAA-AC 150/5345-39, and manufacturer's installation procedures and as shown on the Contract Drawings.

1. Type 'A' markers shall be installed in core-drilled holes or pipes, of the depth and diameter shown on the Contract Drawings. Apply vinyl tape around the marker at the base and force-fit into the hole or pipe to prevent entrance of water and to support markers in a straight and upright position.

2. Type 'B' markers shall be nailed-down or glued-down, using fasteners or adhesive approved by the Engineer.

END OF SECTION

SECTION 16541

AIRPORT ELEVATED RETROREFLECTIVE TAXIWAY EDGE MARKERS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

Installation procedures for elevated retroreflective taxiway edge markers.

B. Catalog Cuts

1. Elevated retroreflective taxiway edge markers.
2. Vinyl tape.
3. Fasteners.
4. Adhesives.

END OF APPENDIX "A"

SECTION 16541

AIRPORT ELEVATED RETROREFLECTIVE TAXIWAY EDGE MARKERS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.01 A.1)	Tube types.
(2.01 A.2)	Tube and band color, if other than blue and yellow, respectively.
(3.01 A)	General locations of markers.
(3.01 B)	Installation details.
(3.01 B.1)	Depth and diameter required for installation of markers.

B. Precautions

Ensure that the Contract Drawings show the acceptable means of installing markers. Special structural decks, such as the LaGuardia runway extensions SHALL NOT be core-drilled. Consult Structural/Civil Engineers for appropriate installation details.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16542

TAXIWAY/RUNWAY LIGHT FIXTURES

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for light fixtures, light bases and accessories for Taxiway and Runway Lighting Systems.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

	Federal Specifications
SS-S-1401	Sealant, Joint, Non-Jet-Fuel-Resistant, Hot Applied, For Portland Cement And Asphalt Concrete Pavements
	Federal Aviation Administration, Advisory Circulars (FAA-AC)
FAA-AC 150/5340-4C	Installation Details for Runway Centerline and Touchdown Zone Lighting Systems
FAA-AC 150/5340-19	Taxiway Centerline Lighting System
FAA-AC 150/5340-24	Runway and Taxiway Edge Lighting System
FAA-AC 150/5345-26B	Specification for L-823 Plug and Receptacle, Cable Connectors
FAA-AC 150/5345-42C	Specification for Airport Light Base and Transformer Housings, Junction Boxes, and Accessories
FAA-AC 150/5345-46A	Specification for Runway and Taxiway Light Fixtures
FAA-AC 150/5345-47	Isolation Transformers for Airport Lighting Systems
FAA-AC 150/5370-10	Standards for Specifying Construction of Airports
	American Society for Testing and Materials (ASTM)
ASTM A 386	Structural Steel
ASTM A 572	High-Strength Low-Alloy Columbium Vanadium Steels of Structural Quality
ASTM D 3405	Joint Sealants, Hot-Poured, for Concrete and Asphalt Pavements
	National Fire Protection Association (NFPA)
NFPA 70	National Electrical Code

1.03 QUALITY ASSURANCE

A. Entities performing the Work of this Section shall have experience on at least two projects involving complexities similar to those required under this Contract.

B. Before any light fixture type is installed in a permanent installation, it shall meet the requirement of a successful one-year test installation at an Authority airport.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in manufacturers original, unopened, protective packaging.

B. Store materials in a clean, dry space and protect them from weather.

C. Handle in a manner to prevent damage to finished surfaces.

D. Where possible, maintain protective coverings until installation is complete and remove such coverings as part of final cleanup.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 LIGHT FIXTURES

A. General

1. Quantity, type, location, beam direction (unidirectional, bidirectional or omnidirectional), and other requirements of light fixtures shall be as shown on the Contract Drawings.
2. Lamp type and wattage and filter color shall be as shown on the Contract Drawings.
3. Light fixtures and components for which there are established UL standards, shall be UL listed and shall bear the Underwriters Laboratories Inc. (UL) label.
4. Light fixtures shall be furnished completely, assembled and, unless otherwise shown on the Contract Drawings, shall be furnished with two 40-inch leads terminated in an FAA Specification L-823 two pole plug, and one color-coded green ground wire.
5. Light fixtures shall comply with environmental, photometric, dimensional and other requirements specified in the latest edition of FAA-AC 150/5345-46(A).

B. Runway Inpavement Light Fixtures

1. General

Runway inpavement fixtures shall have a light assembly that produces a beam with color and photometric distribution as specified in FAA-AC 150/5345-46. Unless otherwise noted on the Contract Drawings, the casting that houses the light assembly shall be high strength Nickel-Molybdenum alloy. The casting shall be a single piece construction or an inset type with an adapter ring.

Runway inpavement fixtures shall be connected to the light bases by means of six threaded bolts. Studs or other spacers are not permitted for the runway fixtures.

2. Runway Centerline Light Fixtures; L-850A

Each such fixture shall have a light assembly that produces a narrow bidirectional beam and utilizes a quartz halogen lamp rated at 6.6 amperes. The lamp life shall be rated at a minimum of 5000 hours if operated at brightness Step III.

3. Runway Touchdown Zone Light Fixtures; L-850B

Each such fixture shall have a light assembly that produces a narrow unidirectional beam and utilizes a quartz halogen lamp rated at 6.6 amperes. The lamp life shall be rated at a minimum of 5000 hours if operated at brightness Step III. Each casting shall have a directional 4° toe-in arrow stamped in window area that denotes a location of the runway centerline.

4. Runway Edge Light Fixtures; L-850C

Each fixture shall have a light assembly that produces a bidirectional narrow beam and utilizes a quartz halogen lamp rated at 6.6 amperes.

5. Runway Threshold/End Light Fixtures; L-850D

Each such fixture shall have a light assembly that produces a narrow unidirectional or bidirectional beam and utilizes a quartz halogen lamp rated at 6.6 amperes. The beam shall be toed-in 32° towards the runway centerline.

6. Approach Threshold Light Fixtures; L-850E

Each such fixture shall have a light assembly that produces a wide unidirectional beam and utilizes a quartz halogen lamp rated at 6.6 amperes.

C. Taxiway Inpavement Light Fixtures

1. General

Taxiway inpavement fixtures shall have a light assembly that produces a beam with color and photometric distribution as specified in FAA-AC 150/5345-46. Unless otherwise noted on the Contract Drawings, the casting that houses the light assembly shall be high strength Nickel-Molybdenum alloy. The casting shall be a single piece construction or an inset type with an adapter ring.

2. Taxiway Centerline Light Fixtures, straight sections; L-852A

Each such fixture shall be Type IV and shall have a light assembly that produces a narrow beam, is bi-directional and utilizes a quartz halogen lamp rated at 6.6 amperes.

3. Taxiway Centerline Light Fixtures, curved sections; L-852B

Each such fixture shall be Type IV and shall have a light assembly that produces a wide beam, is bidirectional and utilizes a quartz halogen lamp rated at 6.6 amperes.

4. Narrow Beam Fixtures; L-852C

Each such fixture shall have a light assembly that produces a narrow beam, is bidirectional and utilizes a quartz halogen lamp rated at 6.6 amperes.

5. Wide Beam Fixtures; L-852D

Each such fixture shall have a light assembly that produces a wide beam, is bidirectional and utilizes a quartz halogen lamp rated at 6.6 amperes.

6. Omnidirectional Fixtures; L-852E

Each such fixture shall have a light assembly that produces a omnidirectional light and utilizes a quartz halogen lamp rated at 6.6 amperes. The casting that houses the assembly shall be totally flush.

D. Elevated Light Fixtures

1. Elevated Runway/Taxiway Light Fixtures; L-861

Each such fixture shall be furnished with breakable couplings and stems to provide for an overall height of 16 inches. The light source shall be a 45-watt quartz halogen lamp housed in a glass globe with 360 degree, internal blue filter.

2. High Intensity Runway Edge Light Fixtures; L-862

Each such fixture shall be furnished with breakable couplings and stems to provide for an overall height of 12 inches above the surface. The light source shall be a 115-watt quartz halogen lamp housed in a glass globe with internal lens assembly and 180/360 degree internal color filters.

E. Accessories

1. Isolation Transformers; L-830

Isolation transformers shall be rubber encapsulated, 5000-volt rated, series to series, with primary ampere rating as shown on the Contract Drawings, and a 6.6-ampere secondary. The wattage rating shall be as shown on the Contract Drawings. The flanged receptacle on the secondary cable shall conform to FAA Specification L-823, Figure No. 15. Transformers shall comply with FAA-AC 150/5345-47 and shall conform to FAA Specification L-830.

2. Ground Rods

Ground rods shall be copper bonded with diameters and lengths as shown on the Contract Drawings.

3. Single Pole Plug and Receptacle Connectors; L-823

Single pole plug and receptacle connectors for 5000-volt series lighting cable shall comply with FAA-AC 150/5345-26B and shall conform to FAA Specification L-823f Fig. No. 1.

4. Double Pole Plug and Receptacle Connectors; L-823

Double pole plug and receptacle connectors for 600-volt secondary system shall comply with FAA-AC 150/5345-26B and shall conform to FAA Specification L-823, Fig. No. 1.

2.02 LIGHT BASES

A. General

1. Quantity, type, location and other requirements of light bases shall be as shown on the Contract Drawings.

2. All electrical materials and equipment for which there are established UL standards, shall bear the UL label.

B. Base Cans and Extensions for Taxiway Centerline Fixtures; L-868

1. Base Cans

Base cans shall be 12 inches in outside diameter, of ASTM A 386 hot-dipped galvanized steel, with 1/4-inch thick bottom plate protruding 3/16 inches outward from the outside face of the cylindrical wall. A ground lug shall be provided to accept a #6 AWG grounding cable as shown on the Contract Drawings. The base can overall depth shall be as shown on the Contract Drawings and shall be provided with grommeted openings for conduit entrance as shown on the Contract Drawings. The top flange shall have twelve, 3/8-inch diameter tapped holes, equally spaced on an 11-1/4-inch bolt circle to accept the mounting of top section base can. The base can shall comply with FAA-AC 150/5345-42C and shall conform to FAA Specification L-868.

2. Base Can Extensions

Base can extensions shall be 12 2 inches in outside diameter, of ASTM A 386 hot-dipped galvanized steel, with provision on the top flange for twelve, 3/8-inch diameter tapped holes, equally spaced on an 11 1/4-inch bolt circle, to accept a taxiway centerline fixture mounting. The bottom of the can shall be provided with six, 7/16-inch diameter holes equally spaced on an 11 1/4-inch bolt circle and six 3/8-inch stainless steel bolts and two piece lockwashers of the proper length for mounting to the top of the bottom section base can. The exact depth of the top section base can shall be determined from field measurements. Minimum depth shall be 2 inches. The base can shall comply with FAA-AC 150/5345-42C and shall conform to FAA Specification L-868.

C. Base Cans for Elevated Edge Light Fixtures; L-867

Base cans shall be 13 2 inches in outside diameter, of ASTM A 386 hot-dipped galvanized steel, with 1/8-inch thick bottom plate protruding 3/16 inches outward from the outside face of the cylindrical wall with six, 4 5/8-inch long, 3/8-inch deep steel ribs welded radially on its underside. A 3/8-inch by 2-inch bar shall be welded around the circumference at the top of the can. The top flange shall be provided with six, 3/8-inch diameter tapped holes, equally spaced on a 10 1/4-inch bolt circle for mounting of the base plate. The base can shall be 10 inches in overall depth and shall be complete with grommeted openings for conduit entrance as shown on the Contract Drawings. A ground lug shall be provided to accept a #10 AWG ground cable. Additional requirements shall be as shown on the Contract Drawings. The base can shall comply with FAA-AC 150/5345-42C and shall conform to FAA Specification L-867.

D. Type I Marker Light Boxes; L-867

Type I boxes shall be of reinforced concrete construction and shall be 15 inches wide by 36 inches long (inside dimensions) with a depth as shown on the Contract Drawings. The steel cover shall be capable of accepting a base plate for an elevated taxiway, edge light fixture. All ancillary equipment and additional requirements shall be as shown on the Contract Drawings. Precast boxes may be substituted for those shown on the Contract Drawings subject to the approval of the Engineer. All precast boxes shall meet the same requirements as specified herein and as shown on the Contract Drawings.

E. Type III Marker Light Boxes; L-867

Type III boxes shall be concrete encased ASTM A 386 hot-dipped galvanized steel base cans 17 1/4-inches in diameter by 20 inches deep. A 3/8-inch by 2-inch bar shall be welded around the circumference at the top of the can. Boxes shall be provided with 2-inch couplings at 180 degrees at the bottom of the box. A ground lug shall be welded on the inside wall of the box and a 1 3/8-inch diameter hole shall be provided at the bottom of the base for the installation of a ground rod. The hole shall be plugged with a solid neoprene plug. Additional requirements shall be as shown on the Contract Drawings. Boxes shall comply with FAA-AC 150/5345-42C and shall conform to FAA Specification L-867.

F. Base Plates for Elevated Edge Light Fixtures

Base plates shall be ASTM A 572, Grade 50 steel, 12 inches in diameter and 2-inch thick, complete with a 1 2 or 2 inches threaded conduit hub, gasket, stainless steel bolts and a connector clamp capable of supporting an FAA Specification L-823 flanged secondary receptacle. Base plates shall have six, 7/16-inch holes on a 10 1/4-inch bolt circle, except for Type III marker box which shall have 14 1/4-inch bolt circle.

G. Flanged Secondary Receptacles; L-823

Flanged secondary receptacles shall be clamped to the underside of the taxiway edge light base plate, where required, and have two #14 AWG, 15-inch long pigtails molded, under one jacket, to the receptacle body. Receptacles shall comply with FAA-AC 150/5345-26B and shall conform to FAA Specification L-823, Fig. No.1C.

H. Flange Rings for L-868 Cans

Flange rings shall be composed of a 12 1/8-inch by 2-inch thick ASTM A 386 zinc plated steel ring containing six, 7/16-inch diameter holes equally spaced at 60 degree intervals on an 11 1/4-inch bolt circle. An indented 'O' ring gasket shall be furnished with the flange ring to render the unit weatherproof. An 1/8-inch thick ASTM A 386 zinc plated steel ring shall be continuously welded to the outside edge of the flange ring providing an overall height of 1 1/8 inches and an overall outside diameter of 12 3/8 inches.

I. Temporary Mud Covers for L-867 and L-868 Cans

Temporary mud covers shall be 12 3/8 inches in outside diameter containing six, 7/16-inch diameter holes on an 11 1/4-inch bolt circle for L-868 cans and 10 1/4-inch bolt circle for L-687 cans. Mud covers shall be made of a 1/8-inch thick, hot-dipped galvanized steel plate with three raised concentric rings, two one-inch thick knockouts about the center, and an indented center point mounted on a 5/8-inch thick exterior grade plywood cover.

J. Spacer Rings for L-868 Cans

Spacer rings shall be 12 inches in outside diameter, 1/8-inch thick zinc coated steel or 1/4-inch thick hot-dipped galvanized steel, as required, with a 10-inch diameter hole and six, 7/16-inch diameter holes equally spaced on an 11-1/4-inch bolt circle.

K. Blank Cover Plates for L-867 and L-868 Cans

Blank cover plates for FAA L-867 and L-868 cans shall be 12 inches in outside diameter and of 2-inch thick ASTM A 572, Grade 50 hot-dipped galvanized steel with six, 7/16-inch diameter holes on a 10-1/4-inch bolt circle for L-867 cans and 11-1/4-inch bolt circle for L-868 cans.

2.03 MISCELLANEOUS MATERIALS

A. Flexible Non-Metallic Conduit

1. Flexible non-metallic conduit shall be made up of a polyvinyl chloride smooth inner core, a reinforcing nylon mesh and a polyurethane outer jacket.
2. Fittings shall be of a type designated to provide a liquid tight continuation of the conduit system as per manufacturer's recommendation.

B. Hot Rubberized Asphalt Sealer

Hot rubberized asphalt sealer shall conform to Federal Specification SS-S-1401 and ASTM D 3405.

C. Adhesive Sealant

Adhesive sealant shall be as shown on the Contract Drawings.

D. Cement Compound

Cement compound shall be a two-component adhesive compound and shall comply with the requirements of FAA-AC 150/5370-10, P-606.

E. Concrete and Grouting

Concrete and grouting shall be in accordance with applicable Section(s) of the Specifications or as shown on the Contract Drawings.

F. Mildew and Rot-Proof Rope

Rope shall be 2 inch in outside diameter, of mildew and rot-proof hemp rope.

G. Special Materials

Special materials, required for proper installation of the Work, shall be as shown on the Contract Drawings.

PART 3. EXECUTION

3.01 INSTALLATION

A. General

1. Employ the services of a Land Surveyor licensed in the state where the Work is to be performed to establish the proposed locations of lighting fixtures whose general locations are shown on the Contract Drawings.
2. Mark the proposed location and alignment for each base can or box. These locations and alignments shall be approved by the Engineer.

B. Fixtures that have been installed shall be made operational prior to the end of the Work period.

C. Provide a sufficient quantity of waterproof tarpaulins or employ other approved means of preventing blown sand, water and other foreign materials from entering the kerfs and cored holes.

D. Heat rubberized asphalt sealer compound in a double-boiler, indirect-fired kettle. The space between the inner and outer shells shall be filled with suitable heat transfer oil having a flash point of not less than 550 degrees F. The kettle shall be equipped with satisfactory means of agitating the sealer at all times without excessive incorporation of air. High temperature shall not be necessary to melt the sealer. The kettle shall be equipped with thermostatic control for automatic regulation of the temperature of the oil bath and sealer and shall have a recording thermometer of the sealer temperature. A hose shall be directly connected to the melting kettle in such a manner as to permit pumping the melted sealer through the hose to a shoe-type applicator that shall direct and control the filling of the joints.

E. All Work shall be in conformance with NFPA 70 requirements.

F. All electrical connections shall be covered with heat shrink tubings. The heat shrink shall cover a minimum 3" of cable on both sides of the connection.

G. Flush Runway and Taxiway Light Fixtures

1. Installation of flush taxiway centerline light fixtures shall comply with FAA-AC 150/5340-19 and be done in accordance with fixture manufacturers installation procedures and as specified herein.

2. Installation of flush runway centerline and edge light fixtures shall comply with FAA-AC 150/5340-4C and be done in accordance with fixture manufacturer's installation procedures and as specified herein.

3. Longitudinal and Transverse Spacing

   Space light fixtures longitudinally as shown on the Contract Drawings with a tolerance of plus or minus 10 percent. Locate light fixtures laterally not less than one foot from the designated centerline of taxiing paths. Displace lights a maximum of two feet from the designated centerline where necessary to avoid undesirable locations. Apply this lateral tolerance consistently to avoid abrupt and noticeable changes in guidance, i.e., no "zigzagging" from one side to the other side of the centerline.

4. Orientation of Light Beam

   a. On runways and on all straight portions of taxiway centerlines, orient the axis of the centerline light beam parallel to the centerline of the runway or taxiway path, respectively.

   b. On curved portions of taxiways, excluding long radius exit taxiways, orient the axis of the two beams of bidirectional taxiway centerline lights parallel to the tangent of the nearest point of the curve designated as the true centerline of the taxiway path; orient the axis of a unidirectional light beam so that it is "toed-in" to intersect the centerline at a point approximately equal to four times the spacing of the lights on the curved portion and such spacing shall be measured along the chord of the curve.

   c. On runways, orient the edge light beam as specified in FAA-AC 150/5340-4C.

H. Installation of Elevated Runway and Taxiway Edge Light Fixtures

   Installation shall comply with FAA-AC 150/5340-24 and shall be done in accordance with fixture manufacturer's installation procedures.

I. Installation of Semi-Flush Runway Touchdown Zone Light Fixtures

   Installation shall comply with FAA-AC 150/5340-4C and shall be done in accordance with fixture manufacturers installation procedures.

J. Light base manufacturer representative shall be present on site on the first day of installing light bases.

3.02 FIELD TESTS

A. General

1. Provide all labor and materials for functional and operational tests required and furnish the power for the functional tests. Power for the operational tests will be furnished by the Authority.

2. Should the tests reveal any defects in Taxiway and Runway Lighting System Equipment installed under this Contract, promptly correct such defects and rerun the tests until the entire installation is satisfactory to the Engineer in all respects.

3. Report immediately to the Engineer any defect found in portions of the Taxiway and Runway Lighting System not installed under this Contract. Do not attempt to rectify any defect found in a component of the system not installed under this Contract unless specifically instructed to do so by the Engineer. The Contractor's compensation for the rectifying of such defects at the direction of the Engineer will be determined in accordance with the clause of the Contract providing compensation for Extra Work.

B. Functional Tests

1. Perform functional tests, in the presence of the Engineer, to demonstrate the reliability of the electrical installation for the following:

   a. Runway and taxiway edge lighting system in accordance with the requirements of FAA-AC 150/5340-24;

   b. Taxiway centerline lighting system in accordance with the requirements of FAA-AC 150/5340-19;

   c. Runway centerline and touchdown zone lighting systems in accordance with the requirements of FAA-AC 150/5340-4C.

2. Furnish the Engineer with a copy of the "Megger" readings for the tests specified in 3.02 B.1 above, together with an outline of the method used. If, in the opinion of the Engineer, any reading is lower than the values required by the above FAA-AC specifications, promptly replace the fixtures and accessories involved, or by other means raise the readings to acceptable values.

C. Operational Tests

After the functional tests have been completed, operate, in the presence of the Engineer, all electrical equipment for a period of twenty-four hours.

END OF SECTION

SECTION 16542

TAXIWAY/RUNWAY LIGHT FIXTURES

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Station layout for taxiway and runway light fixtures
2. All light fixtures
3. Light fixture accessories, including isolation transformers, ground rods and plug connectors
4. Light bases, including base cans, light boxes, base plates, flange rings, mud covers, spacer rings, cover plates
5. Setting fixture (jig) and installation method description
6. Miscellaneous materials, including sealants and the special materials shown on the Contract Drawings

B. Submit an itemized list of spare parts, as recommended by the manufacturer, for the electrical equipment to be supplied under this Contract. The list should include quantities required, current unit prices and sources of supply. The Authority is not obligated to purchase any item on such a list.

C. Prior to any installation operations at the construction site, submit a listing of the proposed equipment and methods to be used to install base cans and/or boxes in the pavement subject to the approval of the Engineer

D. Submit field test reports, including AMegger" readings, with an outline of the method used.

END OF APPENDIX "A"

SECTION 16542

TAXIWAY/RUNWAY LIGHT FIXTURES

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(1.05.A.2.d) (2.03.G)	Special materials required for installation of fixtures but not specified
(1.05.C)	Installation details for base cans or boxes in the pavement
(2.01.A.1)	Quantity, type, location, beam direction (unidirectional, bidirectional or omnidirectional), and other requirements of light fixtures
(2.01.A.2)	Lamp type and wattage and filter color
(2.01.A.3)	Fixture lead length other than 40 inches
(2.01.H.1)	Primary amperes and wattage rating of isolation transformers
(2.01.H.2)	Diameters and lengths of ground rods
(2.02 A.1)	Quantity, type, location and other requirements of light bases
(2.02 B.1)	Location of ground lugs, depth and conduit entrance openings of bottom section base can
(2.02 C)	Additional requirements of base cans for elevated taxiway edge light fixtures other than specified
(2.02 D)	Depth, ancillary equipment and additional requirements of Type I boxes
(2.02 E)	Additional requirements of Type III boxes other than specified.
(2.03 D)	Concrete and grouting details, in lieu of inclusion of applicable Section(s)
(3.01 A.4)	Equipment and methods to be used to install base cans or boxes in the pavement
(3.01 B.3)	Longitudinal spacing of flush runway and taxiway light fixtures

B. Other Items

Ensure that the Specifications include the following Section(s) referenced in this Section:

(2.03 E)	Concrete and grouting details; Consult Structural/Civil Engineers for appropriate Section(s) for this Work.

C. Recommended Manufacturers

(2.01.B.2)	Flush Runway Centerline Light Fixtures; L-850A. Fixtures shall be as manufactured by the Crouse-Hinds Co. No.20561P or approved equal.
(2.01.B.3)	Semi-Flush Runway Touchdown Zone Light Fixtures; L-850B. Fixture shall be as manufactured by the Crouse-Hinds Co. No.20581P, or approved equal.
(2.01.B.4)	Runway Edge Light Fixtures; L-850C. Fixtures shall be Crouse-Hinds Co. No.850C, or approved equal.
(2.01.B.5)	Runway Threshold Light Fixtures; L-850D. Fixtures shall be Crouse-Hinds Co. No.850D or approved equal.
(2.01.B.6)	Approach Threshold Light Fixtures; L-850E. Fixtures shall be as manufactured by the Crouse-Hinds Co. No.850E1, or approved equal.
(2.01.C.2)	Taxiway Centerline Light Fixtures, straight sections; L-852A. Fixtures shall be as manufactured by the Crouse-Hinds Co. No.852NF, or approved equal
(2.01.C.3)	Taxiway Centerline Light Fixtures, curved sections; L-852B. Fixtures shall be as manufactured by the Crouse-Hinds Co. No.852WF, or approved equal.
(2.01.C.4)	Narrow Beam Light Fixtures; L-852C. Fixtures shall be as manufactured by the Crouse-Hinds Co. or approved equal.
(2.01.C.5)	Wide Beam Light Fixtures; L-852D. Fixtures shall be as manufactured by the Crouse-Hinds Co. or approved equal.
(2.01.C.6)	Omnidirectional Light Fixtures, curved sections; L-852E. Fixtures shall be as manufactured by the Crouse-Hinds Co. No.20552P, or approved equal.
(2.01.D.1)	Elevated Light Fixture, 45 watt; L-861T. Fixtures shall be Crouse-Hinds No. 40938-45, or approved equal.
(2.01.D.2)	Fixture, 115 watt; L-862. Fixtures shall be Crouse-Hinds No. 40722-E-115, or approved equal.
(2.01.E.1)	Isolation Transformers; L-830. Transformers shall be Crouse-Hinds Co. Series 33000, or approved equal.
(2.01.E.2)	Ground Rods. Rods shall be Carolina Galvanizing Corp. Series P, or approved equal.
(2.01.E.3)	Single Pole Plug and Receptacle Connectors; L-823. Plug and receptacle shall be Amerace-Esna Corp., Style 90P or 90R. as required, or approved equal.
(2.01.E.4)	Double Pole Plug and Receptacle Connectors; L-823. Plug and receptacle shall be Amerace-Esna Corp., Style 90P or 90R, as required, or approved equal.
(2.02.B.1)	Base Cans. Base cans shall be Jaquith Industries Inc. No. 241OFS, or approved equal.
(2.02.B.2)	Base Can Extensions. Base can extensions shall be as manufactured by Jaquith Industries Inc. No.2419X, or approved equal.
(2.02.C)	Base Cans for Elevated Edge Light Fixtures; L-867. Base cans shall be as manufactured by Jaquith Industries Inc. No.2122, or approved equal.

(2.02.D)	Type I Marker Light Boxes; L-867. Boxes shall comply with FAA-AC 150/5345-42B and shall conform to FAA Specification L-867. Type I Boxes shall be Berri-Roche BR-17, or approved equal.
(2.02.E)	Type III Marker Light Boxes; L-867. Type III boxes shall be as manufactured by Jaquith Industries Inc. No.6322, or approved equal.
(2.02.F)	Base Plates for Elevated Taxiway Edge Light Fixtures. Base plates shall be Jaquith Industries Inc. No. 1602, 1605, 2732, 2735, or approved equal.
(2.02.G)	Flanged Secondary Receptacles; L-823. Receptacles shall be Crouse-Hinds Co. No. FL1017, or approved equal.
(2.02.H)	Flange Rings. Flange rings shall be Jaquith Industries Inc. No. 5402-8Y. or approved equal.
(2.02.I)	Temporary Mud Covers. Mud covers shall be Jaquith Industries Inc. No. 5417,5427, or approved equal.
(2.02.J)	Spacer Rings shall be Jaquith Industries Inc. Nos. 5421-02 and 5421-04, or approved equal.
(2.02.K)	Blank Cover Plates shall be Jaquith Industries Inc. No. 1600, 4000, or approved equal.
(2.03.A.1)	Flexible Non-Metallic Conduit shall be Electriflex Company Liquatite Type LNM or The Anaconda Company Sealtite Type CN, or approved equal.
(2.03.B)	Adhesive Sealant shall be Dow Corning Corp. >Selastic 732 RTV=, or approved equal.
(2.03.C)	Cement Compound. Compound shall be Dynatron Bondo Inc., or approved equal.
(2.03.E)	Mildew and Rot-Proof Rope shall be J.T. Pearson Co., or approved equal.

D. Coordination with other Sections

This Section applies specifically to Taxiway and Runway Light Fixtures. For installation of a complete Taxiway and Runway Lighting System, ensure that the following Sections, at a minimum, are incorporated in the Specifications:

RACEWAYS
UNDERGROUND CONDUIT SYSTEMS
WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS)
WIRES, CABLES, SPLICES, TERMINATIONS (MEDIUM VOLTAGE)
BOXES AND FITTINGS
TAXIWAY/RUNWAY WIRES AND CABLES

END OF INSTRUCTIONS

DIVISION 16

SECTION 16549

AIRPORT CONSTANT CURRENT REGULATORS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for constant current regulators for airport Taxiway and Runway Lighting Systems.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

Federal Aviation Administration, Advisory Circular (FAA-AC)

FAA-AC 150/5345-10E	Constant Current Regulators and Regulator Monitors (FAA Specification L-828 and L-829).
FAA-AC 150/5340-19	Taxiway Centerline Lighting System.
FAA-AC 150/5340-24	Runway and Taxiway Edge Lighting System.

1.03 QUALITY ASSURANCE

Before regulators are installed, they shall meet the requirement of a successful one-year test installation at a Port Authority airport.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver constant current regulators and accessories in manufacturer's original, unopened, protective packaging.

B. Store constant current regulators and accessories in a clean, dry space and protect them from weather.

C. Handle in a manner to prevent damage to finished surfaces.

D. Where possible, maintain protective coverings until installation is complete and remove such coverings as part of final cleanup.

E. Touch up any damage to finishes to match adjacent surfaces.

1.05 SPARE PARTS

Furnish a spare printed circuit board of each type, for each constant current regulator furnished.

1.06 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 CONSTRUCTION FEATURES

A. Constant Current Regulators; L-828 and L-829

1. Location, type, primary voltage and output current and KW rating of constant current regulators shall be as shown on the Contract Drawings.

2. Regulators shall be constant current, stepped brightness controlled, with a 6.6-ampere (Class 1) or 20-ampere (Class 2) output current at the highest step. Control circuitry shall be solid state, mounted on printed circuit boards.

3. Regulators shall have a barrier to separate the high voltage and low voltage compartments. Each compartment shall have a separate door. The high voltage compartment door shall have an internal screen and provision for padlocking.

4. Regulators shall have a non-vacuum, 5 KV internal primary switch with control power provided from an external source. Key interlock the internal primary switch with the external 5 KV fused disconnect so that access to the fused disconnect cannot occur without de-energizing the regulator. The key interlock shall be Kirk Key Interlocks as manufactured by the Railway and Industrial Engineering Company. No substitutions will be permitted.

5. Output Monitors

   a. FAA Specification L-828 regulators shall be furnished with factory installed output current "on/off" monitor, to indicate status of regulator output circuit. The monitor circuitry shall be modular, and shall be completely equipped with all accessories to permit field modification from FAA Specification L-828 to L-829.

   b. FAA Specification L-829 regulators shall be furnished with factory installed monitoring in conformance to FAA-AC 150/5345-10E. Furnish auxiliary alarm relays, with SPDT contacts rated 2-amperes (resistive) at 120 volts ac, individually annunciating the five fault conditions required by FAA Specification L-829, and the "regulator-on" status condition.

6. For wet type regulators, an oil-sampling valve shall be provided with a threaded pipe outlet. The oil level holes shall be equipped with petcocks or eye-level sight gauge.

7. Unless otherwise shown on the Contract Drawings, dry type regulators shall be wall-mounted and wet type regulators shall be pad-mounted. The pad-mounted regulators shall be provided with two I-beams, welded to the base of the regulator case to provide 8 inches of clearance between concrete pad and base of regulator case. Steel surfaces in contact with concrete shall be coated with two coats of asphaltic paint.

8. Regulators shall comply with FAA-AC 150/5345-10E and shall conform to FAA Specification L-828 or L-829.

9. Regulators 10 KW and smaller shall be dry type, Crouse-Hinds Co. Series 31360, or approved equal.

10. Regulators larger than 10 KW shall be wet type, Crouse-Hinds Co. Series 31060, or approved equal.

B. Series Circuit Absolute Cutouts

Series circuit absolute cutouts shown on the Contract Drawings shall be Type S-1 at 5 KV and shall be Crouse-Hinds No. 30196, or approved equal.

C. Concrete and Grouting

Concrete and grouting shall be in accordance with applicable Section(s) of the Specifications or as shown on the Contract Drawings.

2.02 SHOP TESTS

Perform all factory (shop) tests required to ensure compliance with the requirements of FAA-AC 150/5345-10E.

PART 3. EXECUTION

3.01 INSTALLATION

A. Construct a concrete pad for each pad-mounted regulator as shown on the Contract Drawings.

B. Install supporting struts or channels for each wall-mounted regulator as shown on the Contract Drawings.

C. Install each regulator and make all input, output and control connections as shown on the Contract Drawings.

D. Install the series circuit absolute cutout in the output circuit of each regulator as shown on the Contract Drawings.

3.02 FIELD TESTS

A. General

1. Provide all labor and materials for functional and operational tests required and furnish the power for the functional tests. Power for the operational tests will be furnished by the Authority.

2. Should the tests reveal any defects in Taxiway and Runway Lighting System Equipment installed under this Contract, promptly correct such defects and rerun the tests until the entire installation is satisfactory to the Engineer in all respects.

3. Report immediately to the Engineer any defect found in portions of the Taxiway and Runway Lighting System not installed under this Contract. Do not attempt to rectify any defect found in a component of the system not installed under this Contract unless specifically instructed to do so by the Engineer. The Contractor's compensation for the rectifying of such defects at the direction of the Engineer will be determined in accordance with the clause of the Contract providing compensation for Extra Work.

B. Functional Tests

For each regulator, perform functional tests, in the presence of the Engineer, to demonstrate the reliability of the electrical installation of the regulators in accordance with the requirements of FAA-AC 150/5345-10E.

C. Operational Tests

For each regulator, perform operational tests for a 24-hour period, in the presence of the Engineer, on a runway and taxiway lighting load furnished by the Engineer. Such operational tests shall be in accordance with the requirements of FAA-AC 150/5340-19 and FAA-AC 150/5340-24.

END OF SECTION

SECTION 16549

AIRPORT CONSTANT CURRENT REGULATORS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

Schematic diagrams for constant current regulator control system, including connections and interconnections.

B. Catalog Cuts

1. Constant current regulators.
2. Series circuit absolute cutouts.

C. Test Reports

Submit certified factory (shop) test reports on constant current regulators.

END OF APPENDIX "A"

SECTION 16549

AIRPORT CONSTANT CURRENT REGULATORS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(2.01 A.1)	Location, type L-828 or L-829, primary voltage and output current and KW rating of regulators.
(2.01 A.7)	Other than wall-mounting for dry type and pad-mounting for wet type.
(2.01 B)	Series circuit absolute cutouts.
(2.01 C)	Concrete and grouting details; Consult Structural/Civil Engineers for appropriate Section(s) for this Work.
(3.01 A)	Concrete pad details for pad-mounting.
(3.01 B)	Supporting strut or channel details for wall-mounting.
(3.01 C)	Power and control connections to regulators.
(3.01 D)	Installation details for series circuit absolute cutouts.

B. Coordination With Other Sections

This Section applies specifically to Airport Constant Current Regulators. For installation of a complete Taxiway and Runway Lighting System, ensure that the following Sections, as a minimum, are included in the Specifications:

RACEWAYS
UNDERGROUND CONDUIT SYSTEMS
TAXIWAY/RUNWAY WIRES AND CABLES
WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS)
WIRES, CABLES, SPLICES, TERMINATIONS (MEDIUM VOLTAGE)
BOXES AND FITTINGS
SUPPORTING DEVICES

END OF INSTRUCTIONS

DIVISION 16

SECTION 16550

ROADWAY LIGHTING

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for Roadway Lighting.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

	American Association of State Highway and Transportation Officials (AASHTO)
AASHTO LTS-2	Structural Support for Highway Signs, Luminaires, and Traffic Signals
	American Society for Testing and Materials (ASTM)
ASTM A 153	Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM B 108	Aluminum - Alloy Permanent Mold Casting
ASTM B 117	Method of Salt Spray (Fog) Testing
ASTM B 136	Method for Measurement of Stain Resistance of Anodic Coatings on Aluminum
ASTM B 137	Method for Measurement of Weight of Coating on Anodically Coated Aluminum
ASTM B 221	Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes, and Tubes
ASTM B 244	Method for Measurement of Thickness of Anodic Coatings on Aluminum and of Other Nonconductive Coatings on Nonmagnetic Basic Metals with Eddy-Current Instruments
	Underwriters Laboratories (UL)
UL 57	Electric Lighting Fixtures
UL 1029	High-Intensity-Discharge Lamp Ballasts
UL 1572	High Intensity Discharge Lighting Fixtures
	The Energy Policy Act of 1992
	Lamp Efficiency Labeling and Standards
	Illuminating Engineering Society of North America (IESNA)
ANSI/IES RP8-1983	American National Standard Practice for Roadway Lighting

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. The roadway lighting system shall provide safe and uniform illumination levels on roadway and parking lot pavements. The lighting levels shall be as specified or as produced by the lighting systems shown on the Contract Drawings. In no case the lighting levels shall be lower than recommended by the ANSI/IES RP8-1983 or it's latest editions.

B. The complete roadway lighting standard including shafts, luminaires, appurtenances and accessories shown on the Contract Drawings, including but not limited to: mast arms, traffic signals, pedestrian signals, fixed signs, arms, bases and anchor bolts shall be designed to support the weight of the equipment and withstand a maximum wind force of 90 mph (unless otherwise shown on the Contract Drawings) without sustaining permanent deformation, rupture or structural failure.

C. The roadway light standards and accessories shall be designed in accordance with AASHTO LTS-2. Maximum deflection shall be limited to 5 percent of shaft length under static load test.

D. Design calculations shall be certified by a Professional Engineer licensed in the State where the installation will take place.

E. Where a manufacturer's model number is shown on the Contract Drawings, it shall establish the standards of quality and performance, accessories, including the construction features, lighting and electrical performance, finish and other physical and technical properties of the equipment.

F. Roadway lighting fixtures shall be furnished with an optical assembly which complies with IESNA light distribution classification and as specified on the Contract Drawings.

G. Install and adjust roadway lighting as specified in this Section and on the Contract Drawings.

1.04 QUALITY ASSURANCE

Entities performing the Work of this Section shall have experience on at least two projects involving complexities similar to those required under this Contract.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in manufacturer's original, unopened, protective packaging.

B. Materials shall be wrapped for protection during delivery, storage, and handling. Wet or damp wrapping shall be removed, and disposed of, to prevent staining shaft finish.

C. Store materials in original packaging in a manner to prevent soiling and physical damage, prior to installation.

D. Handle in a manner to prevent damage to finished surfaces.

E. Where possible, maintain protective coverings until installation is complete and remove such coverings as part of final cleanup.

1.06 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MATERIALS

Unless otherwise noted on the Contract Drawings, materials for roadway lighting standards and assemblies shall be as specified below, or approved equal:

A. Shafts, Mast Arms, Pole Caps - ASTM B 221, Aluminum alloy 6063 heat-treated to produce a T6 temper.

B. Anchor Bases (including Bolt Covers) and Transformer Bases - ASTM B 108, Aluminum alloy 356 heat-treated to produce a T6 temper.

C. Anchor Studs, Lockwashers, Flatwashers, Screws, Nuts, Bolts, and Hardware -Stainless Steel

D. Anchor Rods - Hot-rolled steel; galvanized in accordance with ASTM A 153 for thread exposure, plus 3 inches minimum toward "hook" end.

E. Anchor Couplings - Hot-rolled steel; galvanized in accordance with ASTM A 153.

F. Luminaire Housings - Low copper content (less than 0.4%) aluminum alloy 360.4 heat-treated to produce a T6 temper.

2.02 CONSTRUCTION FEATURES

A. General

1. Components and sizes (lengths and diameters) of roadway lighting standards and assemblies shall be as shown on the Contract Drawings.

2. Electrical equipment for which there is a nationally recognized standard shall be safety tested and bear the conformance labeling of the third party inspection authority, such as Underwriters Laboratories Inc. (UL), ETL, Factory Mutual, or approved equal, certifying that the lighting fixtures and electrical equipment are listed as suitable for the purpose specified and shown on the Contract Drawings.

B. Luminaires

1. General

a. Roadway luminaires described in this specifications are of three general types:

(1) Highway luminaires-pole mounted luminaires for open roadways.

(2) Underpass luminaires-ceiling or wall mounted luminaires for covered portions of roadways.

(3) Sign luminaires-sign mounted luminaires for traffic signs.

b. Supply and install roadway luminaires in accordance with Section 16510, this Section of specifications and lighting fixture descriptions and manufacturer's model number as shown on the Contract Drawings.

c. Unless otherwise noted on the Contract Drawings, roadway luminaires shall be constructed of a metal housing, optical assembly, and a lens door. All mounting hardware shall be constructed of corrosion resistant material.

d. Optical assembly shall consist of specular aluminum reflector and borosilicate glass refractor or flat lens. Polycarbonate, Acrylic or other plastic refractors and lenses are not permitted. Optical assembly shall be self-leveling and sealed with a breathing and filtering gasket to prevent entrance of airborne contaminates. Gasket shall be cemented full perimeter with no metallic clips or fasteners.

e. The hinge mounted lens door shall be fully gasketed and accessible for tool-less or single tool relamping.

f. Ballast shall be mounted on a removable tray and shall have quick disconnect electrical terminals for easy maintenance.

g. Unless otherwise noted on the Contract Drawings, roadway luminaires shall have an electrostatically deposited, thermally set, grey polyester powder coat finish.

h. There shall be optional factory prewired no-tool photoelectric control receptacle. Photocontrol receptacles shall be provided with a stop to prevent rotation beyond 350°.

i. The photometric light distribution of the roadway luminaires shall be classified by IESNA as a one of the following Types:

(1) Type I

(2) Type II (Type II four-way)

(3) Type III

(4) Type IV

(5) Type V

2. Highway luminaires:

a. Unless otherwise noted on the Contract Drawings, highway luminaires shall be a high-pressure Sodium (HPS) type with Type I, Type II or Type III photometric distribution.

b. Highway luminaires shall be furnished with cutoff, semi-cutoff or non-cutoff optics as specified on the Contract Drawings.

c. The highway luminaires shall be equipped with a latched and hinged power door for easy luminaire access.

d. The internal slipfitter shall be furnished with one-piece pipe clamp capable of adapting 1-1/4 through 2-inch pipe without rearrangement of clamp or bolts, and shall be adjustable at least $\pm$ 5° from horizontal.

3. Underpass luminaires:

   a. Underpass luminaires shall be supplied for direct ceiling mounting, direct wall mounting, or for use with surface conduits and boxes. Mounting boxes shall comply with the requirements specified in Section 16135 of this specification.

   b. Unless otherwise noted on the Contract Drawings ceiling mounted underpass luminaires shall be a HPS type with Type I or Type V photometric distribution.

4. Sign Lighting luminaires:

   a. Unless otherwise noted on the Contract Drawings ceiling sign luminaires shall be a Metal Halide (MH) type with wide photometric distribution.

   b. Sign luminaires shall be furnished with integral light shields to minimize back and side glare.

C. Lamps

1. A lamp shall be furnished for each lamp holder of each luminaire. Luminaires and lamps shall be of the type and wattage as shown on the Contract Drawings and as specified in this Section and in Section 16510 of these specifications.

2. Mercury Vapor lamps are not permitted for roadway lighting.

D. Ballasts

1. Unless otherwise noted on the Contract Documents ballasts shall be a Constant Wattage Auto transformer (CWA) type and shall comply with requirements of Section 16510 of these specifications.

2. HPS ballasts, which are not used in a 24-hour operation, shall be furnished with automatic protective starters. An automatic protective starter shall apply pulses for no more than 15 minutes and then deactivate if a lamp arc cannot be initiated.

E. Fuse Assemblies

Fuse assemblies shall be complete with 5 amperes, 600-volt fuses, with 18-inch long leads of No.10 Standard type XHHW or USE wire.

F. Shafts

1. Unless otherwise noted on the Contract Drawings, shaft shall be spun tapered, or octagonal tapered, seamless tubing. Shaft may be drilled to manufacturer's specification for mounting luminaires. Removable aluminum pole cap shall be provided for the top of each shaft.

2. Each shaft shall be furnished with a cable support hook mounted inside the top of the shaft.

3. Welding shall be performed on the shaft only at the anchor base. Field welding shall not be permitted.

4. Where design parameters will result in excessive vibration, shafts shall be provided with factory installed vibration dampeners. Vibration dampener size, location and mounting shall be in accordance with the manufacturer's recommendations, and as approved by the Engineer.

G. Mast Arms

The types and sizes of mast arms shall be as shown on the Contract Drawings.

H. Anchor Bases

Anchor bases shall be free from cracks, pits, and blow holes, and shall be provided with a grounding lug. The base shall be supplied with bolt covers and mounting hardware and shall have provision for anchoring to the transformer base.

I. Transformer Bases

1. Transformer bases shall be frangible type and shall be free from cracks, pits and blow holes. Transformer bases shall be breakaway approved and fatigue tested.
2. Each transformer base shall be sized in accordance with the manufacturer's specifications and by pole height, total weight and bolt circle.
3. All transformer bases shall be provided with internal lugs for mounting on anchorage and a tapped hole inside the base for mounting a ground stud.
4. The base shall be furnished with a suitably sized, lockable, hinged door.

J. Pole Foundations

Pole foundation details and concrete for the pole foundations shall be as shown on the Contract Drawings.

K. Finish

Unless otherwise shown on the Contract Drawings, shafts, mast arms and transformer bases shall be satin finished clear anodized. Anodic coatings shall comply with ASTM B 117, 0 136, 0 137, and 0 244.

L. Accessories

Hardware accessories: slip fitters, mounting plates, screws, nuts, washers, bolts and other hardware necessary for assembling the roadway lighting standards shall be provided. The exposed portion of studs, washers, hex nuts and other hardware shall be well greased.

M. Anchor Bolts

Anchor bolts, including anchor rods, anchor couplings, anchor studs, nuts, installation template and flatwashers and lockwashers, shall he furnished for each lighting standard.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install concrete foundations, including conduits and anchor bolts, as shown on the Contract Drawings and in accordance with the manufacturer's anchor bolt template.

B. Install underground conduits as shown on the Contract Drawings and as specified in Section 16115 of this specification.

C. Install conduit bodies and mounting boxes for underpass luminaires as shown on the Contract Drawings and as specified in Section 16135 of this specifications.

D. Install roadway lighting standards, fixtures and appurtenances in accordance with the Contract Drawings, manufacturers' installation procedures and as specified herein.

E. Connect all equipment as required for proper operation and as shown on the Contract Drawings.

F. Set lighting standards plumb with variation off-true-vertical not to exceed 1/8-inch in ten feet. Vertical alignment shall be achieved by shimming, grouting or other approved means. Grout all bases after final alignment has been completed.

G. Set underpass and sign luminaires plumb with variations off-true-horizontal between two adjacent fixtures not to exceed 1/8-inch. Fixture mounting variations from a straight line between the first and the last fixture in a row shall not exceed 1/8-inch.

H. Requirements for mounting heights shall be as shown on the Contract Drawings.

3.02 FINISH REPAIR

All abraded or damaged anodized surfaces of roadway lighting standards, fixtures and appurtenances shall be repaired in a manner satisfactory to the Engineer.

END OF SECTION

SECTION 16550

ROADWAY LIGHTING

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Manufacturer's established installation procedure manuals for each type of specified roadway lighting standard and fixture.
2. For each roadway lighting standard and fixture type: Clearly illustrate assembly methods, detailed dimensions, anchor bolt templates, mounting details, materials, finishes, electrical components, and light sources.
3. For each lighting fixture type: Submit independent testing laboratory photometric report, and performance data in IESNA format
   a. Luminaire, ballast and lamp and optical assembly description and manufacturer's complete catalog number
   b. Luminaire schematic drawing with basic dimensions
   c. Isolux (isofootcandle) Curves for street and house sides
   d. Lumen Utilization Curves for street and house sides
   e. Zonal Lumen Summary Table
   f. Input Watts
   g. Luminaire Efficiency
4. For each ballast type: Submit manufacturer's data with ballast description, catalog number, lamp type, input voltage, input wattage, ballast factor, power factor, minimum starting temperature, operating temperature and wiring diagram.
5. Photoelectric Control Devices: Submit manufacturer's data for ambient light sensors and contactors.

B. Calculations

1. For each roadway lighting standard type specified on the Contract Documents submit calculations verifying that total weight and Effective Projected Area (EPA) of the selected lighting standard with accessories and appurtenances do not exceed manufacturers Maximum Recommended Total Load.

C. Samples

For items indicated on the Contract Drawings submit working samples for review and approval upon request by the Engineer. Install and energize samples as shown on the Contract Drawings or as directed by the Engineer.

D. Mock-up

1. If requested on the Contract Drawings, provide mock-up installation for review and approval by the Engineer. The mock-up shall simulate specified roadway lighting conditions as shown on the Contract Drawings.

2. For each substitution item which is not specified on the Contract Drawings provide mock-up installation at no cost to the Authority if requested, and as directed by the Engineer.

END OF APPENDIX "A"

DIVISION 16

SECTION 16561

TAXIWAY AND RUNWAY GUIDANCE SIGNS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for taxiway and runway guidance signs.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

	American Association of State Highway and Transportation Officials (AASHTO)
AASHTO	Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.
	American Society for Testing and Materials (ASTM)
ASTM A 153	Specification for Zinc Coating for Hot Dip on Iron and Steel Hardware.
ASTM D 4956	Specification for Retroreflective Sheeting for Traffic Control.
	Federal Aviation Administration (FAA) Advisory Circulars
AC 150/5340-18C	Standards for Airport Sign Systems.
AC 150/5345-26	Specification for L-823 Plug and Receptacle, Cable Connectors.
AC 150/5345-42	Specification for Airport Light Base and Transformer Housings, Junction Boxes, and Accessories.
AC 150/5345-44G	Specification for Taxiway and Runway Signs.
AC 150/5345-47	Isolation Transformers for Airport Lighting Systems.
	National Fire Protection Association (NFPA)
NFPA 70	National Electrical Code.

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. General

Taxiway and runway guidance signs, hereinafter referred to as "Signs," shall be retroreflective and shall be the internally illuminated, non-fiber optics type, and shall conform to AC 150/5345-44G or it's latest edition, other referenced publications, and to the requirements of this Section. In the event of conflict, the more stringent of these shall apply.

B. Design Requirements

1. Types

   a. Type L-858YDirection, Destination, and Boundary Signs: Sign faces shall contain a black legend on yellow background.

   b. Type L-858RMandatory Instruction Signs: Sign faces shall contain a white legend on a red background.

   c. Type L-858LTaxiway and Runway Location Signs: Sign faces shall contain a yellow legend and border on a black background.

   d. Type L-858BRunway Distance Remaining Signs: Sign faces shall contain a white legend on a black background.

2. Size

   a. Types L-858Y, L-858R, and L-858L signs shall be Size 3, as defined in AC 150/5345-44G.

   b. Type L-858B shall be Size 4, as defined in AC 150/5345-44G.

3. Style

   a. Unless otherwise indicated on the Contract Drawings, all Signs shall operate from either a Style 3, 5-step series lighting circuit, or a Style 5, single-step series lighting circuit, as defined in AC 150/5345-44G, and shall be energizeable and operable at any incoming current value of the series lighting circuit between 2.8 and 6.6 Amperes without flickering.

   b. The Signs operating on a Style 3 series lighting circuit shall have an internal current regulator maintaining required secondary current through the lamp at all current values of the series lighting circuit between 2.8 and 6.6 Amperes. Signs operating on a Style 5 series lighting circuit shall operate without the use of an internal current regulator. The illumination level and uniformity shall be maintained across all brightness steps.

4. Class: Signs shall operate in Class 1 conditions, as defined in AC 150/5345-44G.

5. Sign Legend: The dimensions of the sign legend characters, numerals and graphics shall be in accordance with AC 150/5340-18C and AC 150/5345-44G.

6. Structural Criteria

   a. Legend panels, panel supports, and mounting legs shall conform to the requirements of Article 3.3.2 of AC 150/5345-44G.

   b. The allowable design stress for all items other than the frangible points and tether shall be 125% of the allowable stresses specified in AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals".

   c. A high-strength, galvanized steel tether shall be furnished and attached to each mounting leg at the breakaway section and its foundation. Each tether and its connections shall be designed to withstand its proportional static load of 1.3 psi acting normal to the sign panel with a factor of safety of 4.0. The length of the tether shall be as shown on the Contract Drawings and shall not allow for sign to snap in case of the sign failure.

C. Performance Requirements

1. Sign Operation

a. The luminance level and uniformity of the Sign shall be maintained across all series lighting circuit current values, as measured from the primary side of the isolation transformer.

b. Power input from the series lighting circuit shall be made through isolation transformers, properly rated, and conforming to AC 150/5345-47.

2. Sign Face

a. The sign legend shall consist of a polycarbonate material with the sign message bonded to it. The background color shall be a retroreflective material bonded to the polycarbonate material behind the sign message. The color and luminance factor of the retroreflective panels shall be in accordance with ASTM D 4956 for Type I sheeting. The manufacturer shall guarantee the bonding of the retroreflective material against peeling for 2 years.

3. Sign Luminance

a. The internally illuminated background of the Type L-858Y Signs and the legend of the Type L-858L Signs shall have an average luminance from 50 to 150 cd/m^2 (15 to 44 footlamberts). The background luminance of the Type L-858R Sign shall have an average luminance of 10 to 30 cd/m^2 (2.9 to 8.7 footlamberts). The legend of the Types L-858R and L-858B Signs shall have an average luminance from 100 to 300 cd/m^2 (29 to 87 footlamberts). The luminance ratio between red and white elements of the Type L-858R Signs shall not exceed 1:10. The message of all Signs shall be clearly visible and legible from a distance of 800 feet. These luminance levels shall be maintained across all brightness steps.

b. The luminance uniformity of the Sign background shall not exceed a maximum to minimum ratio of 5 to 1. The luminance uniformity of the Sign legend shall not exceed a maximum to minimum ratio of 5 to 1. The luminance uniformity shall be maintained across all brightness steps.

1.04 QUALITY ASSURANCE

A. Entities performing the Work of this Section shall have the following qualifications:

1. The sign manufacturer shall have been manufacturing runway/taxiway guidance signs and aeronautical lighting products as a major product line for a minimum of three (3) years.

2. Installation Experience: The installer shall have three (3) years prior experience and technical expertise in the installation of aeronautical series lighting and signage technologies. The Contractor shall have installed, and have satisfactorily operational, a minimum of three (3) installations, preferably located in the United States. These installations shall be of a similar size, type and complexity as described herein. These installations shall be in satisfactory operation for a minimum of one year.

B. Product

1. The Runway/Taxiway guidance signs shall be fully certified to be in compliance with all aspects of FAA Advisory Circular and 150/5345-44G.

2. The Sign shall be internally illuminated by high output (HO) fluorescent lamps operated by cold temperature ballast.

3. Identical lamps and ballasts shall be used in all sizes and types of Signs supplied for ease of maintenance. Lamps and ballasts shall be manufactured in the United States and shall be readily available from commercial electrical supply dealers within the Port Authority District.

4. The electrical and mechanical components or subassemblies shall be available to be purchased as spare parts from a minimum of one (1) source of supply.

5. The minimum power factor of each sign, for all brightness steps, as measured from the primary side of the isolation transformer shall be 0.85. The maximum VA load on each sign, at the highest brightness step, as measured from the primary side of the isolation transformer, shall be as follows:

   a. Single face

      (1) Four-foot Sign: 80 Volt-Amperes.

      (2) Six-foot Sign: 80 Volt-Amperes.

      (3) Eight-foot Sign: 165 Volt-Amperes.

      (4) Ten-foot Sign: 165 Volt-Amperes.

      (5) Twelve-foot Sign: 165 Volt-Amperes.

   b. Double face

      (1) Four-foot Sign: 80 Volt-Amperes.

      (2) Six-foot Sign: 165 Volt-Amperes.

      (3) Eight-foot Sign: 165 Volt-Amperes.

      (4) Ten-foot Sign: 165 Volt-Amperes.

      (5) Twelve-foot Sign: 225 Volt-Amperes.

6. The luminance of each sign shall comply with FAA AC 150/5345-44G and the requirements of this Section.

7. The rated life of the lamp(s) used to illuminate the Sign shall be no less than 9000 hours, at rated voltage and rated current.

8. The tether shall be constructed of high-strength steel cable, and its connections shall be hot dip galvanized as per ASTM A 153.

1.05 DELIVERY, STORAGE, AND HANDLING

A. The Signs shall be wrapped for protection during delivery, storage and handling. Wet or damp wrapping shall be removed, and disposed of, to prevent staining finish.

B. Deliver materials in manufacturer's original, unopened, protective packaging.

C. Store materials in original packaging in a manner to prevent soiling and physical damage, prior to installation.

D. Handle in a manner to prevent damage to finished surfaces.

E. Where possible, maintain protective covering until installation is complete and remove such coverings as part of final cleanup.

1.06 MANUALS

Twenty (20) instruction booklets shall be included with each order of signs that shall include installation instructions, maintenance procedures, troubleshooting procedures (including operating voltage and point readings), and a complete parts list. It shall also describe the lamp wattage or current needed to maintain the luminance levels specified herein.

1.07 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MATERIALS

A. Each sign shall include mounting legs and hardware; electrical disconnects; any required series circuit adapter units for Style 3 signs; and instruction booklets. Materials used shall not deteriorate or rust. Separators shall be used to avoid contact between dissimilar materials.

2.02 CONSTRUCTION FEATURES

A. Sign Construction

1. The Signs shall be constructed of lightweight, non-ferrous materials and shall be designed for installation on a concrete pad. No sign shall present a target for ground radar sweeps. All required mounting hardware, except anchor bolts, shall be supplied with each sign.

2. Each multiple lamp Sign shall be equipped with a lamp bypass circuit that shall maintain a reduced illumination level upon failure of one lamp.

3. Signs shall consist of legends mounted on one or both sides, as required by the Contract Drawings or the requirements of this Contract. The Sign legends shall have retroreflective material that shall meet the color and reflectivity requirements of ASTM D 4956 Type I sheeting.

4. The exterior color of the sign enclosure shall be black. Reflective material tags shall be applied to the back and sides of the sign such that the sign shall be visible to vehicles during hours of darkness.

5. The sign face assembly shall have gasketing between the Sign material and the housing so that the interior of the Sign enclosure shall remain free from dirt, sand and dust.

6. Sign Numbering: The manufacturer shall affix white, reflectorized, 4" high, stick-on numerals on the side of each Sign enclosure. The number shall correspond to the Sign number shown in the Sign Legend on the Contract Drawings.

B. Mounting Legs: Mounting legs for each Sign shall be equipped with frangible couplings with breakaway points located no more than two inches above the concrete pad. The frangible couplings shall withstand wind loads of 200 miles per hour, and shall break before reaching an applied static load of 1.3 psi. Each frangible coupling shall be permanently marked with the manufacturer's name and size of the Sign for which the coupling is intended.

C. Tether: Each Sign shall be supplied with tethers, each of which shall be secured to one of the mounting legs at the breakaway section. The tethers shall remain attached to the mounting leg and sign foundation.

D. Nameplate: The nameplate shall be mounted to the exterior of the sign enclosure at the topside of the sign. The nameplate data shall include the maximum VA load from the primary side of the transformer.

E. Electrical Features

1. Ballasts and all other electrical components shall be easily accessible in an enclosure mounted to the exterior of the sign structure.

2. The Signs shall be relampable without the use of tools. Loose parts shall be tethered to, or otherwise prevented from blowing away from, the installed Sign enclosure. All screws or latches shall be the captive type, and shall be easy to open and close.

3. Power input from the lighting circuit shall be made through an isolation transformer conforming to AC 150/5345-47.

4. The length of the power input leads shall be field adjustable and shall allow for lead termination in a Type I, Class A, Style 9 receptacle, conforming to AC 150/5345-26.

5. The minimum power factor and maximum load, in Volt Amperes, of each Sign, for all brightness steps, as measured from the primary side of the isolation transformer, shall be as specified in Article 1.04 of these Specifications.

6. Electrical Disconnect: An external electrical disconnect switch shall be included in each sign assembly. This switch, when activated, shall de-energize the Sign for relamping purposes while maintaining continuity of the series lighting circuit. The switch shall be a make-before-break type.

7. All wiring shall conform to the requirements of NFPA 70. All wiring shall be color-coded, and shall be clearly labeled. There shall be no exposed wiring, except for the power cord.

8. All electrical materials and equipment for which there is a nationally recognized standard shall bear the conformance labeling of the third party inspection authority, such as Underwriters Laboratories, Inc., Factory Mutual, ETL, or approved equal.

F. Environmental Requirements

1. Temperature: Each Sign shall operate in an ambient temperature range of -20 degrees Celsius to +55 degrees Celsius.

2. Wind: Each Sign shall withstand exposure to wind velocities that will produce an applied static load over the legend panel of 1.3 psi.

3. Precipitation: Each Sign shall operate while exposed to fog, wind-driven rain, snow, sleet or other normally encountered ambient humidity conditions.

PART 3. EXECUTION

3.01 INSTALLATION

A. Employ the services of a Land Surveyor licensed in the state where the Work is to be performed to establish the proposed locations of taxiway/runway signs whose general locations are shown on the Contract Drawings.

B. Install the Signs on concrete foundations as shown on the Contract Drawings.

C. Place the mounting flanges over the threaded studs in the mounting pad and securely fasten. Attach tethers to ½ inch anchor bolts.

D. Make electrical connections as shown on the Contract Drawings. Adjust length of the power cord to remove excessive external cord slag. Adjust jumper for lamp bypass circuit to use with a series or shunt regulator.

E. All Signs installed end to end shall be oriented with the ballast housings facing outward. Signs shall be at least 2 inches apart.

3.02 FIELD TESTS

A. Provide all labor and materials for functional and operational tests required and furnish the power for the functional tests. Power for the operational tests will be furnished by the Authority.

B. Should the tests reveal any defects in Taxiway and Runway Sign Equipment installed under this Contract, promptly correct such defects and rerun the tests until the entire installation is satisfactory to the Engineer in all respects.

C. Report immediately to the Engineer any defect found in portions of the Taxiway and Runway Sign Equipment not installed under this Contract. Do not attempt to rectify any defect found in a component of the system not installed under this Contract unless specifically instructed to do so by the Engineer. The Contractor's compensation for the rectifying of such defects at the direction of the Engineer will be determined in accordance with the clause of the Contract providing compensation for Extra Work.

D. Furnish the Engineer with a copy of the "Megger" readings, together with an outline of the method used. If, in the opinion of the Engineer, any reading is lower than the values required by the FAA-AC specifications, promptly replace the fixtures and accessories involved, or by other means raise the readings to acceptable values.

E. After the functional tests have been completed, operate, in the presence of the Engineer, all electrical equipment for a period of twenty-four hours.

END OF SECTION

SECTION 16561

TAXIWAY AND RUNWAY GUIDANCE SIGNS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Sign assembly, including all fabrication, assembly methods, isolation transformer and transformer base, internal and external wiring diagrams.
2. Internal bracing of each Sign type, including all bolting and/or welding details.
3. Tether assembly, including all its connections.
4. Ballast compartment details, including mounting of all components.

B. Catalog Cuts

1. Taxiway and Runway Guidance Sign and Base, which shall show the following:
   a. Features and Accessories.
   b. Installation Details.
   c. Material Specifications.
2. List of electrical and mechanical components or subassemblies for the Sign, indicating the source of supply for each.
3. Testing
   a. Results of tests performed by an independent laboratory testing source in accordance with AC 150/5345-44G. These results shall address the following areas:
      (1) Visual Examination.
      (2) Wind Load and Frangibility Test: Assembly shall include tethers and their connections.
      (3) Photometric Test results, including luminance maps.
      (4) Rain and Emission Test.
      (5) Low and High Temperature Test.
      (6) Production Test.
   b. Load and power factor data for all brightness steps, as measured from the primary side of the isolation transformer.
   c. Sampling tests for frangible points shall be required. The test procedure shall be submitted to the Authority for approval. The number of samples required for testing shall conform to MIL Std 105D, Inspection Level 1.

4. FAA Certification documentation demonstrating that the Signs comply with the requirements of AC 150/5345-44G.

5. Samples

   a. Sign face material with all combinations of retro-reflective material, paint and color film applied to sign face.

   b. Sign face panel with legend and directional arrow as requested by the Engineer.

6. Calculations

   a. Submit design calculations for the entire sign assembly including tethers and their connections for the Authority's approval.

   b. Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the installation will take place.

END OF APPENDIX "A"

SECTION 16561

TAXIWAY AND RUNWAY GUIDANCE SIGNS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Documents show the following Electrical Drawings:

1. Taxiway and Runway Guidance Sign layouts indicating:
   - a. Sign Installation Notes.
   - b. Switchboard, Transformer and Power Panel Schedules.
   - c. Sign Circuit Schematic Diagram
     - (1) Manholes and handholes locations and numbers.
     - (2) Sign locations with identification numbers based on the Functional Drawings.
     - (3) Civil coordinate schedule (if required).
2. Base Plans:
   - a. Underground ductbanks and conduits.
   - b. Size and number of conduits in ductbank.
   - c. Sign locations, single or double face, orientations and identification numbers.
3. Sign installation Details
4. Sign Legend
   - a. Sign Identification Number.
   - b. Sign Face Legend (front & back).
   - c. Sign Face Bearing.
   - d. Near Corner of Sign to T/W or R/W.
   - e. Circuit Destination.
   - f. Type of Foundation.
   - g. Sign Size.

B. Ensure that the Contract Drawings show the following items specified in the text:

(1.03 B.1)	Sign types:	Direction, Destination and Boundary Signs Mandatory Instruction Signs Taxiway and Runway Location Signs Runway Distance Remaining Signs
(1.03 B.3)	Sign styles:	Style 3, Style 5
(1.03 C.1.b)	Isolation transformer ratings	

(1.04 B.2)	Lamp length, wattage and color
(2.02 A.1)	Sign enclosure material and fabrication method
(3.01 B)	Sign detailed drawing including Sign foundation

C. Manufacturers

Subject to compliance with the requirements of these Specifications, specify taxiway and runway guidance signs of one of the following manufacturers, or approved equal:

ADB Alnaco, Inc.
Crouse-Hinds Airport Lighting Products
NKI, Inc.
Standard Signs, Inc.

D. Coordination with other Sections

This Section applies specifically to Taxiway and Runway Guidance Signs. For installation of a complete Taxiway and Runway Lighting System, ensure that the following Sections, at a minimum, are incorporated in the Specifications:

RACEWAYS
UNDERGROUND CONDUIT SYSTEMS
WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS ORLESS)
WIRES, CABLES, SPLICES, TERMINATIONS (MEDIUM VOLTAGE)
BOXES AND FITTINGS
TAXIWAY/RUNWAY WIRES AND CABLES

END OF INSTRUCTIONS

DIVISION 16

SECTION 16570

FIBEROPTIC CHANGEABLE MESSAGE SIGNS AND LANE CONTROL SIGNALS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for Fiberoptic Changeable Message Signs (CMS) and Lane Control Signals. This Section includes both the internally illuminated and the remotely relampable types of Fiberoptic Changeable Message Signs and Lane Control Signals, lamp controllers, and associated remote light source cabinets, hereinafter referred to as "Fiber Optic Equipment Cabinets (FOECs)".

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

American Association of State Highway and Transportation Officials (AASHTO)

Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals.

American Welding Society (AWS)

AWS D 1.2 Structural Welding Code – Aluminum.

American Society for Testing and Materials (ASTM)

ASTM B 209 Aluminum and Aluminum - Alloy Sheet and Plate.

ASTM B 686 Aluminum Alloy Castings, High Strength.

Electrical Testing Laboratories, Inc. (ETL)

Federal Highway Administration (FHWA)

Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD)

Standard Highway Sign Manual.

Illuminating Engineering Society of North America (IESNA)

Lighting Handbook.

International Commission on Illumination (CEI)

Light Signals for Road Traffic Control (Publication No. 48 – TC 1.6).

International Municipal Signal Association (IMSA)

Traffic Signal Lighting Cable Specifications (Series 19/20 - 600 volts).

Institute of Transportation Engineers (ITE)

ITE ST-006 Standard for Lane-Use Traffic Control Signal Heads.

National Fire Protection Association (NFPA)

NFPA 70 National Electrical Code.

National Electrical Manufacturer Association (NEMA)

NEMA TS- 1	Standard for Traffic Control Systems.
NEMA 250	Standards for Enclosures for Electrical Equipment.
NEMA WD6	Standards for Wiring Devices - Dimensional Requirements.

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. Unless otherwise specified on the Contract Drawings or in this Section, the Fiberoptic Changeable Message Signs and Lane Control Signals, hereinafter referred to as the "Signs and Signals," shall conform to the requirements of NFPA 70, all local codes, all other publications referenced in 1.02 herein.

B. Sign and Signal size, message content, lettering size and style, structural details and materials shall conform to the requirements of this Section and the Contract Drawings.

C. The electrical and electronic hardware, structural materials and equipment housings, required for fully operational, integrated, real-time Signs and Signals shall operate on a twenty-four hour per day, seven day per week basis with high system reliability of 99.7 percent and shall conform to the requirements of this Section.

D. The Signs and Signals shall be composed of all items of hardware necessary to generate, transmit and effect the display of changeable message text on fiberoptic sign panels as specified herein and as shown on the Contract Drawings. In general, the Signs and Signals shall consist of readily available, reliable and proven hardware, software and firmware elements that fully comply with the requirements of this Section and the Contract Drawings. All of the Work of this Section shall be coordinated with the current operation of the facility.

E. All assemblies, sub-assemblies and modules shall be readily accessible for removal, testing or replacement without removal of the other modules, assemblies or cabinet components. Components shall be located so that there is visibility and access for the use of hand tools and standard test probes where maintenance is required. Test points shall be provided to facilitate troubleshooting.

F. Environmental Requirements

1. Unless otherwise specified on the Contract Drawings, the Signs and Signals shall operate over an ambient temperature range from -35 degrees Fahrenheit to + 120 degrees Fahrenheit (-37 degrees Celsius to +50 degrees Celsius). Operation of the equipment shall not be degraded by rain, snow, fog or normally encountered ambient humidity conditions.

2. Unless otherwise specified on the Contract Drawings, all equipment shall operate without degradation or damage under all weather conditions, vibration, lightning and electromagnetic/ electrical interference existing at the construction site.

1.04 QUALITY ASSURANCE

A. Qualifications

1. Contractor: Demonstrate a minimum of five years experience and technical expertise in performing contracts comparable in size and complexity, and that the work was performed skillfully in a satisfactory manner and on time. Submit a complete list, which shall consist of a minimum of three installations, one of which shall be located in the United States, which shall have included Signs and Signals work, comparable in type, size and complexity as specified herein. Said installations shall be in satisfactory operation for the last three consecutive years, minimum, and shall have included at least one contract that required the installation of Signs and Signals on existing roadway sign bridges.

2. Manufacturer: The manufacturer of the Signs and Signals shall be a business entity that is substantially engaged in the type and scope of work specified in this Section and shall demonstrate that they have been manufacturing both internally illuminated and remotely relampable Fiberoptic Changeable Message Signs and Lane Control Signal Systems for the last three consecutive years and shall demonstrate prior experience on at least two projects of similar size and complexity to what is required under this Contract. The equipment furnished shall be the manufacturer's standard line of merchandise. The manufacturer shall have demonstrated the operation of at least one successful remote fiber optic sign and signal installation with a minimum of 40-foot harness in a U.S. highway application.

3. System Integrator: The system and its components shall be supplied by one System Integrator of established reputation and experience who shall have provided technical assistance to contractors and shall have performed systems integration for the installation of both internally illuminated and remotely relampable Fiberoptic Changeable Message Signs and Lane Control Signal Systems for that last three consecutive years and shall demonstrate prior experience on at least two projects of similar size and complexity to what is required under this Contract.

4. Maintainer: The Signs and Signals manufacturer and the System Integrator, if applicable, shall have authorized maintenance personnel and resources available within the Port Authority District, as demonstrated by existing contracts, to provide maintenance for equipment comparable to the equipment furnished in accordance with the requirements of this Section.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in manufacturer's original, unopened, protective packaging. Said packaging shall be clearly labeled to identify the manufacturer and product name including storage requirements and instructions.

B. Store materials in a clean, dry space, protected from weather.

C. Handle in a manner to prevent damage to finished surfaces.

D. Where possible, maintain protective covering until installation is complete and remove such coverings as part of final cleanup.

E. The sign enclosures shall be supported for their full lengths during shipment. Structures shall be shimmed, braced, blocked and tied down to prevent distortion or other damage from occurring during transportation. The Contractor shall not use any device that does not support the member for its entire length. Lifting eyes or their equivalent shall be provided to facilitate handling and mounting of the sign enclosure.

F. Touch up damage to finishes to match adjacent surfaces, including re-coating of galvanized or plated surfaces where damaged, cut or drilled.

1.06 SPARE PARTS

A. The Contractor shall confirm that there is a minimum of three established agencies within the United States which stock a full inventory of spare parts for the Signs and Signals supplied. In the event that there are not three sources of supply, the Contractor warrants that all Sign and Signal components will be made available by the Contractor for a period of ten years from the date of acceptance of the Signs and Signals.

B. Submit to the Engineer a priced parts list, with the Sign and Signal manufacturer's recommendations of the type and quantity of spare parts to be stocked for a 20-year design life of equipment. Include names and telephone numbers of the nearest sources of supply for each item.

1.07 MAINTENANCE OF THE SYSTEM

Furnish full preventive service and remedial maintenance of the Signs and Signals including all labor, parts, material and supplies for one year from the rendering of the Certificate of Final Completion. The Contractor shall respond to a service call by traveling to the construction site within four hours of the call, 24 hours per day, 7 days per week, including holidays.

1.08 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with the requirements of this Section, furnish and install the following of one of the manufacturers as shown on the Contract Drawings:

1. Signs and Signals.
2. Lamp Controllers.
3. Fiber Optic Equipment Cabinets (FOECs).

2.02 MATERIALS

A. General

1. Each Sign and each Signal shall consist of the following:

   a. Sign housing shall be constructed of 0.140 inch extruded aluminum with a 1/8 inch flat aluminum back welded into the housing. The sign housing construction shall be reinforced with 1/4 inch aluminum "Z" stock struts, as required for stiffness. Sign face shall be 0.160 inch flat aluminum. Signal face shall be equipped with a no-glare, 3/16-inch thick, polycarbonate sunscreen. All comers and seams shall be heliarc welded to provide a weatherproof seal around the entire case. Continuous full-length stainless steel hinges, 0.040 inches by 1-1/16 inch open, shall connect the housing and the extruded aluminum door. The sign housing shall be equipped with mechanically latching brackets and bracing as appropriate to support the sign face, when opened. Sign and signal housings shall be front-accessible.

   b. Signal housing shall be constructed of 0.080 inch extruded aluminum with a 0.063 inch flat aluminum back welded into the housing. Signal face shall be 1/8 inch inch flat aluminum.

   c. Door gaskets shall be 3/16 inch by 1 inch neoprene to provide a weathertight seal. Each door for each sign or signal housing is to be fitted with a sun hood of 0.063 inch aluminum, 6 inches deep, to span the width of the door. Drainage shall be provided by four drain (weep) holes located at the four comers of the housing bottoms.

   d. Weatherproof signal face, housing and door.

   e. Weatherproof FOECs for lamps and lamp controllers.

   f. Fiber Optic Harnesses made of PVC-coated glass fibers.

      (1) The fiber optic harnesses shall consist of PVC-coated glass on glass-fiber optic bundles, with 5% spare fibers and a maximum transmission loss of 200 dB/km. Each output bundle at the sign face shall be 1 mm in diameter. Each fiber optic harness shall be furnished with weather resistant polyethylene spiral wrapping for its entire length.

   g. Color filters for desired directional arrows and cross colors, and Halogen Lamps.

   h. Fixture mounting plates, as shown on the Contract Drawings.

   i. Lock hardware, keyed to match the Facility's Lock System, as specified on the Contract Drawings.

2. The fiber bundles shall be connected to the sign or signal face through a lens to be fitted over the end of each glass bundle. The output lens shall be mounted through the signal face from the inside outward. Each point shall be drilled into a flat black-painted aluminum faceplate.

3. Fiberoptic Components

a. The Signs and Signals shall consist of high quality fiberoptic glass bundles arranged on the sign face to define the changeable messages specified on the Contract Drawings. Each bundle shall consist of multiple individually tightly packed optical glass fibers. The fiberoptic bundles shall be ground smooth and optically polished at the input and output ends for maximum light transmission. The individual bundles shall be flexible and not rigid. For fiber protection during routing maintenance and operation, the individual fiber bundles shall be encapsulated in a polyvinyl-chloride (PVC) protective jacket.

b. The fiberoptic glass bundles shall be connected to the Sign and/or Signal faceplate through a receptor or lens to be fitted over the end of each glass bundle. The output receptor shall be snap-mounted through the faceplate from the inside outward. No fiber bundles shall be connected directly to the faceplate. No epoxies or glues shall be necessary to hold the output bundle receptors in place.

c. In the receptors, the light from the fibers shall be focused through a lens into the required beam and projected uniformly on the Sign and/or Signal faceplate. The individual receptors may accept one or several bundle endings, as required.

d. The number and size of the bundles required shall vary on a per sign basis according to the number and context of messages at the Sign and/or Signal location. The quantity and size of the bundles used in the Signs and/or Signals shall be suitable for obtaining the viewing distance and cone of vision requirements specified in this Section or as shown on the Contract Drawings.

4. The bundle receptors shall be non-reflective and shall be flat black in color to minimize legibility when the fibers are deactivated and to maximize legibility when the fibers are activated. The Signs and Signals shall be completely blanked-out when not energized. No phantom messages shall appear on the receptor lens when the fibers are deactivated regardless of ambient light conditions.

5. Each fiberoptic harness shall contain spare bundles equivalent to 10 percent of the total bundles employed for each legend segment. Damaged output bundles shall be easily replaceable using the spare bundles. No special tools shall be required to complete this replacement.

6. The fiberoptic bundle groups for each message segment shall be returned to common endings within the lamp assemblies, where the color filters, light source and reflectors for the message segment are located.

7. Each optical light bundle fitted into the faceplate shall contain a convergence cone producing an emission-controlled angle as specified above. The minimum light intensity output of each light point forming the message, depending on light guide length and filter, is shown in the following table:

LIGHT INTENSITY PER POINT WITH AND WITHOUT FILTER
(14 Degree Viewing Cone, measured in Candela)

Light Guide Length (feet)	Without Filter	Red Filter	Yellow Filter	Green Filter
4	15.8	3.5	7.9	4.7
10	13.8	3.0	6.9	4.1
20	10.9	2.0	5.4	3.3
30	8.8	1.9	4.4	2.6
40	7.7	1.7	3.9	2.3
50	6.6	1.5	3.4	2.0

8. Unless otherwise shown on the Contract Drawings, all displayed messages from all Signs and Signals shall maintain luminance levels, under all levels of ambient luminance within the cone of visibility specified in this Section and on the Contract Drawings, equal to the values shown in the following table, as a minimum:

Color	Low Ambient Luminance* (cd/ft^2)	Medium Ambient Luminance* (cd/ft^2)	High Ambient Luminance* (cd/ft^2)
White	30.0	65.0	125.0
Red	6.6	14.3	27.5
Yellow	15.0	32.5	62.5
Green	9.0	19.5	37.5

*As defined in the IESNA Lighting Handbook.

These luminance levels shall be achieved while the lamp brightness is at 90% of the manufacturer's rated value for design lumen output. The luminance shall be uniform for all messages. This uniform brightness shall be provided by means of optically correct glass filters with varying opacity as required, and with both lamps dimmed to 90% of full brightness.

9. Lamp Assemblies

   a. The lamp assemblies shall contain the common bundle endings, the message color filters, and the illumination lamps and light reflectors. The assemblies shall not be rigid mounted and shall be equipped with a suitable mechanism to reduce the mechanical transmission of shock forces and vibrations. The assemblies shall be mounted so as to prevent them from collecting water due to condensation and/or possible housing leakage.

   b. Ensure that the quantity and wattage of the lamps utilized in the fiberoptic CMS panels is suitable for obtaining the viewing distance and cone of vision requirements specified for the CMS panels in this Section or as shown on the Contract Drawings.

10. The lamps and light reflectors may be separate or one-piece unit(s).

    a. In order to avoid confusion during relamping, only one type of lamp/reflector unit shall be used in all fiberoptic CMS panels furnished as part of this Contract.

    b. The lamp receptacle socket shall include a suitable lamp grip mechanism to prevent the lamps from working loose due to vibration. No special tools shall be required to remove and/or replace a lamp. One spare lamp with reflector shall be provided for each lamp assembly supplied.

11. The light reflectors for separate lamp and light reflector units shall be Alzak finished aluminum, or approved equal. The reflector surface shall be totally free of flaws, scratches, defacements or mechanical distortions.

    a. The reflector mounting mechanism shall be sufficiently designed and assembled to secure the proper optical center alignment between the lamps and the fiber bundle common end. The reflectors shall be easily removable without the use of special tools.

12. Message color shall be provided by tempered, optically correct glass color filters which meet the boundary equations of the standard observation chart in the International Commission on Illumination (CEI) Publication No. 48 (TC-1.6) and as specified in ITE Standard ST-006. Initial message color shall be as specified on the Contract Drawings. Thereafter, messages color shall be changeable in the field by replacing the color filters.

13. Message colors shall be provided by tempered, optically correct, glass color filters. These glass color filters shall be supplied as an integral part of the light projection assembly. The filters shall be appropriately protected from the heat of the lamps to prevent damage. Removal of the lamp assembly shall not be required to replace the filters. No tools shall be required to complete a filter replacement.

14. The rated lamp life of the type of lamp proposed for use in the Signs and Signals, measured while the lamp is operating at 100% rated voltage and 100% rated current, shall be no less than 4000 hours.

15. No more than one type of lamp and one type of lamp controller shall be used in all sizes and types of Signs and Signals supplied for ease of maintenance. Variations of the wattage or the type of lamp used shall subject to the approval of the Engineer. Lamps, lamp controllers and transformers shall be readily available from commercial electrical supply dealers within the Port Authority District.

16. The color of any directional arrow and cross may be changed in the field by replacement of the color filters without removing the sign or signal. Door panels and lens holders shall be colored flat black to maximize legibility. No color shall appear in the lenses when deactivated regardless of ambient light conditions.

17. All fasteners and hardware shall be corrosion-resistant stainless steel.

18. All components shall be readily accessible for maintenance when the door is open.

19. No tools shall be required for lamp replacement.

B. Remotely Relampable Fiberoptic Changeable Message Signs and Lane Control Signals

1. The remote light source for each message shall utilize a minimum of two halogen lamps that transmit light to two fiber optic harnesses by means of a beam-splitting mirror. This arrangement will permit continued operation of the message at a reduced output level in the event of a lamp failure.

C. Lamp Controllers

1. Nighttime dimming shall be accomplished through a photocell and lamp controller unit providing two levels of light intensity. Where multiple Signs and/or Signals are located at the same location and are located at varying distances from the light source, lamp intensity adjustments shall be done on a coordinated basis so that the light intensity of like symbols on those signs and/or signals is equal.

2. The lamp controller shall have the following features:

   a. One status output for each lamp circuit, primary and secondary. Status is determined by a true current monitor for reliable lamp failure indication.

   b. Two fully adjustable light intensity levels. The light intensity levels shall be:

      (1) DAY: Primary and secondary lamps dimmed.

      (2) NIGHT: Secondary lamp off and primary lamp dimmed for low light levels. While in NIGHT mode, if the primary lamp fails the circuit shall automatically switch on the secondary lamp.

c. The light intensity levels shall remain constant regardless of any line voltage variations in the DAY and NIGHT intensity levels.

d. Dual redundant circuitry. Failure in the primary lamp transformer circuit shall not affect the secondary lamp transformer circuit.

e. Unless otherwise specified on the Contract Drawings, special internal logic shall be provided that only allows one symbol to be displayed at a time. Unless otherwise specified on the Contract Drawings, all lamps shall shut down if more than one symbol is selected at a time.

f. The lamp controller module shall be designed such that in the event of a lamp failure the sign shall continue to display a discernible and readable legend.

g. All control input lines shall provide a balanced AC load and include noise rejection circuitry.

h. Double terminal block for all control lines, for ease in wire termination.

D. Fiber Optic Equipment Cabinets

1. Each FOEC shall consist of the following:

a. Remote light source optical delivery assembly.

b. Halogen lamps for each message.

c. Lamp transformers.

d. Lamp controllers.

e. Cable management tray assembly.

f. Terminal strips as required.

g. Backplate with above equipment installed thereon, as shown in the Contract Drawings.

h. Cabinet of size and manufacturer as shown on the Contract Drawings.

i. Lock hardware keyed to match the facility lock system, as shown on the Contract Drawings.

j. Photocell for dimming.

2. All fiber optic equipment cabinets shall be equipped with white enameled steel backpanels.

3. FOECs installed in locations accessible to the public shall be vandalproof, as shown on the Contract Drawings.

2.03 CONSTRUCTION FEATURES

A. Message Display Module: Functional Requirements

1. There shall be no movable part within the Signs and Signal panels to affect message formation, illumination or legibility.

2. Unless otherwise shown on the Contract Drawings, message lettering and symbols shall comply with the size dimensions and graphic characteristics of the standard highway alphabets Series C through E(m) as specified in the FHWA "Manual on Uniform Traffic Control Devices" and the FHWA "Standard Highway Sign Manual". Spacing for letters of the same word and between words and symbols shall be 150 percent of the FHWA specified requirement for the associated alphabet.

a. Unless otherwise shown on the Contract Drawings, the vertical spacing between lines shall be equal to 75 percent of the lettering height, minimum.

3. The Signs and Signals shall provide for light indication in one direction only. The panels shall be so designed and assembled that no light can escape from the panel enclosure other than through the fiberoptic bundle endings in the direction for which the sign is intended.

4. The displays shall be visible from a point not less than 50 feet per inch of letter height in advance of the sign location in the center of the approaching traffic lanes for which the sign message is intended under all types of atmospheric conditions.

5. All messages shall be clearly legible, attracting attention under any lighting conditions, including low angle sunlight on the front of the sign (direct illumination) or behind the sign (backlighting). Unless otherwise shown on the Contract Drawings, the Signs and Signals, at full intensity, shall be highly visible anywhere within a minimum 35-degree cone centered about the optic axis. A visor or hood shall not be required to obtain message legibility.

6. For improved night visibility the light output shall be automatically reduced by means of a photoelectric switch. Dimming of the CMS shall be accomplished by reducing the supply voltage to the lamps using solid state equipment in proportion to ambient light conditions. The dimming voltage reduction levels shall be user-selectable during and after installation to accommodate local conditions.

   a. Where multiple fiberoptic Signs and Signals are located on the same sign structure and facing the same direction, lamp dimming shall be done on a coordinated basis, so that the voltage reduction (or increase) is implemented at the same time and uniformly for all CMS panels at that location. These locations shall be as shown on the Contract Drawings.

7. Electrical Interface

   Individual lamp transformers shall be utilized in each Sign and Signal panel to reduce the incoming 120 VAC to between 10.0 and 12.0 VAC, as required. The transformers shall contain Class A insulation and weatherproofing.

B. Panel Enclosures

CMS panel enclosures shall be of such design and shape as to house all necessary fiberoptics, transformers and lamp assemblies. The overall dimensions and external color of the required housings shall be as shown on the Contract Drawings.

1. Construct of corrosion resistant aluminum material conforming to the following: (isolate adjacent dissimilar materials)

   a. Sheet aluminum shall be fabricated from aluminum alloy sheet meeting the requirements of ASTM B 209, Alloy 5052, Temper H3 or equivalent, minimum 0.125-inch thick. All overlapping seams for aluminum cabinets shall meet the requirements for Type 4 enclosure according to NEMA 250.

   b. Cast aluminum shall be fabricated from aluminum alloy meeting the requirements of ASTM B 686, Alloy A 356 (A 13560) or equivalent. Flat cast surfaces exceeding 12 inches in both directions shall have a minimum thickness of 0.25 inches. Flat cast surfaces not exceeding 12 inches in both directions shall have a minimum thickness of 0.187 inches.

c. Unpainted aluminum sign enclosures shall be fabricated from mill finish material and shall be cleaned using appropriate methods that will remove oil film, weld black and mill ink marks and render the surface clean, bright, smooth and not sticky to touch.

2. The fiberoptic bundles shall be arranged and mounted on a flat black, non-reflective anodized aluminum faceplate.

3. The CMS panel faceplate shall be protected from weather and vandalism by a weathertight, optically designed polycarbonate lens or approved equal mounted to the front of the faceplate. The protective lens shall be both replaceable and shatter resistant. Removal of the protective lens shall not detract from the light intensity of the message display.

4. All nuts and bolts used in the sign assembly shall be stainless steel. All connecting surfaces shall be weatherproof when secured. All internal components shall be mounted so that there are no external protrusions.

5. Design shall be in accordance with the AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals", except as modified herein:

a. The sign enclosures shall be designed and constructed so as to present a clean, neat appearance and the equipment located inside shall be adequately protected from moisture, dust, dirt, corrosion and excessive heat.

b. All surfaces shall be suitably protected weather and, if required on the Contract Drawings, painted or otherwise color coated. Where required, all comers and seams shall be heliarc welded to provide a weatherproof seal around the entire case.

c. The housings shall be equipped with screened ventilation louvers to facilitate natural cooling. Drainage shall be provided by four one 1- inch screened drain holes located at the four comers of the housing bottom.

d. The CMS panel faceplate, protective lens and housing shall not be adversely affected by salt from the roadways or chemicals discharged from nearby industries and other sources. The interior of the replaceable protective lens and panel faceplate shall be easily accessible for cleaning and other maintenance.

(1) The protective lens shall be attached to the panel housing such that condensation does not occur between the faceplate and the protective lens.

(2) Protective lenses over six square feet shall be stiffened via spacer bars between the fiberoptic faceplate and the lens to prevent glare and uneven focus.

e. Access to the inside of the sign enclosure shall be provided by means of a hinged door attached to the rear of the sign enclosure, or by means of hinged faceplate as shown on the Contract Drawings. Large CMS panels may employ multiple access doors or faceplate openings. The housing door and/or faceplate opening shall be completely weatherproof when closed.

(1) The access door or faceplate shall be equipped with a suitable mechanical fastening device so that it will remain shut when closed. In order to facilitate sign maintenance, a mechanical strut-type locking mechanism shall be provided to hold the door or faceplate in the open position.

(2) Continuous stainless steel hinges equipped with stainless steel hinge pins shall be used to connect the door and faceplate to the CMS housing. Each hinge shall be secured with stainless steel bolts and lock nuts. The hinge pins and bolts shall be tamperproof.

(3) If rear access is provided, ensure that the access doors will open clear of any structural support members.

f. The dead load shall consist of the total weight as installed of the CMS enclosure and appurtenances. The point of application of weights of the individual items shall be their respective center of gravity.

g. Ice load shall be as per AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals", except that ice load shall be applied to all sides and top surfaces of the CMS enclosure simultaneously.

h. Wind load shall be as per AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals", except as modified herein. The CMS enclosure and mountings shall withstand a wind speed of 90 miles per hour.

i. Full 100 percent impact shall be used for handling and erection stress.

j. Unless otherwise shown on the Contract Drawings, housings shall include all mounting brackets necessary to facilitate the pivoting of the housing in any direction to allow for optimizing the viewing angle after installation. Electrical wire access to the inside of the sign panels shall be accomplished through one of these mounting hubs.

k. The CMS shall be capable of being mounted without gaining access to the inside of the enclosure. The CMS housing shall be adaptable for either top and bottom or side to side mounting as shown on the Contract Drawings.

C. Sign Control Function

1. Each fiberoptic CMS panel shall be manually controllable at the construction site by means of a locally housed sign control console.

2. Depending on the control requirements of the installation or of the CMS panels themselves, a single-control console may be used for more than one CMS panel or a separate control console may be allocated for each CMS panel at the installation at the Contractor's option.

3. Appropriate control facilities shall be provided within the sign control mechanism to ensure that only one selected message is illuminated on the individual CMS panels at a given time.

4. The local sign control console shall be solid-state and modular in design, unless otherwise shown on the Contract Drawings.

5. Local Sign Control Field Cabinet

a. The local sign control console and associated electronics shall be housed in a weatherproof and corrosion resistant aluminum cabinet conforming to 2.02 D.1 herein. Placement locations for the field cabinets and mounting details shall be as shown on the Contract Drawings.

b. The sign control field cabinet shall be designed and constructed to present a clean, neat appearance. Where required, all comers and seams shall be heliarc welded to provide a weatherproof seal around the entire enclosure. All nuts and bolts used in the cabinet assembly shall be stainless steel. All internal components shall be mounted so that there are no external protrusions. The external color of the cabinets shall be as shown on the Contract Drawings.

c. All cabinets shall have full width doors that properly fitted to assure complete weatherproofing. Each door shall be key lockable and supplied with two keys. A continuous stainless steel hinge shall connect the door to the cabinet. Each hinge shall be secured with stainless steel bolts and lock nuts. The hinge pins and bolts shall be tamperproof.

(1) In order to facilitate access to the sign control console, a suitable locking mechanism shall be provided to hold the door in the open position. The device shall be capable of holding the door open at 90 degrees (plus or minus 10 degrees) with a load of 15 lb/sq ft applied uniformly over the face of the door.

d. The cabinets shall be provided with a sufficient number of adequately size metal shelves and brackets to support the required control equipment. The shelves and equipment shall be so arranged that it is possible to remove any piece of equipment from the cabinet without removing any other piece of equipment. Shelf locations within the cabinets shall be easily adjustable.

6. Local Sign Control Console

a. Each local sign control console shall contain a series of toggle switches or other acceptable means of positive setting to affect message illumination. The toggle switches shall have the required poles and shall be rated at 200 percent of circuit currents for circuits of 10 amperes or less and 125 percent for circuits over 10 amperes. Circuit breakers used as toggle switches shall be adequate for the application and shall be UL or ETL listed for switching operations.

(1) A separate ON/OFF switch shall be associated with each of the available messages for the CMS panel at the installation.

(2) A separate master or primary power control switch shall be located within the control cabinet, separate from the control console(s), to control overall electrical power to the control console(s) within the cabinet.

b. The control console enclosure shall be a standard unit constructed of aluminum and shall contain provisions for securing it within the control field cabinet. The front surface of the console shall be removable to allow access to the switch wiring. The function of each switch shall be clearly and permanently labeled on the front surface of the console.

D. Electrical Requirements

1. All wiring shall be in accordance with the requirements of the NFPA 70 and as shown on the Contract Drawings or specified herein. No wiring shall be exposed. Electrical connection shall be provided by barrier type terminal blocks as defined in NEMA TS-1. All terminal block connections shall be identified and readily accessible for maintenance.

2. All wire and cable terminations shall be made with insulated spade terminals as defined in NEMA TS-1. Soldering of terminal connections will not be permitted.

3. The circuit number of all cables and wires shall be identified by cable tags attached to each of the cables or wires in all junction boxes, sign panels and cabinets. The cable tags shall be secured to the cable or wire with nylon cable ties. All wires shall be neatly laced into cables with nylon lacing, or similar approved method. All cables shall be secured with nylon cable clamps. Spare wires shall be properly terminated and identified as such. All wires shall be neatly routed to their connections.

4. Where a cable or wire passes through a hole or runs along a surface at any point through or on a completed assembly, such holes and/or surfaces shall be deburred and void of any sharp edges that may damage the cable or wire passing through or along the surface. All deburred holes shall be equipped with a rubber or plastic grommet.

5. All electrical materials and equipment for which there are established Underwriters Laboratories (UL) and Electrical Testing Laboratories (ETL) standards shall bear the UL and ETL labels.

6. CMS Panel and Control Console Interconnection Cable

   The interconnection cable between the CMS panels and the local sign control console shall be multiconductor cable for installation in conduit and metal raceways or as aerial cable supported by a messenger strands, as shown on the Contract Drawings. The cable shall have a 600-voltage rating and shall conform to the requirements of Section entitled "WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS)".

   a. The cable gauge and number of conductors shall be as shown on the Contract Drawings.

7. CMS Panel Enclosure and Control Cabinet Connections

   a. The gauge of all insulated wires between various parts and components of the CMS panels and control cabinets shall be adequately sized for the purpose. All CMS panel and control cabinet wiring shall be in accordance with NEMA TS-1 or approved equal.

   b. All terminal blocks and strips located within the CMS panels and control cabinets shall be accessible to the extent that it shall not be necessary to remove the equipment from the housing to make an inspection or connection.

   c. All wires shall be cut to their proper length before assembly. No wire shall be doubled back to make up for unnecessary slack. However, sufficient slack shall be provided such that any wire end can be cut back, restripped and connected at least twice.

   d. All electrical connections in the CMS panels and cabinets shall have sufficient clearance between each terminal and the housing so as to prevent a leakage path or physical contact under stress. The lay of the cables between components shall be such that when the housing door is closed, it will not press against the cables or force the cables against various components inside the housing.

   e. The ground side of service shall be carried throughout the CMS panels and control cabinets without a break. All equipment grounds shall run directly and independently to the ground bus. The grounding strip shall be connected directly to the housing wall.

8. Circuitry Protection

a. The CMS panels, control cabinets, and electronics shall be protected from an over-voltage situations, such as a lightning strikes and power surges over the power lines.

b. Separate protection devices shall be installed at each CMS panel location and shall be readily accessible for ease of replacement. The components shall be plug-in or screw-in units, which require virtually no system downtime to replace. The devices shall be clearly and permanently labeled.

c. The CMS panels shall be electrically bonded to their support structure. This bonding shall consist of an electrical bond wire or properly prepared electrical contact points.

9. Transformers

Where only 480 volt AC power is available, a 480/120 volt, single phase, 60 hertz transformer, shall be furnished within the local control cabinet for powering the fiberoptic signs.

a. The equipment shall have automatic recovery from a power failure and shall be "brown-out" and "transient spike" protected. "Brownouts" and "transient spikes" shall not damage the components or impair to its future performance.

E. Mechanical Connections

1. All bolted connections other than high strength friction bolted connections, shall be provided with lockwashers, locking nuts or other suitable means to prevent the connection nuts from backing off. All shop connections shall be either bolted or welded. Field welding shall not be permitted. All connections to supporting structures shall be bolted.

2. Dissimilar materials shall be isolated by stainless steel plates or other stainless steel fittings. Stainless steel bolts shall be used for connection at these locations. Coating or plating shall not be considered adequate for isolation of dissimilar metals or other connections.

3. Welding of aluminum shall consist of inert gas shielded metal arc welding with consumable electrodes. All welding of aluminum shall be performed in the shop. No field welding of aluminum will be permitted. All welders shall be qualified in accordance with the qualification procedures of AWS D 1.2.

2.04 SHOP PAINTING

Prior to painting, sign and signal housings and fiber optic equipment cabinets shall be completely cleaned of all grease, oil, loose rust, scale and other objectionable materials. All sign and signal housings, signal faces and signbridge mounted fiber optic equipment cabinets shall be finished with an electrostatically applied powder coating (3 mil thickness), high temperature bonded to the surface for maximum adherence and finish hardness. Sign and signal faces shall be colored flat black. Signal housings shall be colored dark bronze.

2.05 SHOP TESTS

A. All System equipment, materials, hardware, software and firmware furnished and all Work performed shall be subject to inspections and tests by the Authority.

B. No System equipment shall be delivered to the Authority until the system has been inspected, tested and approved for shipment by the Engineer.

C. Unless otherwise directed by the Engineer, the System equipment shall be tested by the system manufacturer and/or the System integrator, and witnessed by the Engineer, in the place of manufacture.

D. First Article Test

1. The Signs and Signals shown on the Contract Drawings, a maximum of one fiberoptic CMS and six, fiberoptic Lane Control Signals, shall be tested by the manufacturer and/or the System Integrator, and witnessed by the Engineer, in the place of manufacture. This inspection and test shall hereinafter referred to as the "First Article Test." Approval of the First Article Test by the Engineer shall be required prior to continuing to the manufacture of the remaining Signs and Signals required by this Contract. The First Article Test shall consist of the following:

a. Photometric tests: Luminance test data shall be collected from points located along the zero degree and 90 degree axes, 60 degrees, 120 degrees, and 150 degrees, in 0.5 degree increments, from zero degrees to +12 degrees and from zero degrees to -12 degrees, referenced to the optical center axis. Prior to testing, light sources used for the tests shall be operated for not less than 150 hours. Before each individual test data record is begun, adequate time shall be allowed for the light source to settle to a stable output value. Individual photometric reports, indicating which light source was used, shall be provided for each item tested. The test results shall document the following:

(1) The light output and lamp voltage for each voltage for each light source both at 90% brightness, to be measured after the output level has stabilized from initial lamp energization.

(2) The light output and lamp voltage for a typical message, both at 90% brightness.

(3) The light output for a typical message meets the values shown on the Contract Drawings.

(4) The light output for a typical fiber optic focusing lens on the signal face is uniformly distributed across the base area of the specified vision cone, with apex at the signal face.

(5) The uniformity of light output between different message types.

2. First Article Testing of the equipment shall continue until the results are satisfactory to the Engineer. Each item of System equipment shown on the Contract Drawings shall be tested in its entirety with the use of simulated inputs and simulated outputs, as required. Furnish all simulation equipment required for the test. Any repairs, construction or modifications required to comply with the requirements of this Section shall be performed by the System manufacturer at no additional cost to the Authority.

E. When the manufacture of all System equipment is complete, the Contractor shall notify the Engineer by requesting, in writing, by registered mail, an inspection and test of said equipment. This written request shall be in the possession of the Engineer a minimum of fifteen working days prior to the requested inspection and test dates.

F. Any approval by the Engineer, however, shall be construed merely to mean that at the time he knows of no good reason for objecting to any equipment, and no such approval shall release the Contractor from its obligation to comply with the requirements of this Section.

PART 3. EXECUTION

3.01 EXAMINATION

A. Inspect all System equipment, and accessories prior to installation. Replace any damaged items.

B. Ensure that the spaces where any electronic equipment is stored and where it is installed is completely free from any foreign substances, such as concrete dust, water or any other material that may otherwise be harmful to electronic equipment and connections. No allowances shall be made to the Contractor for equipment damage, or delays due to environmental/security damage.

C. Unless otherwise shown on the Contract Drawings, Signs, Signals and related equipment to be removed and not required to be reinstalled under this Contract, if any, shall remain the property of the Authority, and be delivered to a location designated by the Engineer. Unless otherwise shown on the Contract Drawings, removed equipment shall not be used in a new installation.

3.02 PREPARATION

A. Field verify dimensions and coordinate conduit entry and all other mounting conditions with the entity manufacturing the Signs and Signals.

B. Ensure the entity manufacturing the Signs and Signals provides on-site technical supervision and assistance during installation and interconnection of the system equipment. Said supervision shall ensure the safety of the proper installation and operation of the system equipment, prior to the installed system beginning the 30-day operational test.

C. After the system equipment has been delivered, an on-site inspection will be made by the Engineer. If any equipment has been damaged or for any reason does not comply with the requirements of this Section, the Contractor will be notified in writing, and shall be required to replace the equipment at no additional cost to the Authority, even though the equipment has been previously inspected, tested and approved for shipment. After such satisfactory replacement, the system shall be installed by the Contractor.

3.03 INSTALLATION

A. Install all System equipment in accordance with the manufacturer's written instructions in the locations shown on the Contract Drawings.

B. All control power and data communications wire shall be wired and harnessed within the equipment enclosure.

C. All wiring shall be clearly labeled with function and wire identification number corresponding to the manufacturer's wiring diagrams and/or approved shop drawings.

D. Where external circuit connections are required, terminal blocks shall be provided and the manufacturer's drawings must clearly identify the interconnection requirements including wire type to be used.

E. All wiring required to externally connect equipment lineups shall be installed by the electrical contractor.

F. Contractor interconnection wiring requirements shall be clearly identified on the "AS-BUILT" system drawings.

3.04 FIELD TESTS

A. After installation, the Signs and Signals shall be tested to show compliance with this Section. Submit the proposed testing procedure to the Engineer for approval two weeks prior to proposed start of test. Said testing shall continue until the results are satisfactory to the Engineer. Perform any repairs, construction or modifications as required to comply with this Section at no additional cost to the Authority.

B. After satisfactory completion of testing, a 30-day operational test shall commence. The Contractor shall correct any malfunctions as they occur, said malfunctions including, but not being limited to, equipment failure or failure of the System to comply with this Section. After the Contractor corrects a malfunction, at no cost to the Authority, the 30-day test shall restart, at day one, and shall continue until the results are satisfactory with the written approval of the Engineer.

C. The Contractor shall completely check out, calibrate and test all connected hardware and software to ensure that the system performs in accordance with the requirements of this Section and sequences of operation submitted.

D. The Contractor shall submit a test report detailing compliance with the requirements of item B and item C above.

E. 30-Day Operational Test

1. Testing shall be performed to verify compliance with the requirements of this Section and shall be performed in accordance with the approved testing plan. Correct any malfunctions as they occur, said malfunctions shall include, but not be limited to, equipment failure or failure of the System to comply with the requirements of this Section. After corrections have been made, the 30-day operational test shall restart and shall continue until the results are satisfactory to the Engineer for a period of 30 consecutive days.

2. Maintain a log during all operational testing. Include a narrative description of corrective measures required and items required or replaced.

3.05 TRAINING

A. Operational and Maintenance Training for the System shall be provided to Authority-designated personnel through the means of practical demonstrations, seminars and other related technical teaching procedures. The training shall be conducted at the construction site.

SECTION 16570

FIBEROPTIC CHANGEABLE MESSAGE SIGNS AND LANE CONTROL SIGNALS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Estimated progress schedule of dates for the Work shall include the following:

1. Project start.
2. Shop drawing submittal.
3. Shop drawing approval.
4. First Article test procedure submittal.
5. First Article test procedure approval.
6. First Article test of the system.
7. On-site rough-in start.
8. Training Curricula submittal.
9. Training Curricula approval.
10. On-site rough-in completion.
11. Recommended spare parts list.
12. Proof of performance testing.
13. Complete system user training.
14. Complete system maintenance training.
15. Acceptance testing.
16. Completion/Resolution of all submittals and/or punch list items.
17. Record documents submittal.
18. Final Acceptance.
19. Complete Bill of Materials.

B. Shop Drawings

1. System Block Diagram.
2. Signs and Signals Operating Manuals.
3. Complete Wiring Diagrams, indicating all field terminal block numbers.
4. Complete, comprehensive, single-line diagrams, including all equipment, devices and cabling completely identified.
5. System Logic Program.

6. Conduit and Raceways.

7. Wire.

8. Enclosures and all Devices.

C. Catalog Cuts

1. Signs and Signals.

2. Lamp Controllers.

3. Fiber Optic Equipment Cabinets (FOECs).

D. Samples

1. Fiber optic bundles.

2. Color filters.

3. Lenses.

E. An independent laboratory test report showing results of testing the light intensity of the signals shall be submitted for the approval of the Engineer.

F. Spare Parts: Submit a complete list of recommended spare parts, which shall include those spare parts required to be furnished in compliance with the requirements of this Section, for approval by the Engineer.

G. Performance Testing Plan: Prepare and submit to the Engineer for approval a performance testing plan for the entire system a minimum of 30 days in advance of the earliest, approved, scheduled inspection and test date. The system test plan shall be divided into the following stages:

1. First article inspection and test of the System, performed by an Independent Laboratory and witnessed by the Engineer.

2. Inspection of the System upon arrival.

3. On-site inspection and test immediately following the complete installation of the system, to demonstrate compliance with the requirements of this Section.

4. A 30-day operational test commencing with the successful completion of the on-site inspection and test, approved by the Engineer.

H. Training: Prior to the on-site inspection and test of the system, prepare and submit to the Engineer for approval a Signs and Signals system user and maintenance training curricula, in accordance with the requirements this Section.

I. Record Documents: Prior to the issuance of the Certificate of Final Completion, deliver to the Engineer the following:

1. One reproducible set of the Contract Drawings and shop drawings, which reflect actual locations and actual wiring details of Signs and Signals system equipment and all revisions to the Work of this Section. In addition, nine sets of prints of said Contract Drawings and shop drawings shall be supplied to the Engineer. Three copies of said drawings shall be marked to the attention of the Facility Supervisor of Electrical Maintenance.

2. System Documentation

The following shall be included in the complete documentation package on the system that shall be furnished at the time of delivery of the System.

a. Software Documentation

Three complete sets of documentation shall be submitted, explaining all system capabilities and options, including system set-up, operation and maintenance (software manuals shall be supplied in hard copy only).

b. Hardware Documentation

Three complete sets of system manuals shall be submitted explaining all system capabilities and options, including but not limited to the installation, set-up, operation and maintenance of all equipment furnished.

c. Operational Documentation

Twelve complete sets of system operations manuals shall be submitted which shall consist of the following:

(1) Operations Run Book (supplied in hardcopy only).

(2) Detailed description of normal system operation.

(3) Error and Alarm handling Procedures.

(4) System Start up and Shutdown Procedures.

(5) Use of Various Logs and Output Data by Operator to Improve System Efficiency.

(6) Description of Operating Procedure and Troubleshooting Procedures for each subsystem.

(7) System Backup Procedures.

d. Test Procedures

Recommended system test procedures shall be no less than thirty days prior to scheduled factory test date. Tests shall include the following:

(1) Factory test of system as witnessed by the Authority.

(2) Field test of system prior to connection to substation components as witnessed by the Authority.

(3) 30-day field performance test in which system shall operate without failure. If a failure is encountered, the 30-day test shall be restarted from the beginning.

END OF APPENDIX "A"

SECTION 16570

FIBEROPTIC CHANGEABLE MESSAGE SIGNS AND LANE CONTROL SIGNALS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(1.03 A)	Specify the codes, standards, and other design requirements that must be adhered to if other than what is specified in this Section.
(1.03 B)	Specify the size, message content, lettering size, structural details, and materials.
(1.03 D)	Specify and locate all items of the sign and signal system.
(1.03 C.1)	The temperature range, if the requirements are other than what is specified.
(1.03 C.2)	Specify any extreme adverse conditions under which the signs and signals are required to operate, if the requirements are other than what is specified.
(2.01 A)	The mfg. and model no. of all acceptable signs and signals equipment from at least two manufacturers.
(2.02 A.1.h.)	Fixture mounting plates
(2.02 A.1.i.)	Lock hardware
(2.02 A.3.a)	Make sure changeable messages are specified.
(2.02 A.3.d)	Make sure the viewing distance and cone of vision requirements are specified.
(2.02 A.8)	The sign and signal luminance within the specified cone of vision, if the requirements are other than what is specified.
(2.02 A.9)	The means to establish uniform luminance, if the requirements are other than what is specified.
(2.02 E.2.e)	Specify any control logic functions, if the requirements are other than what is specified.
(2.02 E.2.g)	Backplate layout.
(2.02 E.2.h)	FOEC size and cabinet manufacture.
(2.02 E.2.i)	Lock hardware.
(2.02 E.3)	Specify which FOECs are required to be vandalproof.
(2.03 A.2)	Message lettering and symbols, if requirements are other than what is specified herein.
(2.03 A.2.a.)	Vertical spacing between lines, if requirements are other than what is specified herein.
(2.03 A.5)	Cone of vision, if requirements are other than what is specified herein.
(2.03 A.6)	Specify which signs and signal location are to perform lamp dimming on a coordinated basis.
(2.03 B)	Overall dimensions and external color.
(2.03 B.5.e)	Hinged faceplate.

(2.03 B.5.j)	Mounting bracket requirements if requirements are other than what is specified herein.
(2.03 B.5.k)	Top, bottom or side mounting.
(2.03 C.4)	The design of the local sign control console, if requirements are other than what is specified herein.
(2.03 C.5.a)	Location and mounting details for local sign control field cabinets.
(2.03 C.5.b)	External color for local sign control field cabinets.
(2.03 D.6)	The installation of interconnection cable between the signs and signals and the local sign control console.
(3.01 C)	Specify what is to be done with removed equipment, if requirements are other than what is specified herein.
(3.03 A)	Ensure all equipment, as well as all installation details, to be installed is shown.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16571

VEHICULAR TRAFFIC SIGNAL HEADS AND MOUNTING HARDWARE

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for vehicular traffic signal heads, including flashing signals, optically programmable units and light emitting diode (LED) signals.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

	American Society for Testing and Materials (ASTM)
ASTM B 85	Specification for Aluminum-Alloy Die Castings.
	Federal Communications Commission (FCC)
Title 47	Telecommunication.
	Federal Highway Administration (FHWA)
MUTCD	Manual on Uniform Traffic Control Devices.
	Institute of Transportation Engineers (ITE)
ITE ST-017B	Equipment and Material Standards of the Institute of Transportation Engineers.
	Vehicle Traffic Control Signal Heads –Part 3: Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Modules.
ITE ST-052	Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Circular Signal Supplement.
	National Electrical Manufacturers Association (NEMA)
NEMA TS 2	Traffic Controller Assemblies with NTCIP Requirements.
NEMA 250	Enclosures for Electrical Equipment (1,000 Volts Maximum).
	The Port Authority of New York and New Jersey (PA)
	Traffic Signal Design and Drawing Preparation Guidelines.
	Underwriters Laboratories, Inc. (UL)
UL 94VO	Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.
	US Department of Defense Military Standards
MIL-STD-883	Test Method Standard Microcircuits.

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. Vehicular traffic signal heads shall conform to requirements specified in this Section. Where specific requirements are not listed herein, the vehicular traffic signal heads shall, as a minimum, conform to the requirements of the standards and publications listed in 1.02.

B. The units furnished as Work of this Section shall be of the size, number of indicators, colors and faces shown on the Contract Drawings, constructed to standard similar dimension sections or combination head arrangements with lenses, aluminum alloy housings, mounting brackets and hardware, aluminum reflectors, lamps, visors, strobes, safety chains and, where shown on the Contract Drawings, with backplates.

C. Polycarbonate housings and visors in the quantities shown shall be furnished only if specified on the Contract Drawings.

D. Vehicular traffic signal heads shall consist of readily available and proven equipment, fully consistent with their intended design and operation as specified herein. Special or custom-built components may be used only upon written approval from the Engineer.

E. Use modular type construction with assemblies, sub-assemblies and modules that are available from a second source of supply wherever possible.

F. All assemblies, sub-assemblies and modules shall be readily accessible for removal, testing or replacement without removal of other modules, assemblies or components. Components shall be located so that there is visibility and access for the use of hand tools and standard test probes where maintenance is required. Test points shall be provided to facilitate troubleshooting.

1.04 ENVIRONMENTAL REQUIREMENTS

A. The vehicular traffic signal head equipment shall operate over an ambient temperature range from minus 40 degrees F to plus 165 degrees F (minus 40 degrees C to 74 degrees C). Operation of the vehicular traffic signal head equipment shall not be degraded by rain, snow, fog or normally encountered ambient humidity conditions.

B. The equipment shall be protected against the intrusion of dust and moisture to protect all internal components.

C. The equipment shall operate without degradation or damage under ambient shock (thermal and mechanical), vibration, lightning and electromagnetic/electrical interference at the construction site.

1.05 QUALITY ASSURANCE

A. Verify that all LED vehicular traffic signal heads have undergone Design Qualification (DQ) testing prior to shipment as specified herein and ITE ST-017B. Failure of any LED signal to meet requirements of the DQ tests shall be cause for rejection. If any equipment has been damaged or if, for any reason, the equipment does not comply with the requirements or test standards specified, the Contractor shall repair or replace the equipment at his own expense. Provide DQ process and test results documentation to the Engineer.

B. Ensure that all LED vehicular traffic signal heads undergo the following production Quality Assurance (QA) testing prior to shipment in accordance with ITE ST-017B. Failure of any LED signal to meet requirements of the QA tests shall be cause for rejection. If any equipment has been damaged or if, for any reason, the equipment does not comply with the requirements or test standards specified, the Contractor shall repair or replace the equipment at his own expense. Provide QA process and test results documentation to the Engineer.

1. Signal Burn-in.
2. Maintained Minimum Luminous Intensity.
3. Power Factor.
4. Current.
5. Visual Inspection.

C. After delivery of equipment, the Engineer may perform a construction site inspection of the equipment. If any equipment has been damaged or if, for any reason, the equipment does not comply with the requirements or testing hereof, the Contractor shall repair or replace the equipment at his own expense, even though the equipment had been inspected for shipment. After such satisfactory replacement and/or repair and the Engineer's subsequent written approval, the equipment may be installed.

D. After installation, test the equipment in the presence of the Engineer to show compliance with the requirements of this Section and with the Contract Drawings. Continue testing until the results are satisfactory to the Engineer. If any equipment has been damaged or if, for any reason, the equipment does not comply with this Section, the Contractor shall repair or replace the equipment at his own expense. Provide installation process and test results documentation to the Engineer. Perform any repairs, construction and modifications required to comply with the Specifications and the Contract Drawings.

1.06 DELIVERY, STORAGE, AND HANDLING

A. All materials shall be delivered to the construction site in original unopened containers or bundles with labels, which clearly identify the manufacturer and product name, including storage requirements and instructions.

B. Properly store and handle all materials delivered to prevent deterioration or damage due to moisture, temperature change, contaminants and other causes.

1.07 SPARE EQUIPMENT

For items with no second source of supply, provide replacement assemblies in quantities as shown on the Contract Drawings.

1.08 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MATERIALS

A. Head Housing and Door: Virgin metal die cast aluminum alloy conforming to ASTM B 85 of one of the following alloys:

1. S12A (A14130).

2. S12B (A04130).
3. SC84A (A13800).
4. SC84B (A03800).
5. SG100B (A03600).

B. Backplates: 1/8-inch thick minimum, black Acrylonitrile Butadiene Styrene (ABS), ultraviolet (UV) stabilized plastic sheet with hair cell finish on the front side, smooth finish on the back side and 3-inch corner radii. Vacuum formed backplates shall have a 5/8-inch flange on all sides providing rigidity and structural integrity. Backplates shall be designed to precisely fit manufacturer's signal head and supplied with necessary mounting hardware.

C. Polycarbonate housings and visors shall be molded, ultraviolet and heat stabilized, flame retardant, unaffected by the heat of the lamp used and permanently colored.

D. All bolts, nuts, washers and lock washers supplied shall be stainless steel.

2.02 CONSTRUCTION FEATURES

A. General

1. Design signal head equipment for operation from line voltage at 120 plus or minus 3 VAC RMS nominal and over a voltage range from 80 VAC RMS to 135 VAC RMS, 60 Hz plus or minus 3 Hz, AC line power. Variations in operating line voltage shall have no visible effect on luminous intensity and shall not vary by more than 10 percent over the entire operating voltage range.
2. Signal heads, bracket arms and mounting attachments shall receive three coats of paint, each of which shall be baked after application. The first or primer coat shall be a non-lead or chromium containing paint for aluminum surfaces. The second and third coats shall be Federal Yellow matching Color No. 13538 conforming to Federal Standard No. 595B, except for the underside of visor, which shall be flat black enamel. Each coat shall be baked on separately. All metal surfaces to be painted shall be suitably cleaned of all foreign deposits, oil and grease, and then neutralized for priming. Paint separate parts before assembly. Do not paint stainless steel housing latching assembly.
3. Unless specified otherwise, equipment shall be fabricated in accordance with ITE ST-017B.
4. Identify all wire terminations and terminal block connections. At mast arm installations, bring separate continuous #14 AWG, 19 strand wires from the terminal block of the signal head to the traffic signal controller cabinet without splicing. At overhead span installations, secure separate continuous traffic signal cables to the span wire and terminate on the traffic signal head terminal block. Terminate cables with insulated spade terminals conforming to NEMA TS 2.

B. Vehicular Traffic Signal Heads

1. Shall be of the size, number of indicators, color and faces as shown on the Contract Drawings.
2. The Vehicular Traffic Signal Heads shall be of the type Optically Programmable or LED as specified herein and as shown on the Contract Drawings.

3. The housing for each signal face shall be of unitized sectional construction and shall consist of as many sections as necessary to provide the signal indications shown on the Contract Drawings. Rigidly and securely fasten sections together into a weather tight signal face. Adjustable traffic signal heads shall consist of two or more signal faces fastened to and supported by a pipe assembly and suitable entrance fittings. No special tools shall be required to fasten the signal heads together.

   a. Arrange each housing with openings in the top and bottom so that it may be rotated about a vertical axis between waterproof supporting brackets or trunnions and shall be capable of being securely fastened at increments of not more than five degrees of rotation, designed to accommodate standard 1-1/2-inch pipe brackets.

   b. The top and bottom of each housing shall have integral cast locking rings or other provisions to provide positive interlocking and indexing. The top and bottom housing coupler shall be free of sharp edges and protrusions that might damage conductor cable insulation and shall provide sufficient space for the entrance of the required signal cable. Provide tees or crosses equipped with pipe plug knobs or caps at the top and bottom of the housings that can be removed to assist in wiring. As an alternative, flat arms or spiders will be acceptable for use on the bottom of adjustable signals. One-section beacons may be supplied without bottom bracket arms.

   c. Each signal face shall be locked by engagement of serrations in the end signal sections engaging with similar serrations in the mounting bracket assembly. The serrations shall be recessed and integral with the signal section. All signal brackets shall be designed for use with a tabbed lock ring to lock the signal face in position.

   d. Housing construction shall permit the assembly of 12-inch signal sections with 8-inch signal sections of the same manufacturer. The assembly shall permit the joining of 8-inch sections to 12-inch sections, either above or below for vertical mounted signals and either to the right or left for horizontally mounted signals.

4. Provide neoprene gaskets between the body of the housing and the doors. The door shall be hinged and forced tightly against the gasket and the housing by a simple stainless steel locking mechanism.

   a. Cast hinge lugs integral with the door. All other exterior hardware such as hinge pins, lens or clips shall be stainless steel. The locking device shall operate without the use of tools.

   b. Arrange hinges to allow convenient re-lamping. On the outside of the door, there shall be a rim encircling the lens opening to prevent any light leakage between optical systems.

   c. Each door shall contain four Number 10-24 tapped holes equally spaced and straddling the vertical centerline through bosses on the door to accommodate visor clip connections on the outside and lens clip connections on the inside of the door.

5. Provide each completed vehicular traffic signal head with a barrier type terminal block, equipped with connectors for the lamp receptacle leads and screw terminals for the field wires, located within the bottom section of the signal unit. The terminal board for standard three-section units shall be a four-position, eight-terminal, barrier-type strip. Attach the white, red; orange and green color-coded section leads to one side of each terminal strip leaving the opposite terminals for field wires. All wires shall be stranded 18 AWG minimum with an insulation rating of 221 degrees F (105 degrees C). Greater than three-section head clusters shall be designed accordingly.

6. The visors shall be separate and removable from the doors, held in place by stainless steel fastenings attached to the door in such a manner as to prevent the possibility of any light leakage between the door and the visor hood, which might be discernible from the side. Fabricate visors of sheet aluminum, not less than 0.050 inches thick, and equip with bayonet slots or other provisions to permit snap-on attachment and rotation of the visor.

   a. Visors shall be either the standard open type or the type shown on the Contract Drawings. Paint the inside of the visors flat black to minimize light reflection to the sides of the signal.

   b. Visors shall tilt down from the horizontal a minimum of 3-1/2 degrees and shall be 10 inches nominally in length for 12-inch diameter lenses and 8 inches nominally in length for 8-inch diameter lenses.

7. Directional Louvers

   a. Furnish and install directional louvers in signal visors where shown on the Contract Drawings.

   b. Directional louvers shall be so constructed as to have a snug fit in the signal visors. The outside cylinder shall be constructed of 0.030-inch nominal thickness, or thicker, sheet steel and the vanes shall be constructed of 0.016-inch nominal thickness, or thicker, sheet steel or the cylinder and vanes shall be constructed of 5052-H32 aluminum alloy of equivalent thickness. Dimensions of louvers and arrangements of vanes shall be as shown on the Contract Drawings.

   c. The entire surface of louvers used in front of signal lenses shall be painted a flat black to minimize light reflection to the sides of the signals.

8. Provide removable black ABS, UV-stabilized plastic backplates at locations and of configuration shown on the Contract Drawings, 1/8-inch minimum thickness. Backplates shall attach to the signal head in such a manner so as not to obstruct the signal housing door opening. The backplates shall be designed to precisely fit manufacturer's signal head and shall be supplied with necessary hardware.

9. The housing assembly shall accommodate the installation and/or replacement of either Optically Programmable or LED vehicular traffic signal head as specified herein.

10. Polycarbonate housings and visors in the quantities shown shall be furnished only if specified on the Contract Drawings.

    a. The polycarbonate housing shall be one piece molded or shall be fabricated from two or more pieces joined into a single piece. The housing thickness shall be a minimum of 0.090 inches thick. All sections shall be identical and interchangeable with each other and shall be so designed that they interlock with each other forming a weatherproof assembly. Hinges or lugs shall be located inside each section for attaching the reflector assembly. Each signal section shall be dust-tight.

    b. The polycarbonate-housing door of each section shall be a one-piece unit with an opening of sufficient diameter to accommodate the lens. On one side of the door, at top and bottom, there shall be a hinge so as to ensure perfect alignment of the door. On the opposite side of the door, there shall be a wingnut assembly-locking device to ensure even gasket pressure. Twelve-inch signal sections shall be secured with two wingnut assemblies. Hinge pins and locking device shall be stainless steel.

    c. Each polycarbonate signal face shall be provided with polycarbonate or metal visor. Polycarbonate visors shall be a minimum of 0.100-inch thick, formed from sheet polycarbonate or assembled from one or more injection, rotational or blow molded polycarbonate sections of black homogeneous colored material with a lusterless finish. Sections shall be joined using thermal, chemical or ultrasonic bonding.

    d. Polycarbonate signal faces that require backplates shall be provided with ABS backplates, a minimum of 1/8-inch thick.

C. Optically Programmable Vehicular Signal Heads

1. Optically programmable vehicular signal heads, if any, shall be located as shown on the Contract Drawings. Such units shall permit the visibility zone of the indication to be determined optically without hoods or louvers. The projected indication may be selectively visible or veiled anywhere within 15 degrees of the optical axis. No indication shall result from external illumination nor shall one light unit illuminate a second.

2. The optical system shall be comprised of the lamp, a lamp collar, an optical limiter/diffuser and the objective lens.

    a. Lamp shall be a nominal 150 watts, 120 VAC, three prong, sealed beam having an integral reflector with stippled cover and an average rated life of at least 7,000 hours, coupled to the diffusing element with a collar including a specular inner surface. The diffusing element may be discrete or integral with the convex surface of the optical limiter/diffuser.

    b. The optical limiter/diffuser shall provide an accessible imaging surface at focus on the optical axis for objects 900 to 1,200-feet distance, and shall permit an effective veiling mask to be variously applied as determined by the desired visibility zone. Provide the optical limiter/diffuser with positive indexing means, composed of heat resistant glass or polycarbonate.

    c. The objective lens shall be a high resolution, planar incremental lens hermetically sealed within a flat laminate of weather resistant acrylic, or approved equal. The lens shall be symmetrical in outline and able to be rotated to any 90-degree orientation about the optical axis without displacing the primary image.

d. The optical system shall accommodate projection of diverse, selected signal displays to separate portions of the roadway such that only one display will be apparent to any viewer.

3. Mount the signals to standard 1-1/2 inch pipe fittings as a single section, as a multiple section face, or in combination with other signals, as shown on the Contract Drawings. Provide the signal sections with an adjustable connection that permits incremental tilting from 0 to 10 degrees above or below the horizontal while maintaining a common vertical axis through couplers and mounting. Terminal connection shall permit external adjustment about the mounting axis in 5-degree increments. Construct the signal such that it can be installed with ordinary tools and serviced with no tools.

   a. Visor, backplate and adapter attachments shall conform and readily fasten to mounting surfaces without affecting the water and light integrity of the signal.

   b. Arrange the programmed signal heads for rigid mounting to maintain optical orientation with the roadway. Where span wires are used, securely tether to the lower span wire.

4. The lamp fixture shall be comprised of a separately accessible housing and integral lamp support, an indexed ceramic socket and a self-aligning, quick-release lamp retainer. Provide electrical connection between the case and lamp housing with an interlock assembly that disconnects the lamp housing when opened. Each signal head shall include a covered terminal block for screw attachment of field wires.

5. Provide each signal section with integral means for regulating its intensity between limits as a function of individual background illumination. Lamp intensity shall not be less than 97 percent of uncontrolled intensity at 1,000 ft-c. and shall reduce to 15 plus or minus 2 percent of maximum at less than one ft-c. over the applied voltage and ambient temperature range. Response shall be proportional and essentially instantaneous to any detectable increase in illumination from darkness to 1,000 ft-c. and damped for any decrease from 1,000 ft-c.

   a. The intensity controller shall be comprised of an integrated, directional light sensing and regulating device interposed between the lamp and field wires; responsive over an applied voltage of 105 VAC RMS to 135 VAC RMS, 60 Hz plus or minus 3 Hz, AC line power, and may provide phase-controlled output voltage but shall also have a nominal open circuit terminal impedance of 1,500 ohms.

   b. The light intensity mechanism shall not produce electrical noise or interference sufficient to adversely affect the operation of solid-state electronic equipment used in the traffic signal controllers and associated auxiliary equipment and shall not cause false tripping of the conflict monitors.

D. LED Vehicular Traffic Signal

1. General

   a. LED vehicular traffic signal shall not require special tools for installation when used as a retrofit replacement for existing traffic signal lamps.

   b. LED vehicular traffic signal shall fit into new or existing traffic housings built in accordance with ITE ST-017B without any modification to the housing.

   c. LED vehicular traffic signal shall be weather tight, shall fit securely in the housing and shall connect directly to existing electrical wiring.

d. Installation of a retrofit replacement LED vehicular traffic signal into the existing signal housing shall require only the removal of the existing optical unit components, i.e., lens, lamps, gaskets and reflector.

e. Each retrofit kit shall include all necessary components to complete conversion, including a one-piece gasket.

2. LED Signal Lens

a. The LED signal lens may be a replaceable part, without the need to replace the complete LED signal.

b. The LED signal lens may be tinted with the appropriate color to enhance on/off contrast. The material used to tint the lens shall not affect the luminous intensity or chromaticity and shall be uniform across the face of the lens.

c. The LED signal lens shall be polycarbonate and shall withstand ultraviolet light (direct sunlight) exposure for a minimum time period of five years without exhibiting evidence of deterioration.

3. LED Signal Construction

a. The LED signal shall be a single, self-contained device, not requiring on-site assembly, for installation into the existing traffic signal housing.

b. All LEDs shall be rated for 100,000 hours or more at 77 degrees F (25 degrees C) and 20 milliamps.

c. All internal LED and electronic components shall be adequately supported to withstand mechanical shock and vibration from high winds and other sources.

d. The signal enclosure shall be made of UL 94VO flame-retardant materials. The lens is excluded from this requirement.

e. The LED signal shall have a prominent and permanent vertical indexing indicator for correct indexing and orientation inside the signal housing.

f. Each individual LED signal shall be identified for warranty purposes with the manufacturer's name, serial number and operating characteristics, such as rated voltage and power consumption.

g. The LED arrow signal pattern shall conform to ITE ST-017B Vehicle Traffic Control Signal Heads – Part 3: Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Modules for color, size and shape. The LED arrow signal shall not require a specific orientation or have a variance in light output, pattern or visibility for any orientation.

h. The LED ball signal shall conform to ITE ST-017B and Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Circular Signal Supplement for color, size and shape.

i. The beam color, beam intensity and radiation pattern shall conform to the requirements for maintained minimum luminous intensity for LED signal and chromaticity as specified in ITE ST-017B Vehicle Traffic Control Signal Heads – Part 3: Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Modules and ITE ST-052 Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Circular Signal Supplement.

j. Red LEDs shall be AlInGaP(Aluminum Indium Gallium Phosphorus) and shall be ultra bright type. ALGaAs LEDs are not permitted.

k. Green LEDs shall be GaN (Gallium Nitride) and shall be ultra bright type.

l. Yellow LEDs shall be AlInGaP (Aluminum Indium Gallium Phosphorus) and shall be ultra bright type. ALGaAs LEDs are not permitted.

4. Environmental Requirements

a. LED signal shall satisfy all the environmental requirements specified in 1.04.

b. LED signal, when properly installed with gasket, shall be protected against dust and moisture intrusion per requirements of NEMA 250 Type 4 enclosures to protect all internal LED, electronic and electrical components.

5. Luminous Intensity

a. The Maintained Minimum Luminous Intensity shall be in accordance with ITE ST-017B Vehicle Traffic Control Signal Heads – Part 3: Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Modules and ITE ST-052 Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Circular Signal Supplement.

6. Chromaticity

a. The measured chromaticity coordinates of the LED signal shall conform to the chromaticity requirement of ITE ST-017B Vehicle Traffic Control Signal Heads – Part 3: Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Modules and ITE ST-052 Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Circular Signal Supplement.

7. Electrical

a. The LED signal shall operate from a 60 plus or minus 3 Hz AC line over a voltage range of 80 VAC RMS to 135 VAC RMS. The current drawn shall be sufficient to ensure compatibility and proper triggering and operation of load switches and conflict monitors in the signal controller units.

b. Nominal operating voltage for all measurements shall be 120 plus or minus 3 VAC RMS.

c. The 8-inch nominal and 12-inch nominal LED ball shall consume no more than 20 watts and 30 watts respectively. The 8-inch nominal and 12-inch nominal LED arrow shall not consume more than 15 watts and 20 watts respectively.

d. The forward current, as measured through each LED, shall not exceed 60 percent of the LED manufacturer's maximum current rating when operating at 77 degrees F (25 degrees C).

e. The LEDs shall emit no visible light when subjected to a 120 VAC, 4-milliamp leakages current from a NEMA-rated solid-state load switch (load switch in the off state).

f. The LEDs shall be wired in series parallel strings. The failure of any one LED, and its associated string of LEDs, shall not cause the loss of more than 20 percent of the light output of the complete LED signal.

g. The LED circuitry shall prevent flicker at less than 100 Hz over the voltage range specified above.

h. The LED circuitry shall include voltage surge protection against high-repetition noise transients and low-repetition noise transients as stated in NEMA TS 2.

i. The LED signal, including its circuitry, shall meet FCC Title 47, Subpart B, Section 15 regulations concerning the emission of noise.

j. The LED signal shall provide a power factor of 0.90 or greater over the operating voltage range and temperature range specified above.

8. Total harmonic distortion (current and voltage) induced in an AC power line by an LED signal shall not exceed 20 percent over the operating voltage range and temperature range specified above.

9. Design Qualification Testing

Complete and document the Design Qualification testing described below. Carry out all Design Qualification testing after a burn-in (module energized for a minimum of 24 hours at 100 percent duty cycle and at an ambient temperature of 140 degrees F (60 degrees C)). Signals submitted for test shall be representative of typical production units.

a. The LED signal shall be measured for chromaticity per the requirements of this Section and ITE ST-017B using a spectroradiometer at an ambient temperature of 77 degrees F (25 degrees C).

b. The LED signal shall be measured for power factor per the requirements of this Section by an independent testing laboratory.

c. The LED signal shall be measured for total harmonic distortion per the requirements of this Section by an independent testing laboratory.

d. The LED signal shall be tested for electronic noise per the requirements of this Section with reference to Class A emission limits referenced in FCC Title 47, Subpart B, Section 15 by an independent testing laboratory.

e. The LED signal shall be tested for compatibility with controller unit, conflict monitor and load switches. These tests are to be conducted in accordance with ITE ST-017B.

f. The LED signal shall be tested for transient immunity (e.g., early electronic component mortality failures, component reliability problems) using NEMA TS 2 by an independent testing laboratory.

g. Mechanical vibration testing shall be performed on the LED signal, by an independent testing laboratory, in accordance with MIL-STD-883, Test Method 2007, using three 4-minute cycles along each x, y, and z axis, at a force of 2.5 Gs, with a frequency sweep from 2 Hz to 120 Hz. The loosening of the lens or of any internal components or any other physical damage shall be cause for rejection.

h. The maintained minimum luminous intensity testing shall be in accordance with ITE ST-017B.

E. Electrical Connections

Wire the traffic signal heads to implement the signal operations shown on the Contract Drawings. At mast arm installations, separate continuous #14 AWG, 19 strand wires shall be brought from the terminal block of the signal head to the base of pole and spliced to the traffic signal cable. At overhead span installations, separate continuous traffic signal cables shall be secured to the span wire and terminated on the traffic signal head terminal block.

F. Mechanical Connections

Furnish safety chain and bolted connections securing the signal heads to the mast arm on all installations. The safety chain shall be a minimum of 1/4 inch hot-dip galvanized coil proof straight link chain with 5/16 inch stainless steel bolts, nuts, flat and lock washers.

PART 3. EXECUTION

3.01 PREPARATION

A. Before manufacture or procurement of equipment, submit Catalog Cuts and Shop Drawings outlining the construction and operation details of all equipment for prior Engineer approval as specified in 1.08. No equipment shall be procured until the Engineer has given written approval.

B. Related equipment to be removed and not required for relocation under the Contract, if any, as shown on the Contract Drawings, shall remain the property of the Authority and shall be delivered to a location in the Port District as designated by the Engineer. Removed equipment, if any, shall not be used in a new installation unless specifically called for on the Contract Drawings.

3.02 INSTALLATION

A. Install signal head equipment in accordance with the guidelines specified in the FHWA Manual on Uniform Traffic Control Devices and as shown on the Contract Drawings.

B. Arrange signal heads for mounting on span wire, mast arms, post tops or vertical pole bracket mounts as shown on the Contract Drawings.

1. For span wire mounting, furnish the signal heads with a span wire clamp and wire outlet fitting, with span wire clamp comprised of a shoe, lock bar, and two "U" bolts, equipped with a balance adjuster. Assemble the heads so that they hang plumb and include means for adjusting the signal heads to the proper vertical alignment, including circuit disconnect hangers, extension pipes and swivel balancer assemblies. In addition to the upper suspension fitting, provide signal heads with similar mounting attachments for securing the signal to an upper or lower span or tether wire as called for on the Contract Drawings.
2. Furnish signal heads for Vertical, Horizontal and Mid-mast arm mounting with a mount consisting of upper and lower horizontal arms attaching to the top and bottom of the signal head housing. The horizontal arm shall attach to a vertical member that in turn clamps to the mast arm. The mast arm mount shall have provision for adjusting the vertical, angular and rotational positioning of the head in relation to the mast arm so that it is plumb, in line with other signal heads and properly oriented in relation to traffic, including the use of extension pipes, plumbizers, and swivel balancers. Safety chains securing the signal heads to the mast arm are required. Conceal wiring within the mounting assembly.
3. Furnish post top mounted signal heads with a post top type slip fitter mount that is designed for use with a tabbed serrated lock ring to lock the signal face in position.
4. Furnish vertical pole bracket mount signal heads with upper and lower horizontal brackets equipped with pole plates for attachment to the pole with stainless steel straps.

C. Until the installed signal heads are placed into operation, they shall be bagged with an opaque or other approved material. The material shall be adequately secured to the signal heads in an orderly and neat manner.

D. After installation of equipment, the Engineer may perform a site inspection of the equipment. If any equipment has been damaged or if, for any reason, the equipment does not comply with the requirements or testing hereof, the Contractor shall repair or replace the equipment at his own expense, even though the equipment had been inspected previously. After such satisfactory replacement and/or repair and Engineer's subsequent written approval, the equipment may be tested as per 1.05 D.

3.03 FIELD TESTS

Perform initial installation test in accordance with 1.05 D.

END OF SECTION

SECTION 16571

VEHICULAR TRAFFIC SIGNAL HEADS AND MOUNTING HARDWARE

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Submit the following to the Engineer within forty-five (45) days after acceptance of Proposal:

1. A list of manufacturers of equipment to be furnished for the Work of this Section.
2. Detailed drawing(s) for signal head equipment, backplates, visors, lens, mounting brackets and hardware including recommended mounting instructions. The submittal shall include the environmental tolerance provisions of the proposed equipment, including the material that the housing, backplates, visors, lens, mounting brackets and hardware were fabricated from. Include within this documentation electrical schematic wiring diagrams for the equipment, defining terminal identification number assignment.
3. Five complete sets and one reproducible master set of all test process and results. This shall include but not limited to the Quality Assurance (QA) process and test results documentation, Design Qualification (DQ) process and test results documentation and installation process and test results documentation.
4. A complete set of reproducible Mylar Shop Drawings for the signal head equipment, from which clear prints can be made.
5. Five complete sets and one reproducible master set of operations and maintenance instructions including preventive and corrective maintenance.

END OF APPENDIX "A"

SECTION 16571

VEHICULAR TRAFFIC SIGNAL HEADS AND MOUNTING HARDWARE

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

1.03 B	Specify the size, number of indicators, colors and faces. Specify sections or combination head arrangements, glass or polycarbonate lenses, aluminum alloy housings, mounting brackets, aluminum reflectors, lamps, visors and backplates.
1.03 C	Specify the size, number and location of polycarbonate housings and visors.
1.07 A	Specify replacement assemblies.
2.02 B.1	Specify the size, number of indicators, color and faces.
2.02 B.2	Specify the Optically Programmable or LED Vehicular Traffic Signal Heads.
2.02 B.3	Show the number of traffic signal head sections to provide the signal indications shown.
2.02 B.6.a	Specify visor type.
2.02 B.7.a	Specify the location and direction of directional louvers.
2.02 B.7.b	Specify the dimension and arrangement of directional louvers.
2.02 B.8	Specify locations and configuration of backplates.
2.02 B.10	Specify the size, number and location of polycarbonate housings and visors.
2.02 C.1	Show locations of optically programmable vehicular signal heads.
2.02 C.3	Show the mounting of the signals to standard 1-1/2 inch pipe fittings.
2.02 E.1	Show the wiring of the traffic signal heads to implement the signal operations. Specify the cable size and number of conductors.
3.01 B	Specify equipment to be removed and not required for relocation. Specify removed equipment, if any, that shall be used in a new installation.
3.02 B	Specify mounting of Vehicular Traffic Signal Heads on span wire, mast arms, post tops and vertical pole bracket mounts.
3.02 B.1	Specify an upper or lower span or tether wire if needed.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16572

TRAFFIC SIGNAL POLES, MAST ARMS, SPAN WIRE AND POLE FOUNDATIONS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for traffic signal poles, mast arms, span wire and pole foundations.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

American Association of State Highway and Transportation Officials (AASHTO)

AASHTO	Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

American Society for Testing and Materials (ASTM)

ASTM A.36	Specification for Carbon Structural Steel.
ASTM A 123	Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
ASTM A 153	Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
ASTM A 325	Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
ASTM A 370	Test Methods and Definitions for Mechanical Testing of Steel Products.
ASTM A 475	Specification for Zinc-Coated Steel Wire Strand.
ASTM A 572	Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
ASTM A 576	Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.
ASTM A 595	Specification for Steel Tubes, Low-Carbon or High-Strength Low-Alloy, Tapered for Structural Use.
ASTM A 615	Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
ASTM B 108	Specification for Aluminum-Alloy Permanent Mold Castings.
ASTM B 221	Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
ASTM B 228	Specification for Concentric-Lay-Stranded Copper-Clad Steel Conductors.
ASTM F 1554	Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.

Federal Highway Administration (FHWA)

MUTCD Manual on Uniform Traffic Control Devices.

National Fire Protection Association (NFPA)

NFPA 70 National Electrical Code (NEC).

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. Traffic signal poles, mast arms, span wire and pole foundations shall conform to requirements specified herein; and where specific requirements are not listed herein, the traffic signal poles shall, as a minimum, conform to the requirements of the standards and publications listed in 1.02.

B. Traffic signal poles, mast arms, span wire and pole foundations furnished as Work of this Section shall be as shown on the Contract Drawings, constructed to standard similar dimension sections.

C. Traffic signal poles, mast arms, span wire and pole foundations shall consist of readily available and proven equipment, fully consistent with their intended design and operation as specified herein. Special or custom-built components may be used only upon written approval from the Engineer.

1.04 ENVIRONMENTAL REQUIREMENTS

A. Equipment shall operate without degradation or damage under ambient shock (thermal and mechanical), vibration, lightning and electromagnetic/electrical interference at the construction site.

1.05 QUALITY ASSURANCE

A. Provide independent test certification of foundations, poles, bases, span wires, guy wire and mast arms to show compliance with the load requirements.

B. Submit design calculations signed and sealed by a professional engineer licensed in the state in which the traffic signals are to be installed to the Engineer for approval for all non-standard foundations, bases, poles, span wires, guy wire and mast arms.

1. Wind load pressure shall be at least 90 miles per hour in accordance with AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

C. After installation, inspect the equipment in the presence of the Engineer to show compliance with the requirements of this Section. Continue inspection until the results are satisfactory to the Engineer. Perform any repairs, construction and modifications as required to comply with the Specifications without additional cost to the Authority.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver all materials to the construction site in original unopened containers or bundles with labels that clearly identify the manufacturer and product name, including storage requirements and instructions.

B. Properly store and handle all materials delivered to prevent deterioration or damage due to moisture, temperature change, contaminants or other causes.

1.07 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MATERIALS

A. Furnish poles and mast arms of material shown on the Contract Drawings as follows:

1. Aluminum Poles and Mast Arms: ASTM B 221, Alloy 6063-T6.

   a. Rotary ground, paper protection wrapped.

   b. Anodized aluminum poles and arms in the quantities shown, shall be furnished only if specified on the Contract Drawings.

2. Aluminum Struts and Plates: ASTM B 221, Alloy 6063-T6.

3. Steel Poles and Mast Arms: ASTM A 595, Grade A, or ASTM A 572, Grades 50 with the following minimum yield strength after fabrication guaranteed by the manufacturer and documented by the submission of certified copies of physical tests performed on material lots from which items were fabricated; and galvanized in accordance with ASTM A 123:

   a. Pole of base diameter of 13 inches or less: ASTM A 595; 55,000 psi.

   b. Pole of base diameter greater than 13 inches: ASTM A 572; 65,000 psi.

B. Shoe Bases

1. Aluminum: ASTM B 108, Alloy 356-T6.

   a. ASTM B 221, Alloy 6005-T5 at hand hole reinforcement.

2. Steel: In accordance with 2.01 A.3.

C. Transformer Bases

1. Aluminum: ASTM B 108, Alloy 356-T6.

2. Furnish powder-coated transformer bases and bolt covers in the quantities shown in the color specified only if specified on the Contract Drawings.

D. Clamps

1. Cast Aluminum Pole Clamps: ASTM B 108, Alloy 356-T6.

2. Steel: In accordance with 2.01 A.3.

E. Connection Devices

1. Aluminum: ASTM B 221, Alloy 6061-T6.

2. Steel: ASTM A 36.

F. Anchor Bolts, Nuts and Washers

1. Bolts for pole base diameter of 16 inches or less.

2. ASTM A 576 modified to minimum yield strength of 50,000 psi, minimum tensile strength of 65,000 psi and minimum elongation of 18 percent in 2 inches, tested in accordance with ASTM A 370.

3. Bolts for pole base diameter exceeding 16 inches: ASTM A 615, Grade 75.

4. Bolts for steel traffic pole base shall be hot-dip galvanized steel ASTM F 1554, Grade 55 or ASTM A 36 modified to minimum yield strength of 55,000 psi.

5. Nuts and Washers: Type and grade of steel compatible and of comparable strength to anchor bolt steel.

6. Galvanize nuts, washers and a minimum of 6 inches of bolt-threaded end in accordance with ASTM A 153.

G. Span Wire Cable: ASTM A 475, with Class A weight zinc coating or ASTM B 228 with a suitable diameter to provide the minimum pound breaking strength as specified on the Contract Drawings.

1. Tether wire, where required, shall be 5/16-inch minimum diameter.

2. Fabricate wire dead ends with heat-treated aluminum alloy strand vice yoke and cartridge and case hardened plated steel alloy jaws. The breaking strength of the strand vice shall be not less than the minimum pound breaking strength as specified on the Contract Drawings.

3. Strand wire attachment shall be 3/4-inch diameter galvanized eye through bolts with double nut and curved stubbing washer.

H. Guy Wire Cable: ASTM A 475, with Class A weight zinc coating or ASTM B 228 with a suitable diameter to provide the minimum pound breaking strength as specified on the Contract Drawings.

1. Guy wire attachment shall be a guy strand vise with a 3/4-inch angle thumb eye bolt and 3/4-inch diameter galvanized through bolts with double nut and curved stubbing washer. Guy guard shall be a minimum of 8 ft. Helix anchor shall be as shown on the Contract Drawings.

I. Foundations

1. Concrete Category VI shall be monolithically poured, cast-in-place of the size and shape shown on the Contract Drawings.

J. Grounding

1. All poles shall be grounded, meeting or exceeding the NFPA 70 National Electrical Code (NEC) standards.

K. Safety Chain: Hot-dip galvanized 1/4-inch coil proof straight link chain shall be fabricated in accordance with ASTM A 36 and galvanized in accordance with ASTM A 123.

2.02 CONSTRUCTION FEATURES

A. General

1. Traffic signal poles shall be of the following types as shown on the Contract Drawings:

   a. Span Wire Poles: Poles for supporting a steel cable or cables to which are attached traffic signals and overhead signs.

   b. Mast Arm Poles: Vertical pole(s) and approximately horizontal arm(s) to which are attached traffic signals and overhead signs.

   c. Post-top Mount Poles: Vertical pole(s) used for mounting traffic or pedestrian signals directly on post top.

   d. Bracket Mount Poles: Vertical pole(s) used to support traffic or pedestrian signals, bracketed from side.

2. Pole shapes shall be round, near round or multisided (8 minimum), of length sufficient to provide roadway clearance for signals as shown on the Contract Drawings; and the length of span wire poles shall allow for a minimum of 5 percent wire sag after all signals and signs are installed while maintaining such roadway clearance for signals.

3. Design anchor bolts for the most critical orientation of the pole. Provide anchor bolts, nuts and washers for each pole supplied.

   a. Anchors for anchor bolts with a yield stress equal to or less than 55,000 psi may be "L" bend terminations.

   b. Anchors for anchor bolts with a yield stress greater than 55,000 psi shall be double nuts and plates or threaded plate terminations.

4. Shop paint shall be rust-inhibitive, non-lead or chromium-based oil/alkyd primer on non-galvanized steel fabrications, junction box frames and covers and exterior exposed metallic conduits and anchor bolts. Field paint all uncoated steel with rust-inhibitive, non-lead primer tinted to distinguish it from shop paint coating; and finish paint one coat of black graphite or foliage green paint.

B. Pole Construction: Fabricate pole of material shown on the Contract Drawings with a uniform wall thickness and a uniform taper, starting at the butt end, decreasing in diameter at a rate of not more than 0.14 inches, but not less than 0.07 inches per foot of length.

1. The maximum base diameter of span wire poles shall be 0.70 inches per foot of pole length.

2. Equip poles with removable end caps and a 1/2-13 threaded bolt, grounding terminal accessible through a hand hole.

3. Fabricate aluminum shafts free of longitudinal welds.

4. Fabricate steel shafts of one-piece construction with full-length high frequency resistance welds. Use submerged arc welds for poles of 13-inch or greater butt diameter.

C. Shoe Base Construction: Weld base to shaft so that connection develops full yield strength of shaft section.

1. Equip base with gussets and anchor bolt slots, sized to fit anchor bolts.

2. Equip shoe base with shoe base bolt covers.

D. Transformer Base Construction

1. Equip aluminum transformer and pedestal bases with a plastic hand hole door type ABS, modified for UV resistance, with stainless steel mounting hardware, steel gray color of the size and thickness shown on the Contract Drawings. A grounding clip shall be located on wall opposite door opening.

2. Attach removable type transformer base to pole shaft by bolting to a shoe base welded to shaft. Attach rotary transformer base into a reinforced collar arrangement that shall accept pole shaft. Arrange shaft disconnections so that no special tools are required for unbolting disconnection.

E. Mast Arm Construction: Fabricate to arm length and configuration and of material shown on the Contract Drawings. Provide a hole with smooth wiring cable guide in flange plates on shaft and on mast arms at signal location for complete internal wire routing.

1. Aluminum Mast Arms

a. Fabricate arms of one-piece horizontal plane ovalized aluminum tubing of minimum 0.125-inch wall thickness, with welded vertical struts.

b. For truss type mast arms, design for both free swinging and adjustable fixed vertical signal mounting. Join outboard ends of arms by welding a one-piece extrusion shaped to accept arm members back to back and maintain a 1/4-inch minimum separation between tubes. Extend upper arm to form a 2-inch slipfitter at outboard end and provide a welded signal strap to mount free-swinging signal.

c. Secure mast arm to pole shaft with aluminum plate clamp welded to inboard end of arm and a matching pole back clamp, with four stainless steel through bolts and locknuts for attachment.

2. Steel Mast Arms

a. Fabricate with longitudinal high frequency resistance welds and provide a uniform taper starting at the butt end, decreasing in diameter at a rate of not more than 0.14 inches, but not less than 0.07 inches, per foot of length.

b. Fabricate arms in one piece for lengths up to 43 feet, over 43 feet fabricate of two-piece construction with an overlap joint length of 1-1/2 times the maximum inside diameter of the outer shaft, and secure with a through bolt and locknut.

c. Provide a removable galvanized steel end cap secured with stainless steel screws.

d. Secure mast arm to pole shaft with a steel plate drilled to fit mast arms, circumferential welded inside and outside. Stiffen plate with horizontal gusset plates both top and bottom and at each side. Secure to the pole shaft with four ASTM A 325 through bolts with nuts, ASTM A 153 zinc-coated.

F. Hand Holes: Equip poles, except transformer base mounted poles, with hand holes. Center holes 12 to 18 inches above the base end of pole. The maximum hand hole size shall not exceed 4 by 8 inches.

1. Internally reinforce poles with metal of a cross section area at least equal to the cross section area of hole area removed.

2. Provide removable door flush with outside of shaft.

G. Ground Lug: Equip poles and transformer bases with ground lug.

H. Safety Chain: Furnish and install hot-dip galvanized 1/4-inch coil proof straight link chain with stainless steel bolts, nuts and washers at all mast arm signal head installations.

PART 3. EXECUTION

3.01 PREPARATION

A. Before manufacture or procurement of equipment, submit calculations, Catalog Cuts and Shop Drawings for prior Engineer approval as specified in 1.03 and 1.05. Do not procure equipment until the Engineer has given written approval.

B. Related equipment to be removed and not required for relocation under the Contract, if and where shown on the Contract Drawings, shall remain the property of the Authority and shall be delivered to a location in the Port District as designated by the Engineer. Removed equipment, if any, shall not be used in a new installation unless specifically shown on the Contract Drawings.

C. Verify that each pole foundation and anchor bolt pattern has been installed using the proper anchor bolt circle for the pole base.

3.02 INSTALLATION

A. Poles

1. Attach pole shaft by bolting shoe base to transformer base or to the foundation. Locate hand hole to face away from traffic.

2. Use shims to level pole to a maximum of 1/4 inch.

3. Traffic signal poles shall be bonded and grounded according to the NEC. Furnish and install a ground cable from the pole's ground lug to a ground rod at the nearest manhole.

4. Install mast arms and span wires so traffic signal heads and signs meet minimum elevation requirements as shown on the Contract Drawings, in accordance with AASHTO standards and MUTCD guidelines.

B. Span Wire

1. Fasten signal control cable to the span wire by non-corrosive metal lashing, messenger rings or weather resistant plastic cable bands, at no greater than 15-inch intervals. Hang signal heads and brackets from the span wire so that the bottoms of the signal heads on each approach are aligned horizontally. The signal cable shall follow the lowest path to the signal heads.

2. Determine the length of span wire required to span the distance between poles, allowing sufficient length for fastening and sag to produce a final assembly that is consistent with the Contract Drawings.

3. Determine all the loads for the span wire and arrange for the cable manufacturer to select the cable based on the determined loads and test for tensile strength subject to the Engineer's written approval.

4. In order to restrict excessive signal movement, install a second tether cable to stabilize signal heads, if and where shown on the Contract Drawings. Attach tether cable to the lower edge of the signal head.

5. Drill through pole at an approximate straight angle at each connection to receive the eye through bolts. In no case shall the span wire pull or strain on the eye bolt at an angle greater than 10 degrees plus or minus from straight.

6. Furnish and install galvanized thimble eyebolts to connect ground wires to round signal poles. Circumferential pole clamps, as an alternative to galvanized thimble eyebolts, may be used to connect span wires to the top of polygonal shaped signal poles.

C. Foundations

1. Concrete foundations shall be cast-in-place.

2. Foundations shall rest on firm ground and shall be poured monolithically. Conduit and anchor bolts shall be placed in proper position and shall be held in place by means of a template until the concrete sets. Forms shall not be removed until the concrete has hardened but not less than 24 hours after the concrete has been placed. Exposed portions of foundations shall be neatly finished with a wood float followed by brushing with a wet, soft-haired brush. Construct tops of foundations to a finished grade elevation of 1 inch above final grade sidewalk. Where sidewalks are not constructed or do not exist, finish foundations to an elevation of 2 inches above the final grade of the surrounding lawn or earth.

3. Conduit installed in foundations shall be set plumb. The conduit shall terminate with a coupling flush with the top of the foundations and shall be provided with a close nipple. Conduit shall be provided with pipe caps during the placement of the concrete. When the finishing of the foundation is complete, the pipe caps shall be removed and insulated grounding bushings shall be installed. If the wiring is not immediately installed, the bushings shall be installed with push-penny plugs.

4. Anchor bolts installed in the foundation shall be set plumb. Bolt transformer or shoe base to foundation using stainless steel washers, lock washers and bolts. Stainless steel shims may be used to a maximum of 1/4 inch to level the pole.

3.03 INSPECTION

Perform final installation inspection in accordance with 1.05 C.

END OF SECTION

SECTION 16572

TRAFFIC SIGNAL POLES, MAST ARMS, SPAN WIRE AND POLE FOUNDATIONS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

Details of all traffic signal poles including their bases, poles, cables, arms, mounting brackets, attachments and fittings, and anchor bolt details and layout.

B. Catalog Cuts, Material Certifications, and Test Results

1. Certified test results for steel poles and mast arms in accordance with 2.01 A.3.
2. Certification for anchor bolt strength in accordance with 2.01 F.
3. Certification for span wire cable strength in accordance with 2.01 G.

C. Samples.

D. Construction Procedures and Quality Assurance Documents.

E. Design Computations

Design computations for all traffic poles in accordance with 1.05 B.

END OF APPENDIX "A"

SECTION 16572

TRAFFIC SIGNAL POLES, MAST ARMS, SPAN WIRE AND POLE FOUNDATIONS

INSTRUCTIONS TO SPECIFIER

A. The Specifier shall review all items listed in Appendix "A". Remove all items that are not applicable to this project and add to the Appendix "A" under the proper headings any submittal items intended to be shown on the Contract Drawings.

B. Ensure that the Contract Drawings indicate:

1. Heights, minimum thickness of walls, and materials for all poles and arms.
2. Foundation details including anchor bolt size, embedment, bolt circle and the design moment at the top of foundation.
3. Indicate that the Contractor's Professional Engineer shall verify the design moment at the top of the foundation as part of the overall submitted design calculation.
4. For span wire installations, indicate tether wire, if required.

C. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

1.03 B	Specify the location of the poles, mast arms, span wires and foundations.
2.01 A	Specify the location and size of poles and mast arms.
2.01 A.1.b	Specify if and where anodized aluminum poles are used.
2.01 C.2	Specify if and where powder coated transformer bases and bolt covers are used.
2.01 H.1	Specify helix anchor size.
2.01 I.1	Specify foundation size and shape.
2.02 A.1	Specify pole type.
2.02 A.2	Specify roadway clearance.
2.02 B	Specify pole material.
2.02 D.1	Specify hand hole door size and thickness.
2.02 E	Specify mast arm material.
3.01 B	Specify equipment to be removed and/or relocated.
3.02 A.4	Specify minimum roadway clearance for signal head and signs.
3.02 B.2	Specify span length.
3.02 B.4	Specify upper and lower tether wire.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16573

PEDESTRIAN TRAFFIC SIGNALS

PART 1. GENERAL

1.01 SUMMARY

This Specification specifies requirements for pedestrian light emitting diode (LED) and incandescent traffic signals.

1.02 REFERENCES

The following is a listing of the publications referenced in this Specification:

American Association of State Highway and Transportation Officials (AASHTO)

Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals

American National Standards Institute (ANSI)

ANSI C 78A-21	Bulb, Medium Screw Base

American Society for Testing and Materials (ASTM)

ASTM B 85	Aluminum-Alloy Die Castings

Federal Communications Commission (FCC)

Title 47,Telecommunications

Federal Highway Administration (FHWA)

Manual on Uniform Traffic Control Devices (MUTCD)

Institute of Transportation Engineers (ITE)

ITE Standard ST-011B	Standard for Pedestrian Traffic Control Indications
ITE Standard ST-017B	Vehicle Traffic Control Signal Heads (VTCSH) – Part 2: LED Vehicle Traffic Signal Modules – An Interim Purchase Specification.

US Department of Defense Military Standards

MIL-STD-883	Test Method Standard Microcircuits

National Electrical Manufacturers Association (NEMA)

NEMA TS-1	Standard for Traffic Control Systems
NEMA TS-2	Standard for Traffic Controller Assemblies with NTCIP Requirements Systems
NEMA 250	Standard for Enclosures for Electrical Equipment (1000 Volts Maximum)

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. Where specific requirements are not listed herein, the pedestrian traffic signals shall, as a minimum, conform to the requirements of the standards and publications listed in Article 1.02 herein.

B. The units furnished as Work of this Specification shall be LED-based Pedestrian Traffic Signals in the quantities shown on the Contract Drawings. Incandescent Type Pedestrian Traffic Signals in the quantities shown, shall be furnished only if specified on the Contract Drawings.

C. The pedestrian traffic signals shall consist of readily available and proven equipment, fully consistent with their intended design and operation as specified herein and shown on the Contract Drawings. Special or custom-built components may be used only upon written approval from the Engineer.

D. Use modular type construction with assemblies, sub-assemblies and modules that are available from a second source of supply wherever possible.

E. All assemblies, sub-assemblies, and modules shall be readily accessible for removal, testing, or replacement without removal of the other modules, assemblies or components. Components shall be located so that there is visibility and access for the use of hand tools and standard test probes where maintenance is required. Test points shall be provided to facilitate troubleshooting.

1.04 ENVIRONMENTAL REQUIREMENTS

A. The pedestrian traffic signal head equipment shall operate over an ambient temperature range from -40 degrees Fahrenheit to +165 degrees Fahrenheit (-40 degrees Celsius to +74 degrees Celsius). Operation of the pedestrian traffic signal head equipment shall not be degraded by rain, snow, fog or normally encountered ambient humidity conditions.

B. The equipment shall be protected against the intrusion of dust and moisture to protect all internal components.

C. The equipment shall operate without degradation or damage under ambient shock (thermal and mechanical), vibration, lightning, and electromagnetic/electrical interference.

1.05 QUALITY ASSURANCE

A. After delivery of equipment, allow the Engineer to make a construction site inspection of the equipment. If any equipment has been damaged or if, for any reason, the equipment does not comply with the requirements or test standards specified, the Contractor shall repair or replace the equipment at its own expense, even though the equipment had been inspected for shipment. After satisfactory replacement and/or repair and subsequent Engineer written approval, the equipment may be installed.

B. After installation, test the equipment in the presence of the Engineer to show compliance with the requirements of this Specification and with the Contract Drawings. Continue testing until test results are satisfactory to the Engineer. Perform any repairs, construction, or modifications required to comply with these Specifications and the Contract Drawings.

C. Arrange for the entity performing work of this Specification to furnish on-site technical assistance during the installation of the equipment.

D. Ensure that all LED-based pedestrian traffic signals undergo the following Production Quality Assurance (QA) testing prior to shipment. Failure of any LED-based pedestrian traffic signal module to meet requirements of these QA tests shall be cause for rejection. Maintain QA process and test results documentation on file for seven years.

1. Signal Module Burn-in

2. The Maintained Minimum Luminous Intensity shall meet Luminous Intensity requirements in accordance with ITE Standard ST-017B.
3. Power Factor
4. Current
5. Visual Inspection

These tests shall be conducted as specified herein and in accordance with ITE Standard ST-017B.

E. Arrange for all LED signals to undergo Design Qualification (DQ) testing prior to shipment as specified herein and in accordance with ITE Standard ST-017B. Failure of any LED signal module to meet requirements of these DQ tests shall be cause for rejection. Maintain DQ process and test results documentation on file for seven years

1.06 DELIVERY, STORAGE, AND HANDLING

A. Arrange for all materials to be delivered to the construction site in original unopened containers or bundles with labels that clearly identify the manufacturer and product name, including storage requirements and instructions.

B. Properly store and handle all materials delivered to prevent deterioration or damage due to moisture, temperature change, contaminants, or other causes.

1.07 SUBMITTALS

For submittals requirements, see Appendix "A" of this Specification.

PART 2. PRODUCTS

2.01 MATERIALS

A. Head Housing and Door: Virgin metal die cast aluminum-alloy conforming to ASTM B 85 of one of the following alloys:

1. S12A (A14130)
2. S12B (A04130)
3. SC84A (A13800)
4. SC84B (A03800)
5. SG100B (A03600)

2.02 CONSTRUCTION FEATURES

A. General:

1. Furnish and install pedestrian traffic signals for operation on 115 volts, plus or minus 30 volts, 60 hertz, single phase AC power, unless otherwise shown on the Contract Drawings. Signals shall operate over a voltage range from 80 VAC to 135VAC, 60 Hz +- 3 Hz, single phase power. Variations in operating line voltage shall produce no visible effect on luminous intensity and shall not vary by more than 10% over the entire operating voltage range.
2. Furnish and install signal heads, mounting bracket, attachments, and fittings for a wind load pressure resulting from a wind speed of at least 90 MPH in accordance with AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.

3. Signal housings, push button housings, bracket arms, and mounting attachments shall have three coats of paint, each of which shall be baked after application. The first or primer coat shall be a non-lead / non-chromium containing paint for aluminum surfaces. The second and third coats shall be Federal Yellow Matching Color No. 13538 conforming to Federal Standard No. 595, except for the message face and the Z-crate visor, which shall be flat black enamel. Each coat shall be baked on separately. All metal surfaces to be painted shall be suitably cleaned of all foreign deposits, oil and grease, and then neutralized for priming. Paint separate parts before assembly. Stainless steel assemblies and polycarbonate components shall not be painted.

4. Unless specified otherwise, equipment shall be fabricated in accordance with ITE Standard ST-011B.

5. Identify all wire terminations and terminal block connections. Terminate cables with insulated spade terminals conforming to NEMA TS-l.

B. Incandescent Pedestrian Traffic Signals:

1. The number, illumination type, and usage of pedestrian signal shall be as shown on the Contract Drawings. The signal indications shall consist of the alternating illumination of the "WALKING PERSON" and "STOP HAND" international symbols.

2. Signal unit shall include a single piece cast aluminum housing, the illumination light source, a polycarbonate message lens, a single piece cast aluminum swing door frame, a blank-out Z-crate type sun visor and other appropriate hardware and mounting brackets. One signal unit shall house both the "WALKING PERSON" and "STOP HAND" symbols. Design the signals to fit both standard post top and side of pole mounting brackets, including clamshell type mounting hardware, as shown on the Contract Drawings. All components and field wiring terminals shall be readily accessible from the front by opening the signal door.

3. Indications shall be made visible by incandescent illumination, and shall be capable of bright and uniform display while being subject to strong ambient light conditions. When illuminated, the "WALKING PERSON" symbol shall be white in color. When illuminated the "STOP HAND" shall be Portland orange. The message lenses, except for the symbols, shall be obscured by an opaque material. When not illuminated, the symbols shall not be distinguishable by pedestrians at the far end of the controlled crossing.

4. "STOP HAND" and "WALKING PERSON" symbols shall each be a minimum of 11 inches in height and 7 inches in width configured as shown in Section 4E.04 of the FHWA Manual on Uniform Traffic Control Devices.

5. Design the optical system for pedestrian signals utilizing incandescent illumination so as to minimize the return of outside rays entering the unit. The system shall consist of a two-symbol color message lens, a single-piece double section parabolic reflector and two lamps and lamp socket sets. The design shall optimize performance per unit of energy consumed and shall accommodate 60, 67, 69, and 116-watt lamps. Screen the inside of each message section with a transparent coating of the appropriate colors in the symbol areas to produce a Portland orange "STOP HAND" symbol and an incandescent white "WALKING PERSON" symbol when illuminated by the signal lamp. The entire background shall be black in color.

a. The lens material shall be 0.025-inch polycarbonate plastic suitably textured on the outside surface to eliminate message "HOT SPOTS", screened and colored to include the required symbol messages, located at least 1.75 inches away from the closest glass envelope extremity of the signal lamps. Fit the inside of the lens with a one-piece sponge neoprene gasket around the lens perimeter to create a weatherproof seal whenever the reflector, lens, doorframe and case are properly mated.

b. Vacuum form the single-piece, double-section parabolic reflector from a 0.250-inch minimum thickness textured polycarbonate plastic sheet textured on the light bulb side of the reflector to insure light uniformity. Reflectorize the lamp side of the reflector by vacuum deposition of an aluminum coating protected by a hard wear resistant coating. Divide the two sections of the reflector by a full depth aluminum divider that properly mates with the message lens to effectively prevent light spillage from one section to the other.

c. Equip each incandescent pedestrian signal with two V-beam, clear, ANSI C 78 Type A-21, 8000 hour rated life, horizontal with medium base traffic signal lamp and sockets sets, one for each section of the double parabolic reflector. Lamp sockets shall be molded bakelite, molded phenolic, or ceramic, with a brass screw and lamp grip. Position lamp socket to be centered and pre-focused in its section when the lamp is installed and mount to the die cast aluminum case so as to efficiently conduct heat away from the socket.

d. Provide each lamp socket with one colored lead from the socket that is non-white and non-green, plus one white lead from the shell. The leads shall be 18 AWG wired to the respective terminals of the field wire terminal block.

6. Provide each signal with a Z-crate type visor designed to eliminate sun phantom, installed directly into the signal doorframe parallel to the face of the "STOP HAND"/"WALKING PERSON" message and held in placed by means of stainless steel screws. The visor shall consist of a minimum of 20 straight horizontal louvers and 21 zigzag pattern horizontal louvers with every other formed louver reversed so as to form one-inch square cells but rotated 45 degrees from the horizontal to provide diamond shaped cells when assembled, with each diamond bisected by a straight louver inserted between each pair of the formed zigzag louvers and each louver intersection joint welded to maintain a firm construction, all enclosed in a mounting frame constructed of 0.040-inch minimum thickness aluminum.

7. Provide a screw-in type terminal block assembly with an aluminum base that is bolted to the signal housing for termination of the returned field wires. Field wiring shall be as specified herein unless otherwise shown on the Contract Drawings.

8. The signal casting shall be a one-piece corrosion resistant aluminum alloy die casting complete with integral cast top, bottom, sides, and back. Provide integral cast hinged lug pairs, two at the top and two at the bottom for operation of a swing door. The doorframe shall be a one-piece corrosion resistant aluminum alloy die casting complete with two integral cast hinged lug pairs, at the bottom of the door and two latch slots at the top of each door. Attach the door to the housing by means of stainless steel spring pins with captive stainless steel wingnuts and washers. The case when properly mated to other signal components and mounting hardware shall provide a dustproof and weather resistant enclosure, with easy access to all components for servicing and replacement.

C. LED Pedestrian Traffic Signals:

1. The number and usage of LED-based pedestrian traffic signals shall be as shown on the Contract Drawings. The signal indications shall consist of the alternating illumination of the "WALKING PERSON" and "STOP HAND" international symbols in solid form.
2. The Hand/ Person pedestrian module shall be designed to display a full "STOP HAND" and "WALKING PERSON" symbol that complies with ITE Standard ST-011B for the size specified in a single housing. The Hand/ Person pedestrian module shall be used for existing installations, where applicable, and all new installations unless otherwise directed by the Engineer.
3. A Hand pedestrian module shall be designed to display a full "STOP HAND" symbol that complies with ITE Standard ST-011B for the size specified in a single housing. A Person pedestrian traffic signal module shall be designed to display a "WALKING PERSON" symbol that complies with ITE Standard ST-011B for the size specified in a single housing. The Hand and Person pedestrian traffic signal modules shall be used for existing installations where required unless otherwise directed by the Engineer.
4. For new installations install one 16-inch (nominal) pedestrian traffic signal housing that includes the LED Hand/Person pedestrian traffic signal module unless otherwise directed by the Engineer.
5. For retrofit replacement the LED-based pedestrian traffic signal modules shall fit into existing signal housings without the need to modify the housing or to modify or remove the reflector. Installation of the retrofit replacement LED-based traffic signal module into existing 12-inch or 16-inch pedestrian traffic signal housings shall require only the removal of the existing message bearing surface and insertion of the retrofit replacement into the area once occupied by the removed assembly.
6. Installation of retrofit replacement modules
   a. LED-based pedestrian traffic signal modules shall not require special tools for installation when used as retrofit replacements for the existing traffic signal lamps.
   b. LED-based pedestrian traffic signal modules shall fit into the existing traffic signal housings built to ITE Standard ST-011B without any modification to the housing.
   c. LED-based pedestrian traffic signal modules shall be weathertight, shall fit securely in the housing and shall connect directly to existing electrical wiring.
   d. Installation of retrofit replacement LED-based pedestrian traffic signal modules into existing pedestrian traffic signal housings shall require only the removal of the existing optical unit components, i.e. lens, lamps, gaskets and reflector.
   e. Ensure that each retrofit kit includes all necessary components to complete conversion, including a one-piece gasket.
7. The Pedestrian traffic signal unit shall include a single piece cast aluminum housing, the illumination light source, a polycarbonate message lens, a single piece cast aluminum swing door frame, a blank-out Z-crate type sun visor and other appropriate hardware and mounting brackets. Design the signals to fit both standard post top and side of pole mounting brackets, including clamshell type mounting hardware, as shown on the Contract Drawings. All components and field wiring terminal shall be readily accessible from the front by opening the signal door.

8. Indications shall be made visible by LED illumination, and shall be bright and uniform displays even under strong ambient light. When illuminated, the "WALKING PERSON" symbol shall be white in color. When illuminated the "STOP HAND" shall be Portland orange in color. Each symbol shall be in solid format, with the interior of the symbol illuminated and containing a number of LEDs to maintain a uniform appearance. The message lenses, except for the solid symbol, shall be obscured by an opaque material. When not illuminated, the symbols shall not be distinguishable by pedestrians at the far end of the controlled crossing.

9. "STOP HAND" and "WALKING PERSON" symbols shall each be a minimum of 11 inches in height and 7 inches in width for nominal 16-inch pedestrian signal housings and 9 inches in height and 5.25 inches in width for nominal 12-inch pedestrian signal housings. They shall be configured as shown in Section 4E.04 of the FHWA Manual on Uniform Traffic Control Devices.

10. Design the optical system for pedestrian traffic signals utilizing LED illumination so as to minimize the return of outside rays entering the unit. The system shall consist of a polycarbonate message lens and a LED solid state signal module.

    a. The lens material shall be clear, UV stabilized, refraction type, polycarbonate plastic. Fit the inside of the lens with a one- piece sponge neoprene gasket fitted around the lens perimeter to create a weatherproof seal whenever the lens, doorframe, and case are properly mated.

    b. The LED-based pedestrian traffic signal module shall be mounted so as to be impervious to shocks generated during shipping, handling and installation. Removal and installation of the module shall not require the use of tools.

    c. Provide the LED-based pedestrian traffic signal module with colored leads conforming to Article 3.02.D of this Section. The leads shall be 18 AWG wired to the respective terminals of the field wire terminal block.

11. Provide each LED-based pedestrian traffic signal with a Z-crate type visor designed to eliminate sun phantoms, installed directly into the signal doorframe parallel to the face of the "STOP HAND"/"WALKING PERSON" message and held in placed by means of stainless steel screws. The visor shall consist of a minimum of 20 straight horizontal louvers and 21 zigzag pattern horizontal louvers with every other formed louver reversed so as to form one-inch square cells but rotated 45 degrees from the horizontal to provide diamond shaped cells when assembled, with each diamond bisected by a straight louver inserted between each pair of the formed zigzag louvers and each louver intersection joint welded to maintain a firm construction, all enclosed in a mounting frame constructed of 0.040-inch minimum thickness aluminum.

12. Provide a screw-in type terminal block assembly with an aluminum base that is bolted to the signal housing for termination of the returned field wires. Field wiring shall be as specified herein unless otherwise shown on the Contract Drawings.

13. The signal casting shall be one-piece corrosion resistant aluminum alloy die casting complete with integral cast top, bottom, sides, and back. Provide integral cast hinged lug pairs, two at the top and two at the bottom for operation of a swing door. The doorframe shall be one-piece corrosion resistant aluminum alloy die casting complete with two integral cast hinged lug pairs, at the bottom of the door and two latch slots at the top of each door. Attach the door to the housing by means of stainless steel spring pins with captive stainless steel wing nuts and washers. The case when properly mated to other signal components and mounting hardware shall provide a dustproof and weather resistant enclosure, with easy access to all components for servicing and replacement.

14. The housing shall have neoprene gaskets between the body of the housing and the doors. The door shall be hinged and forced tightly against the gasket and the housing by a simple stainless steel locking mechanism.

D. Push Button Assemblies:

1. The number and location of push buttons shall be as shown on the Contract Drawings.
2. Push button assemblies shall include the complete push button and housing, suitable wiring from the terminals of the push button to the base of the standard, and instruction sign. All push buttons shall operate on logic ground. Field wiring shall be as specified herein unless otherwise shown on the Contract Drawings.
3. Construct the assembly housings of integral cast aluminum designed to mount securely on any curved surface from 4 inches in diameter to 16 inches in diameter. The push buttons shall operate on no more than 18-volt circuits and shall register a demand with the traffic signal controller for the pedestrian timing of the appropriate phase.
4. Provide an instruction sign in conformance with MUTCD requirements including the international "WALKING PERSON" symbol legend.
5. All exposed screws shall be stainless steel and tamper-proof.
6. Push button standards, if any, shall consist of a traffic signal pedestal and base complete with all mounting hardware and a rain-tight pole cap.

E. Environmental Requirements

1. The pedestrian traffic signal modules and push button assemblies shall satisfy all the environmental requirements specified in Article 1.04 of this Specification.
2. The pedestrian traffic signal modules, when properly installed with gasket, shall be protected against dust and moisture intrusion per requirements of NEMA 250 for Type 4 enclosures to protect all internal LED, electronic and electrical components.

F. Luminous Intensity

1. Maintain minimum luminous intensity in accordance with the ITE Standard ST-011B and as follows as measured perpendicular to the surface at nine separated points on the icon:
   a. The "STOP HAND" LED-based Pedestrian Traffic Signal Module indications shall maintain a luminous intensity of 3,750 candelas/square meter (cd/m^2) minimum and a color of Portland Orange conforming to the requirements of ITE Standard ST-011B and MUTCD.
   b. The "WALKING PERSON" LED-based Pedestrian Traffic Signal Module indications shall maintain a luminous intensity of 5,300 candelas/square meter (cd/m^2) minimum and a color of white conforming to the requirements of ITE Standard ST-011B and MUTCD.
   c. The "STOP HAND" LED-based Pedestrian Traffic Signal Module indications shall maintain minimum luminous intensity values not less than 85% of 3,750 candelas/square meter (cd/m^2) over a useful life of 36 months of continuous use over a temperature range of –40 degrees C to +74 degrees C.
   d. The "WALKING PERSON" LED-based Pedestrian Traffic Signal Module indications shall maintain minimum luminous intensity values not less than 85% of 5,300 candelas/square meter (cd/m^2) over a useful life of 36 months of continuous use over a temperature range of –40 degrees C to +74 degrees C.

2. The luminous uniformity of the "STOP HAND" and "WALKING PERSON" icons illumination shall maintain a ratio of not more than 1 to 5 between the minimum and maximum luminous measurements (in cd/m^2).

3. LED-based pedestrian traffic signal modules shall be designed so that when operated over the specified ambient temperature and voltage ranges, the signal shall attract the attention of, and be readable to, a pedestrian (both day and night) at all distances from 10 ft to the full width of the area to be crossed.

G. Chromaticity

1. The measured chromaticity coordinates of the LED-based pedestrian traffic signal modules shall conform to the chromaticity requirement of ITE Standard ST-011B.

H. Electrical

1. The pedestrian traffic signal module shall operate from a 60 +/- 3 Hz AC line over a voltage range of 85 VAC to 135 VAC. The current drawn shall be sufficient to ensure compatibility and proper triggering and operation of load switches in the signal controller units.

2. Nominal operating voltage for all measurements shall be 120 +/- 3 volts rms.

3. The "STOP HAND" and "WALKING PERSON" LED pedestrian module shall consume no more than 15 watts each.

4. All LEDs shall be rated for 100,000 hours or more at 25 oC (77 oF) and 20ma.

5. The forward current, as measured through each LED, shall not exceed 60% of the LED manufacturer's maximum current rating or the LED manufacturer's recommended drive current to achieve a minimum of 100,000 hours of operation without catastrophic failure, whichever is less, when operating at +25 degrees C.

6. The LEDs shall not emit visible light when subjected to a 120 VAC, 4 milliamp leakage current from a NEMA solid state load switch. (load switch in the off state).

7. The LEDs shall be wired in series parallel strings. The failure of any one LED, and its associated string of LEDs, shall not cause the loss of more than 20% of the light output of the complete LED module.

8. The LED circuitry shall prevent flicker at less than 100 Hz over the voltage range specified above.

9. The LED circuitry shall include voltage surge protection against high-repetition noise transients and low-repetition noise transients as stated NEMA TS-2.

10. The LED-based pedestrian traffic signal module, including its circuitry, shall meet Federal Communications Commission (FCC) Title 47, SubPart B, Section 15 regulations concerning the emission of noise.

11. The LED-based pedestrian traffic signal shall maintain a power factor of 0.90 or greater over the operating voltage range and temperature range specified above.

12. Total harmonic distortion (current and voltage) induced in an AC power line by an LED signal module shall not exceed 20% over the operating voltage range and temperature range specified above.

13. Each LED-based pedestrian traffic signal shall be operationally compatible with the traffic signal equipment that it is designed and intended to interface with. The equipment includes all controllers, conflict monitors, current monitors, switchback and flashers.

I. Design Qualification Testing

Complete and document the Design Qualification testing described below. Perform all Design Qualification testing after a burn-in (module energized for a minimum of 24 hours at 100 percent duty cycle and at an ambient temperature of 60°C (140°F) unless otherwise specified herein). Signals submitted for test shall be representative of typical production units.

1. Measure the pedestrian traffic signal modules for chromaticity per the requirements defined in this specification and ITE Standard ST-017B using a spectroradiometer at an ambient temperature of +25°C (+77°F)
2. Arrange for an independent testing laboratory to measure the pedestrian traffic signal modules for power factor per the requirements defined in this Specification.
3. Arrange for an independent testing laboratory to measure the pedestrian traffic signal modules for total harmonic distortion per the requirements defined in this Specification.
4. Arrange for an independent testing laboratory to test the pedestrian traffic signal modules for electronic noise per the requirements defined in this Specification with reference to Class A emission limits referenced in FCC Title 47 SubPart B, Section 15.
5. Test the pedestrian traffic signal modules for compatibility with controller unit, conflict monitor and load switches. Conduct these tests in accordance with the ITE Standard ST-017B.
6. Arrange for an independent testing laboratory to test the pedestrian traffic signal modules for transient immunity (e.g., early electronic component mortality failures, component reliability problems) using NEMA TS 2.
7. Arrange for an independent testing laboratory to conduct mechanical vibration testing on the pedestrian traffic signal modules, in accordance with MIL-STD-883, Test Method 2007, using three 4-minute cycles along each x, y, and z axis, at a force of 2.5 Gs, with a frequency sweep from 2 Hz to 120 Hz. The loosening of the lens, of any internal components, or any other physical damage shall be cause for rejection.
8. Test for maintained minimum luminous intensity in accordance with ITE Standard ST-017B.

PART 3. EXECUTION

3.01 PREPARATION

A. Before manufacture or procurement of equipment, submit catalog cuts and shop drawings for prior Engineer approval as specified in Article 1.07. No equipment shall be procured until the Engineer has given written approval.

B. Related equipment to be removed and not required for relocation under this Contract, if any, as shown on the Contract Drawings, shall remain the property of the Authority and be delivered to a location in the Port District as designated by the Engineer. Removed equipment, if any, shall not be used in a new installation unless specifically shown on the Contract Drawings.

3.02 INSTALLATION

A. Install pedestrian traffic signals in accordance with the guidelines specified in the MUTCD at locations shown on the Contract Drawings.

B. The orientation of the push buttons shall be convenient to the pedestrians intending to cross the roadway controlled by the push button.

C. Drill and tap each pole to which the pedestrian push buttons are to be attached and install the necessary nipples and bushings to secure the push buttons to the poles. The connections of each push button to the pole shall be weatherproof.

D. Wire the pedestrian traffic signals and push button assemblies to implement the signal operations shown on the Contract Drawings. Route a separate continuous multiple conductor cable to each push button assembly. The cable size and number of conductors shall be as shown on the Contract Drawings. Wire each pedestrian signal and push button assembly in accordance with the following color code:

Signal Indication	Wire Color
Stop Hand	Red
Walking Person	Green
Neutral	White
Assembly Function	Wire Color
Push Button	Black
Neutral	White

E. Until the installed pedestrian traffic signals are placed into operation they shall be bagged with an approved opaque material, which is adequately secured to the signals in an orderly and neat manner.

3.03 FIELD TESTS

A. Perform initial installation test in accordance with Article 1.05.

END OF SECTION

SECTION 16573

PEDESTRIAN TRAFFIC SIGNALS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Submit the following to the Engineer within forty-five (45) calendar days after receipt by the Contractor of the acceptance of his Proposal:

1. Names and locations of at least three users who have had a minimum of one year experience with the equipment. The users may be polled by the Engineer to verify equipment performance, replacement or spare parts availability, delivery and such other items as the Engineer may determine.
2. A list of manufacturers of equipment to be furnished for the Work of this Specification.
3. Detailed drawing(s) for signal head equipment, including recommended mounting instructions shall be submitted to the Engineer. The submittal shall include the environmental tolerance provisions of the proposed equipment, including standard test bars for the signal housings, pours of the metal of which the castings were made, and a certified chemical analysis of the ingot from which the casting was made.
4. A complete set of reproducible mylar shop drawings for the signal head equipment, , from which clear prints can be made shall be submitted to the Engineer. Included within this documentation shall be electrical schematic wiring diagrams for the equipment, defining terminal identification number assignment.
5. Five complete sets and one reproducible master set of operations and maintenance instructions including preventive and corrective maintenance.
6. One compact disk containing electronic files of a complete master set of shop drawings for the signal head equipment, operations and maintenance instructions including preventive and corrective maintenance.

END APPENDIX "A"

DIVISION 16

SECTION 16573

PEDESTRIAN TRAFFIC SIGNALS

INSTRUCTIONS TO SPECIFIER

List of items required to be shown on the Contract Drawings:

Article	Description
1.03.B	Specify number of LED-based Pedestrian Traffic Signals. Specify number of Incandescent Type Pedestrian Traffic Signals if required.
1.03.C	Specify the pedestrian traffic signals' design and operation.
2.02.A.1	Specify power operation other than 115 volts, plus or minus 30 volts, 60 hertz, single-phase AC power.
2.02.B.1	Specify the number, illumination type, and usage of pedestrian traffic signals.
2.02.B.2	Specify the signals' mounting brackets to fit both standard post top and side of pole, including clamshell type mounting hardware.
2.02.B.7	Specify the field wiring.
2.02.C.1	Specify the number and usage of LED-based pedestrian traffic signals.
2.02.C.7	Specify the signals' mounting brackets to fit both standard post top and side of pole, including clamshell type mounting hardware.
2.02.C.12	Specify the field wiring.
2.02.D.1	Specify the number and location of push buttons.
2.02.D.2.	Specify the field wiring.
3.01.B.	Specify related equipment to be removed.
3.01.B.	Specify removed equipment, if any, which shall be used in a new installation.
3.02.D.	Specify the wiring of the pedestrian traffic signals and push button assemblies to implement the signal operations. Specify the cable size and number of conductors.

END OF SECTION

DIVISION 16

SECTION 16574

TRAFFIC SIGNAL CONTROLLER

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for traffic signal controller.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

American Welding Society (AWS)

AWS D 1.2 Structural Welding Code - Aluminum

American Society for Testing and Materials (ASTM)

ASTM B 209 Aluminum and Aluminum - Alloy Sheet and Plate

ASTM B 686 Aluminum Alloy Castings, High Strength

Electrical Testing Laboratories, Inc. (ETL)

Institute of Transportation Engineers (ITE)

Standard for Traffic Control Systems (Publication No. TS - 1)

International Municipal Signal Association (IMSA)

Traffic Signal Lighting Cable Specifications (Series 19/20 - 600 volts)

National Fire Protection Association (NFPA)

National Electric Code

National Electrical Manufacturer Association (NEMA)

Standard for Traffic-Actuated Solid - State Signal Controller (Publication No. ST-005A)

Standards for Enclosures for Electrical Equipment (Publication No. 250)

Standards for Wiring Devices - Dimensional Requirements (Publication No. WD6)

Underwriters' Laboratories, Inc. (UL)

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. The traffic signal controller shall conform to requirements specified herein; and where specific requirements are not listed herein the controller shall, as a minimum, conform to the requirements of the standards and publications listed in 1.02 herein.

B. The traffic signal controller electrical and electronic hardware, interconnect cable, structural materials, equipment housings, and software required for a fully operational, integrated, real-time system shall be capable of operating on a twenty-four hour per day, seven day per week basis with high system reliability (99.5%) and shall conform to the physical and functional requirements of this Section and the requirements shown on the Contract Drawings.

C. The traffic signal controller shall be composed of all items of hardware and software, interconnect cable and associated conduit, boxes and cabinets to provide an operational traffic signal installation for control of vehicular traffic signals, pedestrian traffic signals and roadway vehicle detectors shown on the Contract Drawings. In general, the controller and associated equipment shall consist of readily available and proven hardware and software elements, fully consistent with the system's intended design and operation. Special or custom-built components may be used only upon written approval from the Engineer. Use modular type construction with assemblies, sub-assemblies and modules that are available from a second source of supply, wherever possible. For items with no second source of supply, provide replacement assemblies in quantities sufficient for ten years of operation.

D. Prepare and furnish complete operation and maintenance manuals for the traffic signal controller. Provide information for products furnished under this Section and prepare in the form of an instruction manual that shall be used as the basis for instruction during the operations and maintenance courses. Content shall include, but not be limited to:

1. Each manufacturer's product data annotated to clearly identify product or part.
2. As installed color-coded interconnection wiring diagrams, both "factory" and "field".
3. Equipment wiring or circuit board schematic diagrams indicating "factory" and "field" wiring.
4. Complete nomenclature and commercial number of replacement parts, including current prices, listing of spare parts initially provided, and a second source of supply where applicable, cross-referenced as to component designation.
5. Each manufacturer's printed operating and maintenance instructions.
6. List of recommended cleaning agents and procedures.
7. List of recommended test equipment including manufacturer's name, address, and model number.

E. All assemblies, sub-assemblies, and modules shall be readily accessible for removal, testing, or replacement without removal of the other modules, assemblies or cabinet components. Locate components so that there is visibility and access for the use of hand tools and standard test probes where maintenance is required. Provide test points to facilitate trouble shooting.

1.04 ENVIRONMENTAL REQUIREMENTS

A. The traffic signal controller shall operate over an ambient temperature range from -35 degrees Fahrenheit to +120 degrees Fahrenheit (-37 degrees Celsius to +50 degrees Celsius). Operation of the controller and associated equipment shall not be degraded by rain, snow, fog, or normally encountered ambient humidity conditions.

B. All equipment shall operate without degradation or damage under ambient shock (thermal and mechanical), vibration, lightning, and electromagnetic/electrical interference existing at the construction site.

1.05 QUALITY ASSURANCE

A. After delivery of the traffic signal controller, a site inspection of said equipment may be made by the Engineer. If any equipment has been damaged or for any reason does not comply with the requirements hereof, then the Contractor shall be notified in writing, and shall repair or replace the equipment at the Contractor's own cost and expense even though the equipment had been approved for shipment. After such satisfactory replacement and/or repair and subsequent Engineer's written approval, the equipment shall be installed.

B. After installation, the traffic signal controller shall be tested in the presence of the Engineer to show compliance with the requirements of this Section. Said testing shall continue until the results are satisfactory to the Engineer. Any repairs, construction, or modifications as required to comply with these Specifications shall be performed by the Contractor without additional cost to the Authority.

1.06 DELIVERY, STORAGE, AND HANDLING

A. All materials shall be delivered to the construction site in original unopened containers or bundles with labels that clearly identify the manufacturer and product name including storage requirements and instruction.

B. All materials delivered shall be properly stored and handled to prevent deterioration or damage due to moisture, temperature change, contaminants, or other causes.

1.07 SUBMITTALS

Refer to Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 CONSTRUCTION FEATURES

A. Signal Controller Cabinets

1. House local signal controllers and associate electronics in weatherproof and corrosion resistant aluminum cabinets. The style, construction material, dimensions and field locations for the cabinets shall be as shown on the Contract Drawings. Size and design cabinets to allow for a system type operation including storage accommodations separate conduit access for two-way communications, battery backup and transformer, if, required. Pole mounted cabinets shall contain additional stiffener plates welded to the top and bottom rear walls.

2. Construct sheet aluminum cabinets of ASTM B 209, Alloy 5052-H3 or equivalent, with a minimum 0.125-inch thickness. Fabricate overlapping seams to comply with for TYPE 4 enclosure according to NEMA Standard Publication 250.

3. Construct cast aluminum cabinets fabricated from ASTM B 686, Alloy 356 aluminum. Flat cast surfaces exceeding 12 inches in both directions shall have a minimum thickness of 0.25 inches. Flat cast surfaces not exceeding 12 inches in both directions shall have a minimum thickness of 0.187 inches.

4. All nuts and bolts used in cabinet assembly shall be stainless steel. Mount internal components so that there are no external protrusions.

5. Provide cabinets with a sufficient number of adequately sized metal shelves and brackets to support the required control equipment. Arrange adjustable shelves and equipment so that it is possible to remove any piece of equipment from the cabinet without removing any other piece of equipment. Weld vertical mounting channels to the interior cabinet wall to provide adjustable shelf and panel locations.

6. Equip cabinets with a thermostatically controlled forced air fan system with screen air exhaust openings under the roof overhang. The thermostat turn-on points shall be manually adjustable from +33 degrees to +45 degrees Celsius (91.4° F to 113° F) with a differential of not more than 6 degrees Celsius between automatic turn-on and turn-off. Locate the thermostat on the inside of the top portion of the cabinet not lower than 6 inches from the top of the cabinet.

7. Equip the internal envelope of the cabinet with a fluorescent lighting fixture mounted on the inside top of the cabinet near the front edge which is activated by a door contact when the door is open and turned off when the door is closed. Provide fixture with an F15T8 cool-white lamp operated from a normal power factor UL or ETL listed ballast.

8. Equip cabinets with a duplex, three-prong, NEMA Type 5-15R grounding outlet in accordance with to NEMA Standard WD-6, with ground-fault circuit interrupt as defined by the National Electrical Code. Mount the receptacle in a readily accessible location inside the cabinet.

9. Provide full width doors fitted and gasketed to assure complete weatherproofing. Equip each door with a three point cadmium plated latching mechanism similar and equal to Eberheard #5647 series, with door handle provisions for padlocking and Corbin #1548-1 or approved equal padlock fitted for a standard Corbin #2 key.

   a. Door openings shall have rolled-up lips at the top and flanged lips on the remaining three sides.

   b. Hinge each door with a heavy gauge stainless steel continuous hinge complete with a 0.25-inch diameter stainless steel hinge pin secured with 1/4-20 stainless steel carriage bolts and lock nuts.

   c. Provide louvered air vents on the door complete with filter retainer brackets and filters. Mount a plastic weatherproof pouch suitable for storing the controller's operations manual to the inside of the main door for each cabinet.

   d. Provide each cabinet door with a stop mechanism to limit the door opening to 120 degrees, plus or minus 10 degrees with a load of 15 lb/sq ft applied uniformly over the face of the door, with a catch which shall operate when the door reaches the extreme open position and shall hold the door securely in that position until it is released. The arm of the stop, when closed shall be parallel to the closed cabinet door with a minimum of projection into the cabinet.

10. Locate a small "police door" within the larger main door of the controller cabinets to provide access to a control panel. Hinge shall be continuous 14-gauge stainless steel complete with a 0.120-inch diameter stainless steel hinge pin with a Corbin R357565 or approved equal lock with a key hole cover.

11. House the local control panel in box-like enclosure attached to the inward side of the main cabinet door. Provide access to the control panel via the cabinet "police door". No entry shall be required into the main cabinet to gain access to the control panel. Fit the panel with four, 1/2-inch diameter openings for the mounting of two-position toggle switches, and one, 3/4-inch diameter openings for a remote manual push-button control cord, consisting of a six-foot rubber insulated cable with a weatherproof, normally open momentary contact.

   a. Provide identified toggle switches to initiate remote manual control, local flash operations, signal shutdown, and other special functions as specified on the Contract Drawings. Shield the signal shutdown switch to discourage its use in other than emergency situations.

   b. Toggle switches shall have poles as required for their intended usage and shall be rated at 200 percent of circuit current for circuits of 10 amperes or less and 125 percent of circuit current for circuits over 10 amperes. Circuit breakers used as toggle switches shall be adequate for the application and shall be UL or ETL listed for switching operation.

   c. The flash switch shall, when activated, extinguish all signal indications except the yellows on the major street and the reds on the minor street, which shall flash, as shown on the Contract Drawings. The power supply to the controller unit shall not be affected and the controller shall continue to function in a normal manner. It shall be possible to disconnect and remove the controller without interfering with the flash operation. Activation of the flash switch shall extinguish the AC plus voltage used to feed power to the pedestrian signals, where applicable, and turn them off.

d. Activation of the manual control toggle switch shall discontinue the signal controller's automatic cycle operation by energizing the manual control enable input of the controller. Interval changes shall then be permitted only when the manual push-button is depressed, which, in turn, will energize the interval advance input of the controller. The only exception shall be the phase clearance intervals, which shall be timed and sequenced automatically by the signal controller. The controller cycle sequence shall be the same under manual control as under automatic operation. When energized, the controllers' manual control input shall automatically enter vehicle and pedestrian calls for all available phases.

e. The signal shutdown switch shall when activated extinguish the signal lamp indications. The power supply to the controller unit shall not be affected and the controller shall continue to function in the normal manner. Locate a separate suitably sized circuit breaker inside the main cabinet enclosure to control electrical power to the controller.

12. Provide a separate similar set of toggle switches or other acceptable means of positive setting which enables the manual calling of any available controller phase. Attach switches to the inward side of the main cabinet door. One set of switches shall be available to simulate a vehicle call for the signal phases and shall be capable of issuing momentary and continuous calls. A similar set shall be available for pedestrian actuation simulation. Provide access to the switch panel via the main cabinet door.

13. Cabinet Finish

a. Continuously weld exterior seams. Seal the main door and the "police door" with adhesive black, close-cell, neoprene gaskets.

b. Cabinets shall have a clear anodized aluminum finish.

c. Fabricate unpainted aluminum cabinets from mill finish material, cleaned using appropriate methods that will remove oil film, weld black, and mill ink marks and render the surface clean, bright, smooth, and non-sticky to touch.

14. Cabinet Mounting

a. Cabinet mounting installations shall be as shown on the Contract Drawings. Provide side-of pole mounting cabinets with an adapter, exclusive of lag bolts or banding, necessary to permit mounting to a 4-1/2 inch diameter or larger pole. The adapter shall accommodate lag bolts up to 3/8-inch diameter and steel banding up to 1 inch wide. Provide mounting points at or near the top and bottom of the cabinet.

b. Provide pedestal-mounting cabinets with the hardware necessary to permit post-top mounting on a 4-1/2 inch outside diameter pole.

c. Ground mounted cabinets shall be suitable in design to allow for their installation on concrete foundations as shown on the Contract Drawings. A template shall be obtained by the Contractor from the cabinet manufacturer for locating the cabinet foundation anchor bolts to be supplied with the cabinets.

d. Anchor bolts for base-mounted cabinets shall be 3/4 inch diameter, minimum 18 inches long, with a 90 degree bend with a 2 inch leg with hot-dipped galvanizing or zinc plate treatment. Thread the end opposite the leg for at least 3 inches with a 3/4 - 10 thread. Furnish each anchor bolt with two 3/4 - 10 plated steel nuts and one 1/4 inch plated flat washer.

15. Keys: Provide two sets of cabinet and police door keys with each cabinet. The keys shall not be shipped with the cabinets, but packed separately and mailed to the Engineer

B. Local Signal Control Equipment

1. The controller unit shall be devoted to the selection and timing of the Signal displays. Auxiliary equipment shall include, but not be limited to, detector sensor units, conflict monitors, flashers, load switches, preemption devices, circuit protection, connection wiring harnesses, "D" connector with appropriate harness and coordination interface panel assembly where required for control of equipment as shown on the Contract Drawings.

2. Controller assembly equipment shall conform to the requirements specified in NEMA Standard Publication TS-l - 1983 (latest revisions), parts 13 and 14, and ITE Standard Publication ST - 005A. Where a conflict occurs between these Specifications, and the NEMA and ITE Standards, the requirements of these Specifications shall govern.

3. Group functional operating circuits and their associated components in plug-in printed circuit board assemblies so they may be readily removed without unsoldering or handling individual connections. Each circuit board shall have a unique serial number.

a. Design the units so that each component is identified by a circuit reference symbol. Affix this symbol to the printed circuit boards, to the cover of the unit or in an assembly drawing provided with the unit.

b. All controller units should have the capability of providing different sequences from the front panel. These sequences shall be stored on the EEPROM program chip as part of the controller software program. Four distinct sequences shall be provided as follows:

Single Ring Sequential
Dual Ring Quad/Sequential
Dual Ring Quad Left Turn
Dual Ring Sequential/Quad

c. Connector pin assignment shall be as specified in NEMA Standard Publication TS-1 - 1983 (latest revisions), parts 13 and 14.

4. The basic control equipment shall be capable of expansion to the full number of signal phases and timing intervals as shown on the Contract Drawings. The original controller back panel(s) and power supply shall be adequate in design to accommodate full expansion of the controllers specified. Unless specified on the Contract Drawings, where 2 phase, 4 phase and 8 phase traffic controllers are required, the controller cabinet back panels shall be provided in the following configurations:

Controller Type	Load Bay	Conflict Monitor Type
Two-phase	4-position	6-channel
Four-phase	8-position	12-channel
Eight-phase	12-position	12-channel

Install calling detector circuitry on all phases, including full expansion capabilities. Pedestrian actuation circuitry shall be provided for all phases as shown on the Contract Drawings.

a. No replacement or additional integrated circuits shall be required for expansion of the specified phasing operation, although the addition of load switches and minor wiring revisions may be necessary. The cabinet back panel shall include the wiring, load switch sockets, flasher sockets, and field terminals for total expansibility. Detailed instructions for any required wiring revisions shall be provided by the manufacturer.

C. Traffic Signal Controllers

1. Furnish required solid-state, traffic signal controllers, fully actuated, microprocessor-based that utilize digital timing in their control logic and the power line frequency as a base. The controllers shall be of modular construction and shall provide the control functions required at each signal location as specified in the Contract Drawings. When applicable, specific manufacturer model identification numbers will be shown on the Contract Drawings for acceptable controller types.

a. The controller's power supply and control circuitry shall be housed in a metal case suitable for shelf mounting with an appropriate protection finish. Each controller unit shall have a unique serial number. All external connectors shall be mounted on the front of the controller units.

2. The controllers shall be capable of operating in an isolated or free mode, under the supervision of a satellite master controller, and under the supervision of a remote digital computer. The units shall be equipped for and capable of immediate semi-actuated, fully actuated, and volume density operations, and allow for both sequential and concurrent (non-conflicting) phase servicing. In addition, equip units to allow for concurrent pedestrian phase timing, capable of alternate phase sequencing, phase omission, and all-red rest; and include inhibit maximum phase green time termination, the selection of two alternate maximum green times per phase, interval advance, stop timing, and manual control.

a. Units capable of accepting up to four phases shall contain one timing ring. Units capable of accepting up to eight phases shall contain two timing rings, with no more than four phases per ring. Dual ring Controller units shall be programmable for both single- and dual-entry operations and shall contain the wiring and circuit necessary to produce four internally generated overlaps.

b. Provide separate input, outputs, and programming controls into per phase, per ring and per unit categories. The priority of the input function, the use of the outputs, and the method of establishing the programmable controls, such as overlaps, shall be as specified in NEMA Standard Publication TS-l 1983 (latest revisions), Part 13 and 14. Provide a programmed diagnostic package for use with the controller units.

3. When power is first applied to the controller, an actuation shall be placed on all phases. Thereafter, right-of-way shall not be subsequently given to any phase without actuation thereon; however, provide recall facilities for each phase which when activated, will cause right-of-way to revert to the associated phase despite the absence of traffic thereon. All controllers shall have the capacity to automatically restart following a power failure.

4. The actuation of a detector or push-button for a phase not having the right-of-way shall, after display of the clearance intervals for the phase losing right-of-way, shall cause right-of-way to be transferred to the phase for which the action was received if the existing phase minimum has been satisfied.

   a. Overlapping, non-conflicting phases shall be immediately initiated, in response to an actuation, and timed concurrently with the parallel phase.

   b. The phase next to be serviced shall be determined at the end of the GREEN interval of the terminating phase; except that if the decision cannot be made at the end of the GREEN interval, then it shall not be made until after the end of all vehicle change and clearance intervals.

   c. When a controller is in an ALL RED interval, right-of-way shall be given directly to the phase for which an actuation(s) has been received.

   d. Provisions shall be available for the storage of a call for vehicle service for each vehicle phase when that phase is not displaying a GREEN indication. This vehicle memory feature shall be capable of being disabled. Similar facilities shall be available for the storage of a call for pedestrian service on phases equipped with pedestrian time settings, when that phase is not displaying a WALK indication.

   e. When a phase is terminated with time remaining in the PASSAGE TIME, a call shall be left on that phase. Disabling the vehicle call memory shall defeat this feature. If a phase is terminated with no passage time remaining, no call shall be left on the phase.

5. Variable phase sequence operation shall not be required unless otherwise shown on the Contract Drawings. Where variable sequence phasing is required, provide a minimum of three alternate signal phase sequences in addition to the required single- and dual-ring phase sequences as defined in NEMA Standard Publication TS-l 1983 (latest revisions), Part 13 and 14. Such alternate sequences shall be selectable at the controller front panel or remotely by a traffic responsive satellite master controller or manually through a central control digital computer.

   a. The intent of specifying four unique signal interval sequences is to provide for leading, lagging, or dual left-turn movements and straight through (and right turn) movement configurations in various sequences.

6. As a minimum, the following functional time setting with associated timing ranges shall be provided for all controller phases unless otherwise shown on the Contract Drawings:

Function	Range*	Maximum Increment*
Minimum Green	1 to 30 seconds	1 second
Passage Time	0 to 9 seconds	0.1 second
Maximum 1	1 to 99 seconds	1 second
Maximum 2	1 to 99 seconds	1 second
Yellow Clearance	0 to 7 seconds	0.1 second
All Red Clearance	0 to 7 seconds	0.1 second
Function	Range*	Maximum Increment*
Walk	1 to 30 seconds	1 second
Ped. Clearance	1 to 30 seconds	1 second
Added Initial (per actuation)	0 to 3 seconds	0.1 second
Time to Reduce	1 to 60 seconds	1 second
Time Before Reduct.	1 to 60 seconds	1 second
Minimum Gap	0 to 7.75 seconds	0.1 second

*Zero can be satisfied by a time increment not to exceed 100 milliseconds.

7. Make selection of time intervals, phase sequencing and operational parameters, such as the placement of maximum phase recall, minimum phase recall, phase omission and pedestrian recall, from the front panel of the controller through keyboard entry. Provide suitable means to give a clear visual indication of the timing and parameter settings. Equip each controller with its own front panel so that no additional devices are required for programming the units.

8. Provide identified indicator lamps or displays on the controller unit to check for normal controller operation providing both phase and ring status information with indicator lamps or displays easily readable at a distance of four feet during normal outside lighting conditions.

9. Functional modules for two to four phase controllers of the same manufacturer shall be interchangeable. Functional modules for five to eight phase controllers of the same manufacturer shall be interchangeable. Modules providing control or operational functions in one controller shall be interchangeable with the same module in all other controllers of the same manufacturer that provide the same traffic signal control operations.

10. Provide the controller mainframe with power supply including housing, mounting, and internal interconnection for printed circuit assemblies. Equip the frame with sliding ways and sockets to receive the plug-in, printed circuit assemblies and to allow removal and replacement of all controller circuitry.

    a. Positively fasten assemblies to the frame by means of a captive nut and bolt arrangement or other suitable method with no special tools required to remove or replace individual printed circuit assemblies.

    b. Extender boards or ribbon cables shall be available for use with the controller units. Provide one extension board and/or ribbon cable for every one to five controllers furnished.

11. The controller unit shall be provided with EEPROM for retention of the software program and the specific program data of the intersection. A battery or super capacitor shall be used for retention of real time clock data only. The controller shall contain a reserved database of timing and function variables stored in programmable read only memory (PROM). It shall be possible for an operator to activate the reserve database by loading it into memory through a simple procedure involving front panel controls. These default values shall include all keyboard addressable functions and shall be approved by the Engineer.

D. Time Based Coordination

1. Each controller shall be furnished with software capable of time based coordination and shall be capable of storing and implementing predefined signal timing patterns on a time-of-day/day-of-week schedule basis. In addition, the controller shall be supplied with a "D" connector with the capability for hardwire coordination. Where applicable and in accordance with the plans and specifications, the controller shall be supplied with a six foot "D" harness and coordination interface panel.

    a. Furnish the local intersection controller with time based coordination functions as an integral part of the controller software. In a hardwire system, the time based coordination functions shall be used as a backup system in the event of a loss of communication from the master controller or a local failure.

2. The internal time based coordination software shall have a real time clock with the ability to select cycle, splits, offsets and auxiliary function outputs on a preprogrammed TOD/DOW basis. The clock shall also provide daily a time-based reference point for the start of all cycles. The reference shall be programmable.

3. The time based coordination software shall be provided with EEPROM for retention of the software program and the specific program data for the time based coordination unit. All controller units shall have these time-based coordination features stored on the controller EEPROM as part of the basic controller software package. A battery or super capacitor shall be provided for retention of the real time clock information. The battery shall be located in the unit in such a way as to be easily removed without the use of special tools. The battery or super capacitor shall be capable of retaining this information for a minimum of sixty days without ac power applied. Locate an indicator on the front panel to identify when there is a battery failure.

4. With normal primary power applied, the real time clock shall reference the 60 Hz power line frequency for its time basis. With primary power removed, the clock shall maintain time on standby and battery power, for a period of at least 30 days. During standby battery operation, clock accuracy shall be better than 0.005%.

5. Accomplish operator programmable data entry through a keyboard located on the front panel of the unit. For ease of programming, the front panel shall have in addition to a standard numeric keyboard, a series of function keys that allows immediate access to specified function screens. The controller unit shall be programmable in a menu driven format. The controller unit shall be supplied with serial connectors to provide the following features:

   a. The units shall allow for the upload and download of all local control information at the individual installation site via a portable keyboard terminal with display screen.

   b. The units shall have the capability of outputting all operational data stored in the unit's memory to a portable printer.

6. Provide the front panel with indicators for the various functions as well as status. The basic phase functions shall be in the form of a liquid crystal display. The status indicators can be in the form of either liquid crystal or light emitting diodes or a combination of the two methods. Incandescent indicators shall not be acceptable.

7. When stand-alone time based coordination units are specified they must be current production equipment and of recent manufacture of which identical models are in field operation. Untried or prototype units shall not be considered for acceptance.

8. Stand-alone time based coordinators, when specified, shall be capable of time based features as specified herein.

9. Each controller with internal time based coordination or solid state coordination unit shall have the ability to provide the following minimum features and functions:

   a. Selection of any of the four cycles, four split sets, and three offsets on a time-of-day, day-of-week, and week-of-year basis.

   b. Selection of flash operation and free operation on a time-of-day, day-of-week, week-of-year basis.

   c. Activation (on/off) of three auxiliary outputs on a time-of-day, day-of-week, and week-of-year basis.

   d. 15 different day programs with a minimum of 15 total events. All events shall be programmable to configure each day program. The day programs shall be utilized to form a minimum of 5 different week programs. All events shall be programmable to a resolution of one minute.

   e. A minimum of 20 special event day or exception days to override any day program. Exception days shall be implementable on a day-of-week/ week-of-year basis and on a date specific basis, and shall be implementable on a one-time or perennial basis.

   f. Automatic adjustment for daylight savings time.

E. Conflict Monitors

1. Equip all solid-state controllers with a compatible conflict monitor capable of detecting both the presence of conflicting signal indications and the absence of proper voltage at the RED signal field terminals, with the capacity to monitor for the presence of satisfactory operating voltage output by the controller unit and within itself.

2. Install solid-state construction units external to and electrically independent of the signal controller. All inputs and outputs shall enter the unit through a front panel. The conflict monitors shall be interchangeable and easily programmable to the full operation of the signal controllers they are to supervise.

3. In the event of conflicting green signal indications be they vehicular, pedestrian or both, the monitoring device shall cause the traffic signal to implement a flashing operation. This flashing operation shall be "locked-in" and shall be released only upon activation of a manual reset facility supplied as part of the monitor.

4. Reset to occur only if there are no signal conflicts, no red monitoring failures, and no voltage monitoring failures. Power interruption shall not reset the conflict monitor when it has been triggered by a conflict prior to the power interruption.

5. Monitor all power supplies that provide voltage to logic circuits, except detector logic circuits. If any voltage drops to a level where the equipment will not function properly, then the monitor shall cause the signal to go into flashing operation. Restoration of all proper voltage levels shall reset the voltage monitoring portion of the conflict monitor.

6. Upon detection of a signal conflict or voltage failure, the monitoring device shall automatically disable all functions of the flash and manual switches of the police panel as specified in 2.02 of these Specifications. In addition, it shall not be possible to remove the monitoring device without causing the traffic signals to go into flashing operation.

F. Solid-state Flashers

1. Equip all signal controller assemblies with a jack-mounted, two-circuit, flash control mechanism to periodically interrupt an appropriate source of alternating-current line power for the purpose of providing alternating flash traffic signals. The flashers shall have no contact points or moving parts, and shall be compatible with the specified traffic signal controllers.

2. Provide each flasher with dual output circuits. The flash rate shall be not less than 50 nor more than 60 flashes per minute. The duty cycle for each circuit shall be 50 percent on and 50 percent off, plus or minus 5 percent.

3. The rating of the output circuits shall be the minimum rating for tungsten-lamp or gas-tubing transformer load over a voltage range of 60 to 135 volts at 60 hertz.

4. Input to the flasher shall consist solely of the 60 Hertz, alternating-current power source. This input shall supply the power for both the output circuits and the flasher logic. Switching shall occur at the zero crossover point of the AC voltage. The flasher shall turn on within 5 degrees of the zero voltage point of the alternating current line sinusoid and shall turn off within 5 degrees of the zero current point of the alternating-current line sinusoid.

5. The flasher output shall have a dv/dt rating of 100 volts per microsecond at +20 degrees Celsius (68o F) when tested with the procedures defined in NEMA Standard Publication TS-1 - 1983 (latest revisions), Parts 13 and 14. The output current from the flasher through the load when the flasher is in the off state shall not exceed a maximum of 15 milliamperes RMS.

6. Wire flash transfer relays to be de-energized for the flashing operation and in close proximity to load relays and flashers. Provide flasher output and connections for transfer relays terminated on terminal blocks for programming of Flash 1 and Flash 2 outputs. The load on both circuits of the flasher should always be balanced.

G. Solid-state Load Switches

1. Utilize plug-in mounted solid-state load switches for connection between the alternating current line power and the traffic signals. The switches shall have no moving parts. Electromechanical relay contacts shall not be acceptable. The load switches shall be external to the controller unit. Stacking of load switches shall not be permitted.

2. Provide switching capabilities for three independent circuits in each load switch. The switching device shall utilize zero-point switching, with turn-on at the zero voltage point (plus or minus 5 degrees), and turn-off at the zero current point (plus or minus 5 degrees), of the power line sinusoid.

3. Isolate the switch inputs and direct current voltage input from the power line so that transients applied to the power line with a 25-watt lamp load shall not cause a destructive failure in the load switch. The load switches shall perform all of their defined functions when supplied from a 24 plus or minus 2 volt DC source.

4. Input to the load switches shall be negative true logic. A low-level input (0 to 6 volts) shall cause the output device to conduct. A high level input (greater than 16 volts) shall cause the output device not to conduct. The transition zone of the input circuitry from the conducting state to the non-conducting state (and vice versa) shall occur between 6 and 16 volts.

5. The load switches shall not draw more than 20 milliamperes from a plus 26 VDC supply unless more than one circuit is energized in which case it shall not draw more than 20 milliamperes times the number of circuits energized. Each input circuit of the load switches shall have reverse polarity protection.

6. The output current through the load switches when the load switch is in the off state shall not exceed 20 milliamperes peak at 135 VAC. Each load switch output shall have a peak standing voltage of 500 volts or greater, and shall have a dv/dt rating of at least 100 volts per microsecond when measured by the procedures defined in NEMA Standard Publication TS-1 - 1983 (latest revisions), Parts 13 and 14.

7. Each switching unit shall have a minimum rating of 10 amperes RMS for either tungsten lamp loads or power factor corrected gas tubing transformer loads over a voltage range of 95 to 135 volts at 60 hertz. Each load switch shall be capable of switching currents as low as 50 milliamperes. The load switches shall be rated for 10 amperes total continuous load divided between the circuits in any proportion. Each circuit shall be capable of continuously conducting 10 amperes.

8. Design each load switch circuit to switch a 1200-watt tungsten lamp load operating form a 120 VAC source for a minimum of 10 million operations. Each load switch circuit shall be capable of withstanding a one-second, surge current of 40 amperes RMS at 60 hertz.

9. Provide all load switches with an indicator light for each of the lamp circuit inputs. The lights shall be clearly visible for viewing the installed switching device. The load switches shall be constructed so that personnel inserting or removing the modules will not be exposed to live parts. Provide all load switches with hand pulls. No other equipment within the signal controller Cabinet shall use a socket that will accept a load switch.

H. Preemption

1. Furnish the local intersection controller with internal preemption functions as an integral part of the controller software when specified in the Contract Drawing. For preemption inputs and outputs, the traffic controller shall be supplied with a "D" connector on the front panel of the controller. In conjunction with the preemption requirements, a preemption panel with a six foot "D" harness and relay/or relays shall be provided for isolation of preemption inputs as specified in the Contract Drawings.

2. Activation of the preemption circuit shall be caused by an external input to the controller or by a switch installed in the controller cabinet for the purpose of implementing the preemption. Either action shall cause the pre-empt circuit to override the local signal controller and to implement the interval sequence and signal timing as shown on the Contract Drawings for the installations. The controller shall resume "normal" operation when the preemption circuit actuation ceases or it has "timed out" as appropriate. For actuated controllers, a call shall automatically be entered for all pedestrian and actuated vehicular intervals when the preempt actuation ceases. The preemption circuits shall be provided with independent timing controls for all intervals and sequences it is to implement.

3. Provide indications of preemption status on traffic signal controller. Install a momentary contact switch in the actuation circuit to provide a means to test the preemption circuit.

I. Radio Interference Suppressers

1. Equip each controller cabinet with suitable feed-through radio interference suppressers designed to minimize any broadcast or aircraft frequency interference that may be generated by the controller or other mechanisms in the cabinet. The interference filters shall provide a minimum attenuation of 50 decibels over the frequency range of 200 kilohertz to 75 megahertz when used in connection with a normal installation.

2. Design the suppressers for 125 percent of the total connection load and in no event less than 25 amperes on 120 volts, 60 hertz (Hz), single-wire circuits, meeting UL and ETL standards with unit hermetically sealed in a metal case filled with a suitable insulating compound.

3. Terminals shall be nickel-plated, 10-24 brass studs of sufficient external length to provide space for connecting two No. 8 AWG connectors, mounted so that the terminals cannot be turned in the case. Ungrounded terminals shall be properly insulated from each other, and shall maintain a surface leakage distance of not less than 1/4 inch between any exposed current conductor and any other metallic part, with an insulation factor of 100 to 200 megohms dependent on external circuit conditions.

J. Circuitry Protection

1. Install appropriate devices in the traffic signal controller cabinets to protect the system electronics from an overvoltage situation, such as lightning strikes and power surges over the power lines. Incoming power shall be protected using a device such as an EDCO SH1210 or approved equal. Surge arrestors shall reduce the effects of power line voltage transients and shall have the following rating:

   a. recurrent peak voltages - 184 volts;

   b. energy rating, maximum - 20 joules;

   c. power dissipation, average - 0.85 watts;

   d. peak current for pulse less than seven microseconds - 1,250 amperes.

2. Install permanently identified, separate protection devices at each traffic signal controller cabinet location on the field side of loop detectors and pedestrian button and interconnect lines. The surge suppressers shall be as follows or approved equal:

   Loop Detectors - Edco Model No. SRA16C-1
   Pedestrian Inputs - Edco Model No. SR63
   Modem Interconnect - Edco Model PC642 with Socket
   AC Interconnect - Edco Model SRA64

   The components shall be plug-in or screw-in units, which require no system downtime to replace, mounted on an isolated panel completely wired through its own terminal block.

3. The devices shall be self-restoring under all except catastrophic conditions, whereby they shall be fail-safe or permanently shot to ground.

K. Transformers

1. Where only 480 volt power is available at an installation, as shown on the Contract Drawings, furnish a 5 KVA 480/120 volt, single phase, 60-Hertz transformer to provide power to the controller cabinets.

L. Electrical Requirements

1. All wiring shall be in accordance with the requirements of the NFPA National Electrical Code and as shown on the Contract Drawing or specified herein. No wiring shall be exposed. Provide electrical connection by barrier type terminal blocks as defined in NEMA Standard Specification No. TS-l 1983 (latest revisions), Part 13 and 14. All terminal block connections shall be identified and readily accessible for maintenance.

2. Make all wire and cable terminations with insulated spade terminals as defined in NEMA Standard Specification No. TS-1 1983 (latest revisions), Part 13 and 14. Soldering of terminal connections shall not be permitted.

3. Identify the circuit number of all cables, wires and spare wires by cable tags attached to each of the cables or wires in all terminations. Secure the cable tags to the cable or wire with nylon cable ties. Neatly lace wires into cables with nylon lacing, or approved equal. Secure all cables with nylon cable clamps. Neatly route wires to their connections.

4. Where a cable or wire passes through a hole or runs along a surface at any point through or on a completed assembly, deburr such holes and/or surfaces and void of any sharp edges that may damage the cable or wire passing through or along the surface. Equip all deburred holes with a rubber or plastic grommet.

5. Electrical materials and equipment for which there are established Underwriters Laboratories (UL) and Electrical Testing Laboratories (ETL) standards shall bear the UL and ETL labels.

6. Traffic Signal Cable shall be multi-conductor cable for installation in conduit and metal raceways or as aerial cable supported by messenger strands, as shown on the Contract Drawings. The cable shall have a 600 voltage rating with a straight lay conductor configuration and shall conform to all of the requirements of IMSA Standard 19-1 for polyethylene insulated, polyvinyl-chloride jacketed signal cable. Aerial signal cable with integral messenger shall conform to IMSA Specification 19-3 for polyethylene insulated, polyvinyl-chloride jacketed signal cable with integral messenger.

   a. The cable gauge and number of conductors shall be as specified on the Contract Drawings. In order to increase flexibility when pulling, the cable shall be stranded copper wire. Outer jacket covers shall be colored black. Individual conductors shall be color-coded as per IMSA Specifications 19-1 and 19-3.

   b. Factory Test cable for each conductor insulation resistance and for continuity of conductors. The Contractor shall furnish a certificate report made on the cable to show compliance with the IMSA Specifications 19-1 and 19-3 and shall include the factory test results for conductor insulation resistance and continuity.

   c. Unless otherwise specified, cable splices will be permitted only in pullboxes, junction boxes, utility manholes and at the sign structures. All cable runs between units of equipment shall be without splices unless shown on the Contract Drawings or authorized by the Engineer.

   d. Where joints or splices are necessary they shall be made with a solderless compression connector and shall be secured mechanically and electrically with the proper tool. Thoroughly clean conductors immediately prior to splicing/ joining, with a minimum of insulation removed.

      (1) Insulate all joints or splices, except those in junction boxes, with insulation tape and thoroughly coat with an electrical grade sealant and bonding compound.

      (2) Where joints or splices are necessary in junction boxes, they shall be as specified above and insulated with resin splicing kits.

(3) Any tape supplied in any splice or terminal kit shall have been manufactured no longer than six months prior to its use, and shall be dated by the tape manufacturer to so indicate.

M. Mechanical Connections

1. Provide all bolted connections other than high strength friction bolted connections with lockwashers, locking nuts, or other suitable means to prevent the connection nuts from backing off. All shop connections shall be either bolted or welded. Field welding shall not be permitted. All connections to supporting structures shall be bolted.

2. Isolate dissimilar materials by stainless steel plates or other stainless steel fittings. Use stainless steel bolts for connection at these locations. Coating or plating shall not be considered adequate for isolation of dissimilar metals or other connections.

3. Welding of aluminum shall consist of inert gas shielded metal arc welding with consumable electrodes. Perform all welding of aluminum in the shop, no field welding of aluminum shall be permitted. All welders shall be qualified in accordance with the qualification procedures of AWS D 1.2.

N. Roadway Surveillance Equipment

1. See Division 16, Section 16680 for specification requirements for Loop Detection System or other attached specifications for alternative surveillance system as required by project plans and documents.

PART 3. EXECUTION

3.01 PREPARATION

A. Before manufacture or procurement of equipment, submit detailed specifications, catalog cuts and shop drawings outlining the construction and operation details of all equipment for prior Engineer approval as specified in 1.07 herein. No equipment shall be procured until the Engineer has given written approval.

B. Traffic related equipment to be removed and not required for relocation under this Contract, if any, shall be shown on the Contract Drawings and shall remain the property of the Authority, and be delivered to a location designated by the Engineer. Removed equipment shall not be used in anew installation unless specifically shown on the Contract Drawings.

3.02 INSTALLATION

A. Install equipment and components in accordance with the Contract Drawings and approved shop drawings.

1. For field terminals in cabinet assemblies, use double row, high-type barrier block-type rated for fifty amperes with a minimum barrier height of 5/8 inches. Mount field terminal blocks horizontally at a minimum of ten inches from the bottom of the cabinet secured to the cabinet.

2. Locate terminal blocks and strips within the cabinet to be accessible to the extent that it shall not be necessary to remove the controller from the cabinet to make an inspection or connection.

3. Cut wires to their proper length before assembly with no double back to make up slack.

4. Make electrical connections between the complete controller mechanism and the terminal panel by an "MS" type female cable socket to enable the rapid exchange of the controller without disconnecting or connecting individual wires.

5. Maintain Clearance between each terminal and the terminal and cabinet so as to prevent a leakage path or physical contact under stress. The lay of the interconnect cables between components shall be such that when the cabinet door is closed, it will not press against the cables or force the cables against various components inside the cabinet.

6. Carry the ground side of service throughout the cabinet without a bread. Run equipment grounds directly and independently to the ground buss. Provide a grounding strip having a minimum of nine connections grounded to the cabinet by connection directly to the cabinet wall. Bring remote control circuits to identified fused terminals.

B. Set work accurately in location and alignment. Provide anchorage devices and fasteners where necessary for installation and connection to other construction.

C. Prior to energization, test all field-installed wiring for continuity and hook-up. Tag-identify all terminations.

3.03 FIELD TESTS

A. Perform initial installation test in accordance with 1.05 B herein.

B. After satisfactory completion of the installation test, a 30-day operations test period shall commence. In the event of a failure of any major component, the trial period countdown shall come to a halt. Said malfunctions shall include, but not be limited to, equipment failures or the failure of the traffic signal controllers to comply with the requirements of this Section. After such malfunctions are corrected, at no expense to the Authority, restart the 30-day test.

C. Operations Training Course: Shall be conducted at the start of the 30-day operational trial period. The training shall include, but not be limited to, hands-on operation of all signal control functions and hardware elements of the system. The training course shall be conducted for up to five students. A minimum of three hours of instruction shall be given for the operations training course, encompassing an actual start up and shut down of the operations controlled by the signals.

D. Maintenance Training Course: Shall be conducted after the traffic signal control system has passed the 30-day operations trial period. The course shall be conducted for up to five students. A minimum of seven hours of instruction shall be given for the maintenance training course. As a minimum, the maintenance training shall include the following:

1. An overview of equipment and functions;

2. Theory of operation of all hardware and software components;

3. A complete description and demonstration of all diagnostic routines;

4. Instructions on minor servicing procedures in the field or by means of appropriate display models;

5. Instruction in equipment "trouble shooting" and problem identification procedures; and

6. Complete description of recommended preventive maintenance requirements.

END OF SECTION

SECTION 16574

TRAFFIC SIGNAL CONTROLLER

APPENDIX "A"

SUBMITTALS

A. Submit the following to the Engineer within forty-five (45) calendar days after receipt of the Authority's acceptance of the Contractor's Proposal:

1. Names and locations of at least three users who have had a minimum of one year experience with the software and equipment to be furnished for Work of this Section. The aforementioned may be contacted by the Engineer to verify equipment performance, replacement or spare parts availability, delivery and such other items as deemed necessary by the Engineer.

2. For approval, a list of manufacturers of equipment and software to be furnished as Work of this Section.

3. For approval, two copies each of proposed instruction and maintenance manuals, prepared in accordance with 1.03D herein. After approval:

   a. Submit twelve copies of each: five for use during the training courses and seven additional copies for future distribution by the Authority, and;

   b. Submit one reproducible master set of instruction and maintenance manual documents, as follows:

      (1) Documentation which exceeds 8-1/2″ x 11″ in the form of reproducible mylar drawings 22″ x 36″ in size. No documentation shall be smaller than 8-1/2″ x 11″. All mylars shall be reverse-reading and double-matte, neither folded or creased.

      (2) Bind all 8-1/2″ x 11″ documentation, except standard spiral bound materials in logical groupings in 3-ring loose leaf binders. Each bound grouping of documentation shall be permanently and appropriately labeled. Document pages shall be numbered sequentially.

B. Submit to the Engineer prior to construction site delivery, sample cable and cable manufacturer's factory test certification in accordance with 2.01 L.6.b herein.

C. Submit to the Engineer for approval not less than thirty (30) days prior to the intended start date for the training courses, a complete description of the proposed curriculum for each course.

D. Submit the following to the Engineer in accordance with Division 1 – GENERAL PROVISIONS entitled "Shop Drawings, Catalog Cuts and Samples":

1. Catalog Cuts and Data Sheets: Detailed drawing(s) for all equipment and outdoor environmental housings of the traffic signal controller, including recommended mounting instructions. As part of this submittal the Contractor shall furnish a block diagram illustrating the interrelationship between the various components, including a functional drawing defining the operational configuration of the controller and all other associated devices, the environmental tolerance provisions of the proposed equipment, and the overall dimensions and internal arrangement of the control cabinets.

2. Shop Drawings: A complete set of reproducible shop drawings for the traffic signal controller and associated equipment on mylar, from which clear prints can be made; and 5 sets of prints thereof. Included within this documentation shall be a bill of materials with the manufacturer's name and part numbers, housing wiring diagrams for each control cabinet and electrical schematic wiring diagrams for each different type of equipment, and connection diagrams to the printed circuit board level for the entire control system defining terminal identification number assignment.

E. Submit to the Engineer:

3. Written report test results of the 30-day operations test. Identify equipment, software and components adjusted, repaired or replaced during the 30-day test.

4. Keys in accordance with 2.01 A.15.

END OF APPENDIX "A"

DIVISION 16

SECTION 16620

DIESEL-GENERATOR SET (WITH AUXILIARIES)

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for a complete diesel-generator set with auxiliaries.

1.02 REFERENCES

The following is a listing of the publications referenced in this section:

	American National Standards Institute (ANSI)
ANSI B 16.5	Pipe Flanges and Flanged Fittings
ANSI B 31.1	Power Piping
ANSI B 40.2	Gauges and Indicators, Pressure and Vacuum -Indicating Digital Type
ANSI C 12.11	Instrument Transformers for Metering Purposes, 15 kV and Less
ANSI C 37.2	Electrical Power System Device Function Numbers
ANSI C 37.90	Relays and Relay Systems Associated with Electric Power Apparatus
ANSI C 39.1	Electrical Analog Indicating Instruments
ANSI C 97.1	Low-Voltage Cartridge Fuses 600 Volts or Less
	American Society of Mechanical Engineers (ASME)
	Boiler and Pressure Vessel Code
	American Society for Testing and Materials (ASTM)
ASTM A 53	Pipe, Steel, Black and Hot-Dipped Zinc-Coated Welded and Seamless
ASTM A 106	Seamless Carbon Steel Pipe for High- Temperature Service
ASTM A 120	Pipe, Steel, Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless, for Ordinary Uses
ASTM A 135	Electric-Resistance-Welded Steel Pipe
ASTM A 181	Forgings, Carbon Steel, for General-Purpose Piping
ASTM B 221	Aluminum and Alumina-Alloy Extruded Bars, Rods, Wire, Shapes, and Tubes
ASTM A 234	Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
ASTM A 527	Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock Forming Quality

	Diesel Engine Manufacturers Association (DEMA)
DEMA	Standard Practices for Low and Medium Speed Stationary Diesel and Gas Engines
	Federal Specifications (FS)
FS W-B-134	Battery, Storage, (Lead-Acid, Industrial Floating Service)
FS VV-F-800	Fuel Oil, Diesel
FS WW-P-521	Pipe Fittings, and Flange Fittings, and Flanges: Steel and Malleable Iron (Threaded and Butt-Welding) Class 150
FS WW-V-51	Valve, Angle, Check, and Globe, Bronze (125, 150 and 200 Pound) Threaded End, Flange Ends, Solder Ends and Brazed End, for Land Use
FS WW-V-54	Valve, Gate, Bronze (125, 150 and 200 Pound, Threaded Ends, Flange Ends, Solder Ends, and Brazed Ends, for Land Use)
FS ZZ-H-428	Hose; Non-Metallic and Hose; Preformed: (For the Coolant Systems of Automotive and Other Liquid-Cooled Engines)
	Institute of Electrical and Electronics Engineers (IEEE)
IEEE 43	Testing Insulation Resistance of Rotating Machinery
IEEE 115	Test Procedures for Synchronous Machines
	Military Specifications (MIL)
MIL L-2104	Lubricating Oil, Internal Combustion Engine, Tactical Service
MIL T-52777	Tanks, Storage, Underground, Glass Fiber Reinforced Plastic
	Military Standards (MIL STD)
MIL STD 461	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL STD 705	Generator Sets, Engine Driven, Methods of Tests and Instructions. Generator Sets, Electrical, Measurements and Instrumentations
	National Electrical Manufacturers Association (NEMA)
NEMA AB 1	Molded Case Circuit Breakers
NEMA EI 2	Instrument Transformers
NEMA ICS 6	Enclosures for Industrial Controls and Systems
NEMA MG 1	Motors and Generators
NEMA MG 2	Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators
NEMA PB 2	Deadfront Distribution Switchboards
NEMA PV 5	Constant Potential Type Electric Utility (Semiconductor Static Converter) Battery Chargers
NEMA SG 3	Low-Voltage Power Circuit Breakers
NEMA SG 4	Alternating-Current High-Voltage Circuit Breakers
NEMA SG 5	Power Switchgear Assemblies

National Fire Protection Association (NFPA)

NFPA 30	Flammable and Combustible Liquids Code
NFPA 37	Stationary Combustion Engines and Gas Turbines
NFPA 70	National Electrical Code (NEC)
NFPA 99	Health Care Facilities
NFPA 110	Emergency Power Supplies

National Building Code (BOCA)

1.03 QUALITY ASSURANCE

A. The equipment supplied shall be new and standard product of the diesel-generator manufacturer, who shall be the single source responsibility for warranty, parts, and service.

B. Diesel-generator sets, of the size and type required, shall have been satisfactorily used for purposes similar to those intended herein for not less than five years.

C. Each major component of equipment shall have the manufacturer's name, address, type or style, model or serial number and catalog number on a plate secured to the equipment.

D. Exposed moving parts, parts that produce high operating temperatures, parts which may be electrically energized, and parts that are of such a nature or are so located as to be a hazard to operating personnel, shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. The safety devices shall be installed in such manner that proper operation of the equipment is not impaired.

E. Welding procedures and welders shall be qualified in accordance with Section IX, ASME Boiler and Pressure Vessel Code. Welding procedures qualified by others will be accepted as permitted by ANSI B 31.1.

F. Where materials or equipment are specified to comply with requirements of the referenced publications, evidence of such compliance shall be submitted. The label or listing of the specified agency will be acceptable evidence. In lieu of the label or listing, a written certificate may be submitted from an approved, nationally recognized testing organization equipped to perform such services stating that the items have been tested and conform to the requirements of this Section.

G. The diesel-generator set, all the components, and the means of their attachments and supports shall be designed and constructed to resist the effects of earthquake motion determined in accordance with BOCA National Building Code for seismic hazard exposure group III. The effective peak velocity-related acceleration (AV) which shall be utilized to determine seismic forces shall be 12. For the purpose of classification, this equipment and its enclosures are considered to be emergency or standby electrical equipment, as defined in the Table 1612.6.4(1) of BOCA National Building Code. Submit certification of the above requirements to the Engineer.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver parts, components, and accessories in manufacturer's original, unopened, protective packaging. All equipment shall be properly packed and mounted on pallets or skids to facilitate the handling.

B. Store parts, components and accessories, including engine-generator set, in a clean, dry space and protect them from weather.

C. Handle in a manner to prevent damage to finished surfaces.

D. Touch up any damage to finishes to match adjacent surfaces.

E. Where possible, maintain protective coverings until installation is complete and remove such coverings as part of final cleanup.

F. Replace engine oil, and fuel-oil filters after completion of all load testing.

G. Top-off fuel storage tank after completion of all testing.

1.05 SPARE PARTS

A. Submit a complete list of spare parts for approval by the Engineer.

B. Furnish spare parts in containers or packaging to protect parts from damage. Clearly mark each package to identify the parts contained therein.

C. Furnish two spare engine oil filters and two spare fuel-oil filters and the associated gaskets.

D. Furnish two spare air filters and associated gaskets, per intake.

E. Furnish ten spare lamps and fuses, for each type provided as part of the equipment.

F. Furnish two engine, fan, alternator or pump belts, for each type provided as part of the equipment.

G. The Contractor, or his authorized representative, shall confirm that there are a minimum of three (3) established agencies within the Port Authority district, which stock a full inventory of spare parts for the system supplied. In the event that there are not three (3) sources of supply, the Contractor warrants that all system components will be made available by the Contractor for a period of ten (10) years from the date of acceptance of the system.

1.06 OPERATION AND MAINTENANCE MANUALS

Furnish ten sets of suitable bound Operation and Maintenance Manuals outlining step-by-step procedures required for system start-up and operation. The manuals shall include the manufacturer's name, model number, service manual, parts list, and brief description of each equipment and component and its basic operating features. Prior to issuance of the certificate of final completion, prepare and submit to the Engineer for approval Operation and Maintenance Manuals in accordance with the requirements of the section 16001, entitled Operation and Maintenance Manuals.

A. Maintenance manuals listing routine maintenance procedures, possible breakdowns, and repairs shall be furnished. The manuals shall include schematic and wiring diagrams for the system as installed.

B. Framed instructions under glass or in laminated plastic, including wiring and control diagrams schematically showing the key mechanical and electrical control elements and complete layout of the entire system, shall be posted where directed by the Engineer. Condensed operating instructions explaining control sequence and preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, framed as specified above for the wiring and control diagrams, and posted beside the diagrams. Proposed diagrams, instructions, and other sheets shall be submitted for approval by the Engineer, prior to posting. The framed instructions shall be posted before acceptance testing of the systems.

1.07 TRAINING

Prior to the on-site inspection and test of the system, prepare and submit to the Engineer for approval a curricula, in accordance with the requirements of this Section. Topics shall cover all of the items contained in the Operation and Maintenance Manuals, including control operation, schematics, wiring diagrams, meters, indicators, warning lights, shutdown system, and routine. Conduct a training course for Authority operating staff. The training period, of a total of 8 hours of normal working time shall start after the system is functionally completed but prior to final acceptance tests.

1.08 SUBMITTALS

See Appendix "A" for Submittal Requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide diesel-generator set(s) of manufacturers as shown on the Contract Drawings.

2.02 RATINGS

Subject to compliance with requirements of this Section the diesel-generator set ratings shall be as shown on the Contract Drawings and in conformance to DEMA standard practices.

2.03 CONSTRUCTION FEATURES

Provide labor, materials, equipment and service for a complete installation of diesel engine-driven generator set(s), equipped with all operating accessories such as: engine/generator control panel, generator output protective circuit breaker, governor, exciter regulator, starting batteries, battery charger, exhaust piping and silencer, vibration isolators, fuel day tank and transfer pump, fuel-oil piping and storage tank, automatic transfer switch, remote annunciator, resistive load bank, weatherproof enclosure.

The diesel engine-driven generator set shall consist of a diesel engine coupled to a single bearing generator, all mounted on a common base of welded fabricated structural steel. Operation shall be fully automatic upon normal source power failure.

A. Engine

1. The engine shall be of the general purpose, stationary, direct injection, full compression-ignition diesel type, liquid cooled, 4-cycle, in-line or V-type with solid cast iron or steel block. The engine shall have not less than 4 nor more than 20 cylinders. The engine shall be equipped with replaceable full length, wet type, heat treated cylinder liners. The engine may be either naturally aspirated, scavenged, or supercharged. The engine shall operate without excessive smoke, overheating, or mechanical damage when driving the generator under the specified conditions.

2. The engine shall develop the required horsepower when operating on DF-2 diesel fuel conforming to FS VV-F-800 and with lubricating oil conforming to MIL L-2104 of the type and grade as recommended by the engine manufacturer. The engine shall be started and stopped, and run on DF-2. The engine shall have a standard published net available continuous horsepower rating which, when corrected for specified operating conditions, generator efficiency and after subtracting power for engine and electric driven accessories, auxiliaries and other losses shall be not less than that required to drive the generator continuously at 100 percent of rated full load and 110 percent of rated load for 2 hours out of any 24 consecutive hours of operation. The 100 percent full load rating of the engine shall be the horsepower that the engine will deliver continuously at its coupling or flywheel when in good operating order and under the specified conditions.

B. Engine auxiliaries

1. Fuel pump shall be of positive-displacement engine-driven type, and shall supply an adequate quantity of fuel under all conditions of operation. A relief valve shall prevent the buildup of excessive pressure in the discharge line.

2. The system shall be pressurized by one or more engine-driven lube-oil pumps, and shall conform to NFPA 30 and NFPA 37. Pressure shall be regulated by an appropriate relief valve or other approved means. Pipe connections shall be provided for draining the engine. Each engine shall have a dip stick oil-level indicator. The engine shall be wet sump type.

   a. The proper amount of clean lube oil conforming to MIL L-2104 shall be furnished for each engine. Oil entering pressurized parts of the engine shall pass through a full-flow filtering system consisting of a strainer, lube-oil pumps and a filter, connected in series and in the order listed. The lube oil system shall permit addition of lubricating oil with the engine operating. The strainers and filters shall be in accordance with the engine manufacturer's recommendations.

   b. Strainer and filter inlet and outlet connections shall be plainly marked. Strainer and filter elements shall be designed to be changed without disconnecting the piping or disturbing other engine equipment. Lubricants and greases shall be provided as required to service the generator sets for initial start up, testing and operation.

3. Jacket-water cooling system shall be of the closed loop type, with radiator factory mounted on engine-generator set skid unless otherwise indicated on the Contract Drawings, and shall be arranged to prevent rust and minimize the formation of scale deposits within the engines, and to circulate jacket-water throughout the engine of the temperature and flow rate recommended by the engine manufacturer.

   a. A self contained fail-open thermostatic control valve shall modulate coolant flow automatically to maintain optimum constant coolant temperature as recommended by the diesel-engine manufacturer. Cooling system coolant shall be a combination of water and ethylene-glycol. Cooling system operation shall be fully automatic while the engine is running. Water temperature differential across engine block shall be not more than 15 degrees F. at full load. Failure of the cooling system resulting in over temperature shall stop the engine.

   b. Jacket-water centrifugal circulating pump shall be engine driven. Pump capacity shall be adequate for the application.

   c. Radiator shall be rated for circulated coolant, and shall be fin-and-tube or stacked corrugated-sheet type and constructed of non-ferrous metals. Size of radiator shall be adequate to contain expansion of total system coolant from cold start to 110 percent load condition, when operating with a cooling air temperature of 100 degrees F. at 500 feet above sea level. Supports shall be as necessary for the mounting indicated. Radiator shall be pressure type incorporating a pressure valve, vacuum valve and a radiator cap. Radiator cap shall be designed for pressure relief prior to removal. Cooling system shall be capable of withstanding a minimum pressure of 7 psig. A strong grille or screen guard shall protect the radiator. Hose shall conform to FS ZZ-H-428, grade B. Tapped holes not less than 3/8 inch NPT shall be located at the lowest points in the cooling system, and shall be plugged or equipped with drain cocks. The engine cylinder head or outlet header shall incorporate a high-coolant-temperature safety device. Radiator fan shall be propeller type with four blades or more. Tip speed shall not exceed 17,000 feet per minute, driven by the engine through a suitable V belt drive or reduction gears. The fan and fan drive system shall be adequately shrouded and guarded to protect personnel from injury. Thermostatic control valves in the jacket coolant, shall maintain temperatures within ranges specified.

   d. Ductwork for the diesel engine air cooling system shall be galvanized iron or steel sheets or aluminum sheets. Gauges, reinforcements, and fabrication, including hangers and supports shall be in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible. The ducts shall be straight and smooth on the inside, with joints neatly finished. The ducts shall be anchored securely to the building and shall be installed so as to be completely free from vibration under all conditions of operation. Ducts shall be properly braced and reinforced with angles or other structural members. Internal ends of slip joints shall be installed in the direction of flow. A flexible connection shall connect the diesel engine radiator and the ductwork. Material shall be wire-reinforced glass fabric of suitable weave and weight. The connection shall be rendered practically air tight in a manner approved by the Engineer.

   e. Provide full coolant charge, suitable for operation down to -10 degrees F entering cooling air temperature.

4. Combustion air intake equipment shall include an air filter, in accordance with the engine manufacturer's recommendation. Each type air filter shall have ample capacity and be suitable for connection to the engine air-intake opening element. Expansion elements in air-intake lines shall be rubber.

5. Exhaust piping shall be supported so as to minimize vibration. Where a V-type engine is provided, a V-type connector, with all necessary flexible sections and hardware, shall connect the engine exhaust outlets to a single exhaust pipe sized to reduce gas velocity to less than 5,000 feet per minute. All pipe and fittings for the exhaust system shall be ASTM A53 schedule 40 steel with sufficient flanged fittings so that the system may be entirely dismantled in sections. Fittings shall be flanged or welded type. Bends shall be long-radius type showing no kinks or wrinkles. Horizontal sections of exhaust lines shall be sloped downward away from the engine to a condensate trap and drain valve.

   a. Flexible exhaust section shall be convoluted seamless tube without joints or packing, designed especially for diesel-engine operation, and capable of absorbing vibration of the engine and of compensating for thermal expansion and contraction. Flanges shall be 125 pound type, plain-faced, drilled, and of dimensions to match the flanged exhaust outlet of the diesel engine. Expansion joints shall be bellows type with flanged connections. Expansion elements shall be stainless steel suitable for exhaust gas temperature as recommended by the diesel-engine manufacturer, but not less than 1,000 degrees F. Expansion joints shall be suitable for relieving stress caused by thermal expansion and contraction and shall be suitable for vibration-isolation service.

   b. Exhaust silencer of the chamber type shall be welded steel, sized as recommended by diesel-engine manufacturer, and designed for inside vertical mounting, as shown on the Contract Drawings. Eyebolts, lugs, flanges, or other items shall be provided as necessary for support in the location and position indicated. Pressure drop through the silencer shall not exceed the recommendations of the engine manufacturer. Silencer shall be rated for critical application, with measured sound level according to the DEMA, of 85 dBA or less.

   c. Provide a balanced, stainless steel flapper type rain cap on a vertical exhaust.

   d. Finish silencer and supports with a high-temperature aluminum paint.

   e. Starting System

6. Provide an electric starting system, arranged for both manual starting and fully automatic starting actuated by contacts in the automatic transfer switch.

   a. The engine shall be started by means of a 24-volt automatic starting system energized by storage batteries. The automatic starting system shall be mounted in the engine/generator control panel.

b. The engine shall be equipped with a heavy duty positive engagement electric starter motors of sufficient capacity to crank the engine/power generator rotor combination at sufficient speed to allow full diesel starting when conditioned to, and in ambient temperature of 32 degrees F. (indoor) or -10 degrees F.(outdoor), in conjunction with the specified fuel and lubricants. Starting system, including batteries, shall be adequate to crank the engine for a minimum of four cranking periods without overheating. The cranking cycle shall consist of four cranks of 10 seconds each, with three 10 second rest periods between the cranks. If the engine fails to start after the cranking cycle has been completed, the control will lock out, and actuate the overcrank signal light on the control panel and sound an audible alarm. The cranking motor shall be automatically disengaged when the engine accelerates to 600 RPM by means of a suitable speed sensing circuit.

c. Storage battery shall be nickel cadmium cranking batteries complete with battery rack, intercell connectors, and battery-to-engine cables, all in conformance with manufacturer s requirements. The battery capacity shall be compatible with the cranking duty described in preceding paragraph, in an ambient temperature of -10 degrees F. Batteries shall conform to FS W-B-134. Battery capacity shall provide a minimum of 60 seconds of total cold cranking time.

d. Battery charger shall be adequate to recharge the fully depleted battery in not more than 8 hours and shall automatically control the rate of charge, providing a high-charge rate to a depleted battery and reducing to a trickle-charge rate when the battery is fully charged. Charging rate shall be adjustable. Battery charger shall comply with NEMA PV 5. It shall contain a DC ammeter and voltmeter, a fused input and output and completely isolate the AC input from DC output. Battery charger shall be housed in a NEMA 1 enclosure suitable for wall mounting. It shall be provided with battery charger malfunction and low voltage DC alarm relay.

7. The engine shall be provided with thermostatically controlled tank type coolant heaters to maintain engine block coolant temperatures in the range of 100 - 120 degrees F for reliable automatic starting at the ambient temperature range stated herein. The heaters shall automatically disconnect when the engine starts and shall be provided with hand shutoff valves to facilitate service without draining cooling system.

C. Generator

The generator shall be a three phase synchronous type, brushless design, single bearing, with a 4 pole rotor coupled directly to the engine flywheel through a flexible drive disc to maintain permanent alignment. The generator housing shall be bolted directly to the flywheel housing of the engine and shall be capable of withstanding the combined stress of the supported engine weight and anti-torque reactions without distress. Enclosure shall be close coupled, drip proof construction. The generator shall be capable of 10 percent overload for 2 hours in any 24-hour period of operation without exceeding temperature rise indicated in NEMA MG 1. Design shall be such as to protect against mechanical, electrical, and thermal damage due to vibration, 25 percent over-speed, or voltage, and 10 percent overload. The generator shall meet all requirements of NEMA MG-1, Part 22, in design, performance, and factory test procedures.

1. Permanent Magnetic Excitation System: The generator shall be equipped with a permanent magnet generator (PMG) excitation system. The output of the PMG shall be used to supply power to the voltage regulator and to effectively isolate the regulator power circuits from the distortion that occurs when the generator supplies large non-linear loads. Both the PMG and the rotating brushless exciter shall be mounted outboard of the bearing for ease of service. Under short circuit conditions, the system shall be capable of sustaining 300 percent of rated current for 10 seconds. The rotating rectifier shall use a three-phase full wave rectifier assembly with hermetically sealed silicon diodes protected against abnormal transient conditions by a multi-plate selenium surge protector.

2. Insulation System: The insulation system of both the rotor and the stator shall be NEMA class F or H materials and shall be synthetic, non-hydroscopic, and fungus resistant. The stator winding shall be given multiple dips and bakes of varnish, plus a final coating of epoxy for extra moisture and abrasion resistance.

3. Main Rotor: The rotor shall be dynamically balanced for operating speeds up to 125 percent of rated speed and shall have full amortisseur windings. The main rotor core shall be shrunk-fit and keyed to the shaft.

4. Stator Windings: The stator winding shall be of 2/3-pitch design to minimize the third harmonic and be random wound.

5. Bearing: The rotor bearing shall be pre-lubricated, shielded, ball type with provisions for adding grease.

6. Ventilation and Cooling: The generator shall be self-ventilated and have a one-piece cast aluminum alloy, low noise cooling fan.

7. Conduit Load Connection Box: The generator shall be furnished with a ventilated end mounted load connection box that will allow entry of the load cable conduits through the top, bottom, or either side.

8. Voltage Regulator: The voltage regulator shall be completely solid state with electronic components encapsulated for protection against vibration and atmospheric deterioration. The regulator shall include three phase RMS sensing, true volts per hertz operation with adjustable cut in and provisions for parallel operation. It shall be unit mounted within the generator set terminal box with suitable space for remote connections and control wire terminations.

   A voltage adjusting rheostat shall be provided on the control panel to permit a +/- 10 percent adjustment in generator voltage.

9. Performance: The performance of the generator when driven by the diesel engine shall be as follows:

   a. The unit shall be capable of reaching full rated voltage and frequency within 10 seconds of receiving a start signal and accepting full rated load in one step under the ambient temperature conditions specified herein.

   b. Voltage regulation shall be +/- 0.5 percent maximum deviation from rated generator terminal voltage between no load and full load 0.8 power factor under steady state conditions.

   c. Voltage transient deviation shall be 20 percent maximum from rated generator terminal voltage on one step application or removal of full load when generator is driven by diesel engine.

   d. Frequency regulation shall be +/- 0.25 percent maximum deviation from rated generator terminal frequency at any constant load from no load to rated load.

   e. Frequency transient shall be 12 percent maximum deviation from rated generator terminal frequency on one step application or removal of full load at either 0.8 or 1.0 power factor when generator is driven by diesel engine.

   f. Voltage and frequency transient recovery time shall be 6 seconds maximum for one step application or removal of full load at either 0.8 or 1.0 power factor from the time the generator terminal voltage and frequency leaves the respective regulation limits, to the time the generator terminal voltage and frequency recovers within respective regulation limits when generator is driven by diesel engine.

   g. Electromagnetic interference suppression shall not exceed that specified in MIL-STD-461B, part 9.

   h. The generator waveform harmonic distortion shall not exceed 5 percent total RMS measured line to line at full rated load. The TIF factor shall not exceed 50.

D. Engine/Generator Control Panel

The engine generator shall be provided with a control panel, in a NEMA 1 type 14 gauge steel enclosure, or as shown on the Contract Drawings. It shall be mounted on the generator set, with suitable vibration isolators, and incorporate solid state microprocessor based control circuitry, sealed dust tight, watertight modular components with metal housing and digital instrumentation. Instruments shall be back connected and flush mounted. The panel shall include the following equipment:

1. Generator AC Output Metering Devices

   a. AC Voltmeter, 2 percent accuracy

   b. AC Ammeter, 2 percent accuracy

   c. Combination voltmeter/ammeter selector switch

   d. AC Frequency meter

2. Fault shutdown circuits with individual visual and audible indications for:

   a. High jacket coolant temperature

   b. Low oil pressure

c. Engine overspeed

d. Engine overcrank

e. Low coolant level

3. Engine Control and Monitoring Devices

a. Automatic/manual start-stop control

b. Emergency stop pushbutton

c. Manual-of-auto selector switch

4. Alarm circuits with individual visual and audible indications for:

a. Pre-high jacket coolant temperature

b. Pre-low oil pressure

c. Low coolant temperature

d. Control switch not in Auto

e. Battery charger malfunction

f. Low battery voltage

g. Low fuel level

5. Lamp test switch

6. Alarm horn and silence switch

7. Voltage adjust rheostat

8. Governor speed adjust rheostat

9. Running time meter

10. Remote connection provision for any system fault

11. All necessary control wiring, fuses, fuse blocks, terminal blocks, nameplates, auxiliary contacts, etc.

The mutable alarm horn shall annunciate any alarm condition. At the same time a blinking visual signal shall indicate the cause of alarm. If an emergency device stops the engine, the visual signal shall stop blinking, but remain on and indicate the cause of failure.

Installation shall comply with ANSI B40.2, ANSI C12.11, ANSI C 37.2, ANSI 37.90, ANSI C 39.1, and ANSI C97.1.

E. Generator Circuit Breaker

An enclosed generator mounted main line circuit breaker shall be provided within the generator set terminal box to protect the unit from overcurrent and short circuit conditions. The breaker shall be installed within an enclosure as specified on the Contract Drawings, of suitable size which shall allow for proper bending radius of all conductors as per National Electrical Code. Lugs and supports shall be included. Installation shall comply with NEMA SG3 and NEMA SG4.

Circuit breaker shall be supplied with 24VDC shunt trip device and ground fault trip.

F. Engine Governor System

An engine governor system shall be provided to maintain engine speed within the limits specified herein from no load to rated load. The governor shall be of electronic type. Steady state frequency regulation shall be +/-.25 percent. Governor speed droop shall be adjustable from 0 to 10 percent from no load to full rated load. A remote speed adjusting potentiometer shall be mounted in the control panel.

G. Fuel Oil System

Furnish a complete fuel oil system, as specified in this Section, as shown on the Contract Drawings and in accordance with NFPA 30 and NFPA 37.

1. Provide a main fuel storage tank, with locking fill cap and all necessary tank fittings, as shown on the Contract Drawings and in accordance with MIL T-52777.

2. Provide a day tank, with capacity as shown on the Contract Drawings, installed within the generator enclosure. The day tank containment shall be integral rupture basin with capacity of 150 percent of nominal capacity of day tank. The day tank shall be mounted so as to provide a flooded suction to the engine if so recommended by the manufacturer. Day tank shall be provided with transfer pump and connections for the fuel supply, fuel overflow return, fill, vent and drain pipes. Provide a manual (hand) pump for emergency operation. A double pole float switch on tank shall control a solenoid valve and start the transfer pump on low level and stop it at high level. The solenoid valve shall be installed in the fill line for operation with 120 volt 60 Hz single phase AC. Positive means shall be provided to prevent fuel oil leakage from day tank through injectors into the engine cylinders, when the engine is not running.

3. Provide a high-lift, electric motor-driven fuel-transfer pump to transfer fuel from the fuel storage tank to the day tank. Motor voltage, ratings and characteristics shall be as shown on the Contract Drawings.

4. Provide one duplex, full-flow strainer and one duplex, full-flow filter for each engine. Strainer shall be located on the suction side. When the pump and the high pressure injector equipment are contained in a common housing, the fuel filter may be located between strainer and engine fuel pump. Strainer shall be metal-edge or screen type with a maximum opening of 0.007 inch (80 mesh). Filter case shall be compatible with the filter elements. Strainer and filter shall have inlet and outlet connections plainly marked and shall be mounted in accessible locations. Strainer and filter elements shall be designed to be changed without disconnecting the piping or disturbing other engine components and shall be so valved and arranged as to permit changing without shutting down the engine. An indicating differential pressure gauge shall be provided across the inlet and outlet sides of the filters. A pressure gauge with red line limit shall be provided at the inlet side.

H. Provide complete piping systems for fuel oil and vent from storage tank, to day tank and generator set, and for engine exhaust. Only black iron or wrought steel pipe shall be used for fuel oil and exhaust piping. Galvanized pipe shall not be used.

1. Connections shall ensure unrestricted circulation and permit complete drainage of the system. Changes in supply-main sizes shall be made through eccentric reducing fittings. Pipe shall be cut to measurements established at the project site and shall be worked into place without springing or forcing, clearing all windows, doors, and other openings. Pipe burrs shall be removed by reaming. Pipe supports shall permit free expansion and contraction without damage to joints or hangers. Changes in direction shall be made with fittings. Bending of pipe will not be permitted. Bent pipe showing malformation will not be accepted. Pipes extending through the roof shall be properly flashed. Piping connections to equipment shall be as required for a complete and operating system. Open ends of pipelines or equipment shall be properly capped or plugged during installation to keep dirt and other foreign material out of the system.

2. Metering of pipe to form elbows, notching straight runs to form tees or similar construction will not be permitted. Flanged joints shall be faced true, gasketed, and made up square and tight. Gaskets shall be factory cut in one piece, 1/16-inch thick.

3. Pipe, valves, fittings, and pumps to be installed in the fuel-oil system shall be shipped uncoated with the open ends capped or plugged. Before assembly, pipe interior shall be swabbed to remove any debris. Upon completion of the installation of the fuel oil system, the supply and return pipelines shall be flushed prior to connection to the engine.

4. Pipe, fittings, valves and miscellaneous materials necessary for a complete system shall conform to the applicable requirements of FS WW-P-521, FS WW-V-51, FS WW-F-54, ASTM A 53, ASTM A 106, ASTM A 120, ASTM A 135, ASTM A 181 and ASTM A 234 and ASTM B 16.5.

I. Load Bank

1. The load bank rating shall be as specified on the Contract Drawings. The load bank shall be a completely self-contained unit for mounting in the radiator air stream, unless otherwise shown on the Contract Drawings. The load bank shall include all resistive load elements, load control devices, and protective devices.

2. The resistive elements shall be made of corrosion resistant wire. Resistive elements shall be continuously supported by a ceramic insulated steel rod, securely held at each end. The resistive load steps shall be additive and arranged as shown on the Contract Drawings. The total load shall terminate to a single, 3-phase distribution block.

3. The load bank shall have an over temperature sensor mounted in the top of the core. Load step fusing shall be provided.

4. The controls shall be housed in a Control Panel, including switches for each load step, a master control switch, and power ON-OFF switch. Control Panel is an integral part, located on the side of the load bank.

J. Enclosure for Outdoor Installations

Enclosure shall be pre-engineered and prefabricated sound attenuated, self-contained package, including the generator set, generator circuit breaker, batteries and charger, day tank, air inlet silencer, exhaust silencer and casing ventilation fan and louvers with motor operated dampers.

1. The enclosure design criteria shall be as follows:
   a. Weatherproof and vandal-resistant, walk-in type.
   b. Rigidity for wind loading of 150 mph.
   c. Roof loading of 40 pounds per square foot, reinforced for silencer mounting.
   d. Rain tested for 5 inches of rainfall per hour.
   e. Acoustical attenuated of 25 dBA, measured at three feet form the enclosure.
2. Enclosure shall consist of a roof, underframe, two side walls, and two end walls. It shall be a galvanized steel, metal-clad integral structural steel framed construction, painted inside and out with rustinhibiting primer and an exterior coat of enamel painting, erected on concrete foundation.
3. Provide a thermostatically controlled space heater, which shall operate at one half or less of its rated voltage, and size to prevent condensation.
4. Engine cooling airflow through enclosure shall be adequate to maintain a temperature rise of system components within required limits when unit operates at 110 percent of rated load for two hours, with cooling air inlet temperature of 100 degree F. Provide fixed-engine sound-attenuating cooling air inlet and discharge lovers, designed to prevent entry of rain and snow.
5. Provide enclosure ventilation louvers as required, equipped with insect/rodent screen and filters arranged to permit air circulation when engine is not running. There is no need to remove side panels to provide additional circulation.
6. The engine-generator set shall be shock mounted on a welded steel skid.
7. Enclosure s thermal/acoustical insulation shall be of glass fiber, protected by a perforated sheet metal liners. Insulation thickness shall be as required to maintain winter temperature within limits required by engine-generator set components.
8. Wall panels shall be bolt-in, gasketed, removable from the inside only. To prevent tempering, the housing shall have lockable latches.
9. Required instruments and control shall be mounted within enclosure.
10. Personnel door shall be hinged, and shall be gasketed to seal door watertight. Provide panic bar hardware with three point cadmium-plated locks, with provision for external padlock and opening from inside, in locked condition.
11. Provide a minimum of four 35,000-pound steel lift rings, suitable welded to enclosure.
12. Provide motor-operated, fail-open automatic dampers at engine cooling inlet and discharge. Dampers shall close to reduce enclosure heat loss in cold weather, when unit is not operating.

13. Provide factory-wired, vaporproof light fixtures within housing. Switching shall be adjacent to the personnel door. Provide battery-powered emergency lighting. Lighting shall comply with NFPA 110.

14. Provide convenience receptacles, circuited separately from lighting, of the ground fault interrupting type.

15. Provide an auxiliary distribution panel that shall be prewired to the ancillary generator equipment.

16. The exhaust silencer shall be pre-fitted and shipped loose with necessary mounting hardware including flanges, elbows, and raincap.

17. The enclosure shall be prepiped and prewired, so as to require only unit connections within the control area and to the generator. The enclosure shall include vibration isolation pads between the generator subbase and the floor or underframe.

K. Site Condition

The operating environment of the diesel-generator set shall be as follows:

Altitude: 500 Feet Above Sea Level

Max. Ambient Fan: 120 degree Fahrenheit

Min. Ambient Temperature: -20 degree Fahrenheit

Relative Humidity: 20 to 100%

Coolant System Engine Mounted Radiator

2.04 PAINTING

Unless otherwise specified, surfaces of equipment and component items shall be cleaned, primed and finished painted in accordance with the manufacturer's standard practice.

2.05 FACTORY TESTS

A. Prototype Tests

The diesel-generator set design shall have been tested as a complete unit, on representative engineering prototype models, in conformance to the requirements of NFPA 110, IEEE 43, IEEE 115 and MIL STD 705. Certified test data shall be submitted to the Engineer.

B. Production Tests

Fully test the diesel-generator set with all mounted appurtenances prior to the shipment to the job site. Diesel-generator set shall receive the manufacturers standard production test of the completely assembled engine, generator, radiator, control panel, and mounting base. The manufacturer shall provide written certification and documentation supporting compliance with test requirements.

The following equipment shall be tested at the manufacturer s plant before shipment:

1. Diesel-generator set:

   Diesel generator, production test procedure shall be approved by Engineer. The diesel-generator set shall be tested under balance, rated load and 80% power factor for performance and functioning of control and interfacing circuits. Testing at unity power factor only is not acceptable. Test shall include:

   a. Single step load pick-up per NFPA 110

   b. Transient and voltage dip response and steady state voltage and speed (frequency) checks

   c. Visual inspection and functional test for lube-oil pump, cooling system, exhaust system, and starting system

2. Generator Control Panel

   Control panel production test procedure shall be approved by Engineer.

3. Battery charger

   The battery charger test procedure shall be based on NEMA PV-5 standards and shall be approved by Engineer.

   Factory test, as outlined above, shall be witnessed by the Engineer. The Manufacturer shall notify the Engineer two (2) weeks prior to the date the tests are to be performed.

PART 3. EXECUTION

3.01 EXAMINATION

After the system equipment has been delivered, an on-site inspection will be made by the Engineer. If any equipment has been damaged or for any reason does not comply with the requirements of this section, the Contractor will be notified in writing, and shall be required to replace the equipment at his own cost and expense, even though the equipment has been previously inspected, tested, and approved for shipment. After such satisfactory replacement, the system shall be installed by the Contractor.

3.02 PREPARATION

The Contractor shall be responsible for field verification of dimensions and coordination of conduit entry and all other mounting conditions with the entity manufacturing the equipment.

The entity manufacturing the equipment shall provide on-site technical supervision and assistance during installation and interconnection of the system equipment installed by the Contractor. Said supervision is to insure the safety of the proper installation and operation of the system equipment, prior to the installed system beginning the final acceptance test.

3.03 INSTALLATION

A. Install diesel-generator, auxiliaries and appurtenances as shown on the Contract Drawings, in accordance with manufacturer's instructions, NFPA 70, NFPA 30, NFPA 37, NEMA MG 2, other applicable codes and standards, and as specified herein. In case of conflict, consult the manufacturer before proceeding with installation.

B. Install level concrete foundation and pad, including conduits, piping and anchor bolts, as shown on the Contract Drawings and in accordance with the manufacturer's instructions and approved shop drawings.

C. Interconnect all equipment, for proper operation.

D. Excavation and backfill for fuel storage tank and conduit and piping systems shall be as specified in the Section of the Specifications entitled "EXCAVATION, BACKFILLING AND FILLING".

E. Concrete Work shall be as specified in the Division 3 - Concrete - of the Specifications.

F. Install a complete grounding system for the diesel-generator set and enclosure as shown on the Contract Drawings and as specified in the Section of the Specifications entitled "GROUNDING".

3.04 FIELD TESTS

A. Before being covered, enclosed or placed in use, all fuel-oil piping shall be hydrostatically tested with the normal system fluid to 150 percent of the maximum anticipated pressure of the system, or pneumatically tested to 110 percent of the maximum anticipated pressure of the system, but not less than 5 psig at the highest point of the system. This test shall be maintained for a sufficient time to complete a visual inspection of all joints and connections, but for at least 10 minutes. Upon completion of the testing, the piping shall be properly connected and filled with the fuel oil to be used in the system.

B. The complete installation shall be initially started and checked out for operational compliance by factory-trained representative of the diesel-generator set manufacturer. The engine lubrication oil recommended by the manufacturer shall be provided and installed.

C. Functional Test

Upon completion of initial start-up and system checkout, perform a functional test, in the presence of the Engineer, to demonstrate load carrying capability, operation in accordance with the specifications, and voltage and frequency stability.

D. Operational Test

Perform a full-load test in compliance with NFPA 110, in the presence of the Engineer. The building loads can serve as part of the load, supplemented by a load bank of sufficient size to provide a load equal to 100 percent of the nameplate KW rating of the diesel-generator set. Transfer, on a temporary basis and for the duration of testing, any normal loads necessary to establish the specified generator loading. The duration of the full-load test shall be for a minimum of two hours.

1. Record, throughout the test, time-of-day, coolant temperature, cranking time until prime mover starts and runs, time required to come up to operating speed, voltage and frequency overshoot, time required to achieve steady-state condition with all switches transferred to the emergency position, voltage, frequency, current, oil pressure, ambient air temperature, kilowatts, power factor, battery charger rate, at 5 minute intervals for the first 15 minutes, and at 15 minute intervals thereafter.

E. Provide all labor and materials for functional and operational tests required and furnish the fuel-oil necessary for the load testing. Top-off fuel storage tank after completion of testing.

F. Should the tests reveal any defects in the diesel-generator equipment or auxiliaries installed under this Contract, promptly correct such defects and rerun the tests until the entire installation is satisfactory to the Engineer in all respects.

G. Report immediately to the Engineer any defect found in portions of the diesel-generator system not installed under this Contract. Do not attempt to rectify any defect found in a component of the system not installed under this Contract unless specifically instructed to do so by the Engineer.

H. Submit all the test results to the Engineer for final approval.

END OF SECTION

SECTION 16620

DIESEL-GENERATOR SET (WITH AUXILIARIES)

APPENDIX "A"

SUBMITTALS

A. Shop Drawings

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

1. Electrical wiring diagrams
2. Coolant system schematic
3. Fuel piping schematic
4. Interconnection wiring diagrams, logic and ladder diagrams
5. General arrangement drawing showing location, size, access, workspace requirements, and dimensions of all components and required interfaces. Drawing shall provide data required to completely design the foundation for the unit, including anchor bolt layout.
6. Transient response data of the engine generator set to 100% block loads at 1.00 power factor. Data shall include maximum voltage dips, maximum frequency dips, and recovery times.
7. Weatherproof enclosure

B. Catalog Cuts

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

1. Engine
2. Radiator
3. Generator
4. Engine/Generator control panel
5. Generator output protective circuit breaker
6. Governor
7. Outdoor weatherproof enclosure (as required)
8. Remote alarm annunciator
9. Vibration isolators
10. Flexible fuel lines
11. Exhaust silencer and flexible connections

12. Fuel day tank and transfer pump
13. Anchor bolts
14. Cranking batteries and rack(s)
15. Battery charger
16. Block heater
17. Battery heater blanket (as required)
18. Voltage regulator
19. Enclosure space heater (as required)
20. Resistive load bank (as required)
21. Automatic transfer switch (as required)

C. Evidence of material or equipment compliance per 1.03

D. Spare Parts: Submit a complete list of recommended spare parts per 1.05

E. Operation and Maintenance Manuals per 1.06

F. Training curricula per 1.07

G. Certified Prototype Test compliance per 2.05 A

H. Certified Production Test compliance per 2.05 B

I. Acceptance Testing Plans per 3.04

1. Prepare and submit to the Engineer for approval an installation acceptance testing plan for the entire system a minimum 30 days in advance of the earliest, approved, scheduled inspection and test date. The system plan shall be divided into the following stages:

   a. Inspection upon arrival at the construction site

   b. On-site inspection and test immediately following the complete installation of the system, to demonstrate compliance with the requirements of this section

   c. Operational test commencing with the successful completion of the on-site inspection and test.

J. Field test reports per 3.04

K. Seismic certification

L. Record Documents

1. Prior to issuance of the certificate of final completion, deliver to the Engineer the following:

   a. One (1) reproducible set of the Contract Drawings and Shop Drawings. Nine (9) set of prints of said Contract Drawings and Shop Drawings shall be supplied to the Engineer, three (3) copies of which shall be marked to the attention of the facility Supervisor of electrical maintenance.

b. Nine (9) copies of the final version of the Operation and Maintenance manuals. Three (3) copies of said Operation and Maintenance manuals shall be marked to the attention and the facility Supervisor of electrical maintenance.

END OF APPENDIX "A"

SECTION 16620

DIESEL-GENERATOR SET

(WITH AUXILIARIES)

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in this Section:

(2.01)	Show list of acceptable manufacturers
(2.02)	Specify diesel-generator set following ratings: Standby KW = KW Standby KVA = KVA Power Factor = 0.8 Frequency = 60 Hz Voltage Volts Standby Horsepower = HP
(2.03 B.3)	Show cooling system radiator mounting
(2.03.B.5.b)	Show exhaust silencer mounting
(2.03 E)	Specify Control Panel Enclosure
(2.03 F)	Specify Circuit Breaker Enclosure
(2.03 H)	Show fuel oil system layout
(2.03 H.1)	Specify fuel storage tank
(2.03 H.2)	Specify day storage tank capacity
(2.03 H.3)	Specify fuel-transfer pump rating (voltage, current, HP, etc)
(2.03 J)	Specify load bank rating, steps, and type
(2.03 K)	Specify enclosure for outdoor installation
(3.03 A)	Show diesel-generator set layout, including auxiliaries and appurtenances
(3.03 B)	Show diesel-generator set foundation layout
(3.03 F)	Show diesel-generator set grounding

B. Other Items

1. Specify required submittals by editing Appendix A Submittal Requirements

2. Acceptable manufacturers are:

   Atlantic Detroit Diesel – Allison
   Caterpillar Co.
   Cummins - Onan Engine Co.
   Katolight Corp.
   Kohler Co.

   Verify the acceptability and availability of the diesel-generator set(s) from these manufacturers prior to including in the Contract Drawings.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16630

SUBSTATION BATTERIES AND BATTERY CHARGERS LEAD-ACID BATTERIES

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for batteries and battery chargers.

1.02 REFERENCES

The following is a listing of publications referenced in this Section:

	American National Standards Institute (ANSI)
ANSI 450	Recommended Practice for Maintenance, Testing and Replacement of Large Lead Storage Batteries for Generating Stations and Substations.
ANSI Z55.1	Gray Finishes for Industrial Apparatus and Equipment.
	American Society of Testing and Materials (ASTM)
	Institute of Electric and Electronic Engineers (IEEE)
IEEE 484	Recommended Practice for Installation Design and Installation of Large Lead Storage Batteries for Generating Stations and Substations.
IEEE 485	Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations.
	National Electrical Manufacturers Association (NEMA)
NEMA 250	Enclosures for Electrical Equipment (1000 volts max.).
	Underwriters' Laboratories, Inc. (UL)
UL 50	Cabinets and Boxes.

1.03 QUALITY ASSURANCE

Batteries and battery chargers of types and sizes required shall have been in satisfactory use for purposes similar to those intended herein for not less than three years.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver equipment and separately packaged terminal blocks and accessories in manufacturers' original, unopened, protective packaging.

B. Store equipment and separately packaged terminal blocks and accessories, in original packaging, in a clean, dry space and protect them from weather.

C. Handle in a manner to prevent damage to finished surfaces.

D. Where possible, maintain protective coverings until installation is complete and remove such coverings as part of final cleanup.

E. Touch up any damage to finishes to match adjacent surfaces.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide batteries, racks and battery chargers manufactured by one of the following companies, or approved equal:

A. Batteries and Racks

Exide Corp.
C & D Power Systems, Inc.
Johnson Controls, Inc.

B. Battery Charger

Exide Corp.
LaMarche Manufacturing Co.
C & D Power Systems, Inc.
Johnson Controls, Inc.

2.02 CONSTRUCTION FEATURES

A. General

1. Unless otherwise shown on the Contact Drawings, provide batteries, racks, and battery charger(s) in accordance with the requirements of these Specifications.

2. Batteries and battery chargers and associated equipment shall be for indoor use. Quantity, rating, sizes and locations shall be as shown on the Contract Drawings.

3. No polyvinylchloride (PVC) insulation or materials shall be utilized in the construction, or wiring, of the equipment.

B. Batteries

1. The battery, consisting of identically sized cells of the same construction and connected in series, shall be lead-acid type and conforming to ANSI 450, IEEE 484, and IEEE 485. Lead-antimony batteries will not be accepted.

2. The nominal rated DC voltage of the battery, the number of cells and both the ampere-hour capacity at the eight-hour rate and amperes at the one-minute rate of discharge to 1.75 volts per cell shall be as shown on the Contract Drawings.

3. The cell container shall be transparent, heat and impact resistant plastic, with the cover permanently sealed to container. The cell container shall be provided with high and low level lines at all faces of the cell container.

4. The battery shall be complete with the following accessories:

   a. Flame arrestors

   b. Pressure-sensitive cell number labels.

   c. Inter-tier, inter-rack and inter-cell connectors and cables. Inter-cell connectors shall be lead-plated copper. Across-aisle inter-rack connectors and cables shall be included.

   d. Lead-plated terminal plates and compression-crimp type, solderless lugs for cable connections.

   e. Stainless steel bolt connectors.

   f. Portable hydrometer with wall mount holder.

   g. Thermometer

   h. Cell lifting device.

C. Battery Rack

1. The cells that make up the stationary lead-acid battery shall be mounted on a rack or group of racks. Configuration of the battery racks shall be as shown on the Contract Drawings.

2. Battery racks shall be constructed of steel rails, frames and braces. Rail insulation shall be provided with 0.06-inch thick plastic channels on the rails. The battery cells rest on the plastic channels. The entire rack shall be painted at the factory with two coats of acid resisting enamel paint. Paint color shall be ANSI 61 conforming to ANSI Z55.1.

D. Battery Charger

1. General

   a. The battery charger(s) shall be installed either individually or in parallel as shown on the Contract Drawings.

   b. Battery charger(s) input voltage and voltage source(s) shall be as shown on the Contract Drawings.

   c. Battery charger, each when more than one is operating in parallel, shall be capable of supplying the connected D.C. load and maintaining line voltage even with the battery disconnected.

   d. When two battery chargers in parallel are shown on the Contract Drawings:

      (1) The battery chargers shall be identical;

      (2) Each battery charger shall supply 50 percent of the load +/-5 percent, and shall be capable of assuming the entire load automatically in the event of failure of the other battery charger.

E. The battery charger shall consist of four major sections which work together to produce stable regulated, filtered output as follows:

   a. Power Input Transformer to supply AC voltage of the proper magnitude and capacity to the rectifier section and to supply various other voltages used by the control unit and accessories.

b. Silicon Controlled Rectifier (SCR) consists mainly of voltage regulating SCR and power rectifier diodes to rectify AC voltage to DC and to control voltages magnitude so that the charge output is regulated at all times.

c. Control Unit to control the SCR in response to the charging requirements of the battery load and to monitor and maintain the output voltage of the Battery Charger.

d. Filter Section to smooth the rectifier output and to remove the charging ripple at the battery terminals.

2. Design Criteria

a. The charger shall be designed for use in a 40 degrees F ambient temperature without exceeding the allowable temperature rating of any of the components including their class of insulation. All components shall be rated for continuous duty at the worst possible charging condition for that particular component. All sensitive devices shall be protected for:

(1) All self-generated transients.

(2) Normal external applied transients.

(3) Turning the charger "On" or "Off" at any charging rate with the battery disconnected.

(4) Disconnecting the battery while charging at any charge rate.

b. The AC input shall be as shown on the Contract Drawings.

c. The DC ampere output shall be as shown on the Contract Drawings.

d. The DC voltage output shall be:

(1) Float adjustment range: Minus 11.5 percent to plus 7.7 percent of the nominal voltage shown on the Contract Drawings.

(2) Equalize adjustment range: Minus 4.6 percent to plus 15.4 percent of the nominal voltage shown on the Contract Drawings.

e. The DC output voltage shall be regulated to +/-5 percent from no load to full load with the AC line variations of +/-10 percent voltage and +/-5 percent frequency.

f. The current shall be limited so that it does not exceed 140 percent of rated current.

g. The efficiency shall be at least 90 percent at full load at rated A.C. voltage.

3. Cabinet

a. The cabinet shall be NEMA 1 construction, fabricated from at least 11-gauge steel. Large floor mounted units shall be suitably braced and reinforced to form a rigid structure or have a 3/16 inch angle iron frame work suitably constructed so as to rigidly contain the unit. The sheet metal wrap, covering the structure, shall be at least 11-gauge steel. Equipment in cabinet shall be arranged so that access required to all circuit breakers, meters, relays, switches, etc., shall be from the front. Internal components and connections shall be easily accessible and/or removable through a hinged front door that opens approximately 180 degrees for easy serviceability. Absolutely no access is to be required to be from the back or sides of the cabinet.

b. The cabinet shall be furnished completely wired and ready for installation. Provision shall be made for the incoming and outgoing cables that will enter the side of the cabinet. Wiring shall be color-coded, SIS high temperature, flame retardant, cross-linked polyethylene insulated wire. Test point identification and circuit symbol labeling of internal components shall be provided.

c. The cabinet shall be so designed as to provide adequate ventilation. All air inlet or discharge louvers or grilles shall be provided with replaceable filters, supported by a metallic frame. The external surface temperature of the cabinet shall not rise above 110 degrees F. for an ambient temperature of 85 degrees F. Top of the cabinet is to be provided with a dust cover.

d. Operating controls, meters, pilot lights, etc., shall be identified with black laminated plastic nameplates. On the front of the cabinet, provide nameplate indicating the input voltage and phase.

e. The battery charger and all internal equipment will be installed in an atmosphere containing industrial fumes, non-metallic dust and excessive moisture. Therefore, all accessory parts, protective coats of paint, seals, etc., to be used in or on this equipment shall be selected as to eliminate the harmful effects resulting from excessive dampness and a corrosive atmosphere.

f. All surfaces shall be thoroughly cleaned, treated with an approved rust inhibitor and then painted with two coats of acid resisting enamel paint ANSI 61 in compliance with ANSI Z55.1. The underside of all equipment not readily accessible for repainting, shall be painted with three coats of bituminous paint.

4. Accessories

The battery charger shall be equipped with the following:

a. AC power "On" front panel, indicating light.

b. AC input circuit breaker, front panel mounted.

c. DC output circuit breaker, front panel mounted.

d. AC & DC surge suppressers, metal-oxide varistor (MOV) type.

e. DC output ammeter (0-150A Scale, unless otherwise shown on the Contract Drawings) and DC output voltmeter (0-150 VDC, Scale unless otherwise shown on Contract Drawings), front panel mounted, three 1/2-inch case, 1 percent accuracy.

f. Auto-Equalize timer, Zero to 72 hour, with front panel indicating lights.

g. Float and Equalize adjustment potentiometers, front panel mounted and lockable.

h. Current limit adjustment potentiometer, internally mounted with easily accessible adjustment.

i. DC output blocking diode to prevent battery from discharging back through the filter and rectifier when charger is "Off" due to AC power failure or charger malfunction.

j. DC output protection diode to prevent damage to battery charger and battery due to reversed polarity connections.

k. DC ground detection with front panel indicating lights and ground test and lamp test switch.

l. Forced load sharing to permit connecting two battery charges in parallel to a common battery bank and the load to be shared equally by the two battery chargers. If either charger is shutdown or becomes inoperative, the other will assume the total load up to the point where its current limit circuit operates. It shall be possible to operate each charger independently with an override switch.

m. Filtered Battery Eliminator Battery chargers shall operate as DC power supplies without the battery connected. Filtered battery eliminators will reduce the output ripple voltage to 100 millivolts rms or less.

n. Input lightning arrestors to provide additional input protection against lightning induced transients.

o. Alarm relays with front panel indicating lights for the following alarm conditions:

(1) AC power failure.

(2) DC ground detection.

(3) High DC voltage.

(4) Low DC voltage.

(5) Charger failure.

(6) DC current limit.

(7) Battery discharging.

(8) Common alarm which provides an alarm indication via relay contacts when any one of the alarm circuits being monitored goes into its alarm state. A form "C" DPDT contact shall be provided for connection to a remote alarm system.

p. DC "Zero-Center" ammeter for battery load monitoring to indicate the direction and amount of the battery current. Indication on the meter is to the right of the center when the charger is charging the battery and to the left when the battery discharging or furnishing current to the load.

2.03 SHOP TESTS

A. The Contractor shall notify the Engineer in writing, a minimum of fifteen working days in advance of any factory inspection or test of equipment.

B. The battery charger shall be inspected and tested at the place of manufacture in the presence of the Engineer. The battery charger shall be tested under a simulated service condition to assure the accuracy of the wiring and the functioning of the equipment.

C. Should the test reveal any defects, promptly correct such defects and rerun the tests until the entire assembly is satisfactory in all respects.

2.04 MANUALS

A. Each manual shall contain the following:

1. Calibration data, curves, wiring diagrams and other pertinent information on each component furnished.
2. Operation Procedures, both manual and automatic.
3. Recommended preventive maintenance schedules.
4. Recommended spare parts list.
5. All information that is necessary for proper installation, service, repair and maintenance of all material, equipment and components furnished under this Section.

PART 3. EXECUTION

3.01 EXAMINATION

Notify the Engineer upon discovery of conditions that prevent the proper installation of materials or methods herein specified.

3.02 INSTALLATION

Equipment shall be installed and wired in accordance with the manufacturer's instructions and recommendations and the requirements specified herein.

3.03 FIELD TESTS

A. Field tests shall be performed in accordance with the manufacturer's recommendations, applicable standards, as required herein and/or as directed by the Engineer.

B. All field tests shall be conducted in the presence of the Engineer for the purpose of demonstrating that the equipment and systems comply with specification requirements, to assure the Engineer that the entire installation meets applicable codes and standards requirements, and that all systems will function as designed.

C. Advise the Engineer, in writing, upon failure of any equipment or material to pass the tests performed or to properly function as intended. The Contractor shall provide corrective action as directed by the Engineer when test results are not acceptable.

D. All Work shall be performed with due regard for the protection of personnel and equipment. The Contractor shall provide protection to all personnel during performance of the tests.

E. Tests shall be performed only after equipment has been thoroughly cleaned.

END OF SECTION

SECTION 16630

SUBSTATION BATTERIES AND BATTERY CHARGERS
LEAD-ACID BATTERIES

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Shop drawings, showing all mechanical parts and assemblies including electrical components, complete connection details, as well as a complete list of parts with full identification.
2. Shop drawings for battery racks, battery chargers, enclosures/cabinets with factory or field mounted terminal blocks, relays or switches.
3. Schematic and wiring diagrams.

B. Catalog Cuts

1. Batteries.
2. Cabinets.
3. Terminal Blocks.
4. Relays.
5. Accessories.

C. Maintenance Manuals

Submit installation, operation and maintenance manuals in accordance with the following requirements:

1. Furnish six complete manuals when the final shop drawings are submitted.
2. Furnish nine additional complete manuals, including any required factory corrections, after the equipment has been factory tested.

END OF APPENDIX "A"

DIVISION 16

SECTION 16670

LIGHTNING PROTECTION SYSTEM

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies the requirements for a complete lightning protection system.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

	Lighting Protection Institute (LPI)
LPI 175	Lightning Protectors Installation Code
LPI 176	Material Standard
LPI 176	Inspection Guide
	National Fire Protection Association (NFPA)
NFPA 70	National Electrical Code
NFPA 780	Lightning Protection Code
NFPA 781	Lightning Protection Early Streamer Emission Air Terminals Code (Proposed)
	Underwriters Laboratories
UL 96	Lightning Protection Components
UL 96 A	Installation Requirements for Lightning Protection Systems

1.03 DESIGN REQUIREMENTS

A. Unless otherwise specified on the Contract Drawings or in this Section, the Lightning Protection System shall be manufactured, supplied, and installed in conformance with the requirements of all local codes, and the Publications referenced in Article 1.02 herein.

B. The Lightning Protection System shall be composed of all items of hardware, cables and grounding electrodes necessary to dissipate the lightning current into the mass of the earth. In general, the system shall consist of readily available listed components that fully comply with the requirements of this Section and the Contract Drawings.

C. The Lightning Protection system shall be designed to prevent damage to building structures and property, injury to occupants, and protection of electrical systems including electronic equipment.

D. The Lightning Protection system shall include but not be limited to the following:

1. The entire roof system, gutters, leaders ventilators, and all other metal appurtenances shall be made electrically continuous and shall be grounded to the grounding grid or in the case of structural steel frame construction directly to the building steel with approved fasteners at intervals averaging not more than 100 feet around the perimeter of the structure.

2. All metallic objects inside the building within 6 feet of the Lightning Protection System or metal connected to it shall be bonded to the system with approved fittings and conductors.

3. Air terminals shall be no more than 20 feet apart with the end terminals no more than 2 feet from the ends of the building.

4. Lightning protection conductors shall interconnect all metallic objects on the protected structure, and shall be installed to provide a two way path to ground from each air terminal, and shall be bonded to the steel framework at each roof beam and a minimum of every 60 feet along the ridge beam.

5. Down conductors shall be installed at all four (4) corners of the building, at columns near the center of the north and south building walls and at other locations as required by the referenced codes and good design. They shall be installed as directly as possible to ground.

6. The design of the Lightning Protection System, including the down conductors, shall be compatible with the architectural features of the building or structure, as approved by the Engineer.

1.04 QUALITY ASSURANCE

A. The Contractor shall engage the services of a UL certified lightning protection installer, who shall have designed and installed Lightning Protection Systems that have been in satisfactory use for not less than three years in a minimum of 20 installations for purposes similar to those intended herein.

B. The lightning protection system design and installation shall conform to the requirements of LPI 175, LPI 176, NFPA 70, NFPA 780, NFPA 781, UL 96, and UL 96 A.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in manufacturer's original, unopened, protective packaging. Protective caps shall be removed immediately prior to installation of conduit.

B. Store materials in a clean, dry space and protect them from weather.

C. Handle in a manner to prevent damage to finished surfaces.

1.06 SUBMITTALS

See Appendix "A" for submittal requirements.

1.07 SPARE PARTS

A. The Contractor, or his authorized representative, shall confirm that there are a minimum of three (3) established agencies within the Port Authority District, which stock a full inventory of spare parts for the system supplied. In the event that there are not three (3) sources of supply, the contractor warrants that all system components will be made available by the Contractor for a period of ten (10) years from the date of acceptance of the system.

PART 2. PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with the requirements of this Section, provide a lightning protection system of one of the manufacturers specified on the Contract Drawings.

2.02 MATERIAL

A. General

1. All electrical materials and equipment, shall be labeled or listed by UL for use in Master Labeled Lightning Protection systems. Materials shall be sized in accordance with the materials requirements of NFPA 780 and UL 96A.

2. Generally all materials shall be copper, or copper-bronze (in locations where system components are mounted on aluminum surfaces, aluminum materials shall be used) as specified herein and of the size, weight and construction to suit the application shown on the Contract Drawings and shall be used in accordance with UL and LPI and NFPA code requirements, for class II structures and as per manufacturers recommendations.

B. Conductors

1. Conductors shall be sized in accordance with material requirements above. Down conductors shall be copper.

C. Connections, Splices, and Fasteners

1. Connectors, splicers, fasteners, and cable clamps shall be heavy-duty bronze, approved for lightning protection systems.

2. Bonding plates shall be heavy-duty bronze with a minimum bonding surface of 8 square inches.

3. Fittings for connections to metal tracks, gutters, ventilators, etc., shall be of an approved type and shall be made tight by compression under bolt heads or equivalent.

4. Screws, bolts, nuts, washers and nails shall be stainless steel. Galvanized or plated materials are not acceptable.

D. Roof Penetrations

1. The roof penetrations required for down conductors or for connections to structural steel framework shall be made using thru-roof assemblies.

2. Through the roof connectors shall be bronze, right-angle, thru-roof connectors with clamp type top cable connector, 4 inches square roof flashing plate, 1/2 inches diameter by 15 inches long threaded stem, hex nut and washer, and adjustable bottom cable clamp.

3. Roof flashing shall be compatible with the roofing system.

E. Air Terminals

1. The air terminals shall be as follows:

a. Ridge Type

(1) Air terminal shall be pointed, solid, round, heavy duty, bronze rod for concealed in place installation.

(2) Air terminal shall be 1/2 inches in diameter with a 10-inch nickel tipped point and 15-inch long solid copper stem.

(3) Each air terminal shall be furnished with lead washers, a support bracket for attachment to the ridge member, and an adjustable thru-roof clamp type cable connector.

b. Parapet Type

(1) Pointed, solid, round, heavy duty, bronze rod with 5/8 inches inside threaded adapter for mounting on a point support.

(2) 1/2 inches in diameter with a nickel tipped point and a 24-inch long solid copper stem.

(3) Each terminal shall be furnished with an offset point support and a point extension.

(4) Each offset point support shall be bronze with a 5/8 inch outside thread.

(5) Each point extension shall be bronze, 3 inches long, with a 5/8 inches outside top thread and a 5/8 inches inside bottom thread.

F. Ground Terminations

1. The ground terminations shall be as follows:

a. 5/8" x 10'-0" (minimum) copper-clad rod.

b. Bronze clamp (connecting ground rod and down conductor) having at least 1-1/2" of contact between rod and conductor, or by an exothermic welded connection.

c. Conductors from the ground connections to the ground terminations shall be class II copper lightning conductors.

PART 3. EXECUTION

3.01 INSTALLATION

A. The installation shall be in accordance with LPI 175, LPI 76 and UL 96A.

B. The installation shall he completed by an experienced installer who is a certified Master Installer of the LPI or working under the direct supervision of an LPI manufacturer or his authorized LPI certified Master Installer representative.

C. Terminals shall be installed and all openings sealed in accordance with the Contract Drawings and manufacturers recommendations.

D. Connections to steel framework shall be with bonding plates as described above.

E. Conductors shall be held in place with approved fasteners. Spacing of fasteners shall not exceed 3-foot centers on both horizontal and vertical runs.

F. Approved connectors and splicers as described above shall be used for joining conductors. When attached to conductors they shall be sufficiently tight to withstand a tensile force of two hundred (200) pounds.

G. Down conductors shall be connected to building grounding system with approved fittings. Common grounding of all ground mediums entering the structure shall be ensured by interconnecting to the Lightning Protection System using main size conductors and fittings.

H. The offset point supports for the parapet air terminals shall be shimmed to clear the coping.

I. Conductors for the parapet air terminals shall interconnect all the terminals on the parapet and shall be fastened to the parapet with approved fasteners forming a closed loop around the building. Conductors shall be connected to the down conductors via the thru-roof connector described above.

J. Ground rods shall be located two feet below grade, preferably two feet from foundation walls.

K. Ground rods shall extend a minimum of ten feet vertically into the earth.

L. Grounded metal bodies located within the required bonding distance as determined by NFPA 780 shall be bonded to the Lightning Protection System using bonding connections and fittings.

3.02 COORDINATION

A. The Contractor shall insure a correct, neat and unobtrusive installation.

B. The Contractor shall insure a solid mechanical and electrical connection to the building ground system.

3.03 INSPECTION, TESTING, COMPLETION AND APPROVAL

A. The Contractor shall secure and deliver the LPI System certification to the Engineer upon completion of the installation.

B. The Contractor shall also submit copies of as-built shop drawings with LPI Forms 175A, B and C along with the LPI Certificate System Application.

C. Underwriters' Laboratories Master Label shall be furnished as evidence that the installation complies with the UL 96A requirements.

D. If protected structure is an addition to, or is attached to an existing structure the Contractor shall advise the Engineer of any additional work required on the existing Lightning Protection System or structure with current UL requirements.

END OF SECTION

SECTION 16670

LIGHTNING PROTECTION SYSTEM

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - "GENERAL PROVISIONS".

A. Shop Drawings

1. Connection Diagrams
2. Layout drawing, including type, size and location of the following:
   a. All equipment
   b. Cable routing
   c. Ground rods
3. Any special equipment that must be manufactured or fabricated.

B. Catalog Cuts

1. Wire and cable
2. Air terminals and other equipment
3. Supports, fasteners and hardware

C. Certifications

1. LPI system Certification
2. UL Master Label
3. LPI Forms
   a. 175A
   b. 175B
   c. 175C

D. Spare Parts: Submit a complete list of recommended spare parts, which shall include those spare parts required to be furnished in compliance with the requirements of this Section, for approval by the Engineer.

END OF APPENDIX "A"

SECTION 16670

LIGHTNING PROTECTION SYSTEM

INSTRUCTIONS TO SPECIFIER

A. General

The following general note must be added to all Contracts containing lightning protection as part of the scope of work:

"THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE INSTALLATION OF A COMPLETE SYSTEM IN ACCORDANCE WITH STANDARDS UL 96 AND UL 96A, AND SHALL DELIVER A SYSTEM WHICH COMPLIES WITH UL MASTER LABEL CERTIFICATION REQUIREMENTS. PRIOR TO THE ISSUANCE OF THE CERTIFICATE OF FINAL COMPLETION, DEMONSTRATE COMPLIANCE BY DELIVERING TO THE ENGINEER A MASTER LABEL CERTIFICATE."

B. A list of acceptable manufacturers must be added to the Contract Drawings. The following is a suggested list:

Erico Inc./Electrical Products Croup
Harger Lightning Protection Inc.
Heary Brothers Lichting Protection
Independent Protection Co. Inc.
Or approved equal.

END OF INSTRUCTIONS

SECTION 16670

LIGHTNING PROTECTION SYSTEM

INSTRUCTIONS TO SPECIFIER

A. General

The following general note must be added to all Contracts containing lightning protection as part of the scope of work:

"THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE INSTALLATION OF A COMPLETE SYSTEM IN ACCORDANCE WITH STANDARDS UL 96 AND UL 96A, AND SHALL DELIVER A SYSTEM WHICH COMPLIES WITH UL MASTER LABEL CERTIFICATION REQUIREMENTS. PRIOR TO THE ISSUANCE OF THE CERTIFICATE OF FINAL COMPLETION, DEMONSTRATE COMPLIANCE BY DELIVERING TO THE ENGINEER A MASTER LABEL CERTIFICATE."

B. A list of acceptable manufacturers must be added to the Contract Drawings. The following is a suggested list:

Erico Inc./Electrical Products Croup
Harger Lightning Protection Inc.
Heary Brothers Lichting Protection
Independent Protection Co. Inc.
Or approved equal.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16680

INDUCTIVE DETECTION CABLE AND DETECTOR SENSOR UNIT

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for inductive detection cable and detector sensor unit.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

American Society for Testing and Materials (ASTM)

ASTM D 1248	Specification for Polyethylene Plastics Extrusion Materials For Wire and Cable.
ASTM D 2308	Specification for Thermoplastic Polyethylene Jacket for Electrical Wire and Cable.

International Municipal Signal Association (IMSA)

IMSA Series 50/51	Loop Inductance Detection Cable and Wire Specification.

Institute of Transportation Engineers (ITE)

ITE ST-017B	Equipment and Material Standards of the Institute of Transportation Engineers.

National Electrical Manufacturers Association (NEMA)

NEMA TS 1	Traffic Control Systems.

National Fire Protection Association (NFPA)

NFPA 70	National Electrical Code (NEC).

Underwriters Laboratories, Inc. (UL)

UL 467	Grounding and Bonding Equipment.

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. The inductive detection cable and equipment shall conform to requirements specified in this Section. Where specific requirements are not listed herein, such equipment shall, as a minimum, conform to the requirements of the standards and publications listed in 1.02.

B. The detector sensor units furnished under this Section shall be dual-channel detector units in the quantities shown on the Contract Drawings.

C. The detector sensor unit shall respond to changes in the inductance of the sensor loop/lead-in combination(s) connected to its loop input terminals. The unit shall develop a detection output when there is a sufficiently large change in the magnitude of the connected inductance.

1. The detector sensor unit shall detect all motor vehicle types that normally traverse the public roadways, including motorcycles. The detector sensor unit shall detect all vehicles that are stopped and shall detect all vehicles moving at speeds up to 80 miles per hour within the detection zone of the inductive loop.

1.04 ENVIRONMENTAL REQUIREMENTS

A. The detector sensor unit shall operate without degradation or damage under ambient shock (thermal and mechanical), vibration, lightning and electromagnetic/electrical interference at the construction site.

B. The detector sensor unit shall operate over an ambient temperature range from minus 40 degrees F to plus 165 degrees F (minus 40 degrees C to plus 74 degrees C). Operation of the detector sensor unit shall not be degraded by rain, snow, fog or normally encountered ambient humidity conditions.

1.05 QUALITY ASSURANCE

A. Wires and cables that have been manufactured more than two years prior to installation shall not be used.

B. Verify that sealer is within the manufacturer's established shelf life and has been dated by the sealer manufacturer to so indicate.

C. Sawcutting equipment shall be capable of sawcutting concrete and asphalt pavement to depths of two inches.

D. Air compressor shall be capable of providing the pressure and volume of air sufficient to clear loop sawcut slots of moisture and debris.

E. After installation, test the equipment in the presence of the Engineer to show compliance with the requirements of this Section. Continue testing until the results are satisfactory to the Engineer. Perform all repairs, construction and modifications required to comply with the Specifications at no additional cost to the Authority.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver all materials to the construction site in original unopened containers or bundles with labels that clearly identify the manufacturer and product name, including storage requirements and instructions.

B. Properly store and handle all materials delivered to prevent deterioration or damage due to moisture, temperature change, contaminants or other causes.

1.07 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 CONSTRUCTION FEATURES

A. General

1. All wiring shall be in accordance with the requirements of NFPA 70 National Electrical Code (NEC) as shown on the Contract Drawings. No wiring shall be exposed. Provide electrical connection by barrier type terminal blocks, as defined in NEMA TS 1. Identify all wire terminations and terminal block connections. Locate connections readily accessible for maintenance. Make wire and cable terminations with insulated spade terminals, as defined in NEMA TS 1. Soldering of terminal connections will not be permitted.

B. Detector Sensor Unit

1. Detector sensor units shall meet the requirements of NEMA TS 1 and in ITE ST-017B. Provide units of solid-state design that employ digital techniques, unless otherwise shown on the Contract Drawings. The units shall conform to requirements of 1.03.

2. Detector sensor units shall be as described below and as shown on the Contract Drawings. Provide each detector unit and/or circuit board with a unique serial number.

   a. Shelf-mounted, case-contained units shall include two detection channels and shall operate on an input voltage from 80 VAC RMS to 135 VAC RMS. Power supply shall be contained in the unit. Dual-channel units shall interface with two 10-pin mating connectors, MS311106A-18-1S or approved equal for relay output as described above. Provide varistors between power line leads to limit peak transient voltage to 270 VDC.

3. Provide each detector channel with an isolated output circuit such that detection is indicated by either of the following, based upon the application and the requirements of 1.03:

   a. An output relay, with a contact or resistive load rating of 2 milliamperes through 1 ampere at 18 to 28 volts, 0.5 amperes at 120 VAC and, 1 ohm maximum closed contact resistance; or

   b. An optically isolated solid-state transistor, with an output rating of 20 milliamperes minimum conductance with 1.4-volt drop across the output terminals in the conducting state or a maximum of 50 microamperes with any voltage between 0 and 26 VAC applied across the output terminals in the non-conductive state.

4. Inductive tuning of loops shall be automatic for all types of configurations. The units shall accommodate loop circuits in the range of 20 to 2,000 microhenries. Tuning controls of any kind for this function will not be acceptable. Each unit or detection channel shall be self-retuning on initial turn-on and self-retuning within 30 seconds of reactivation or restoration of electrical power. The sensor units shall automatically accommodate those after-tuning changes in the loop/lead-in electrical characteristics as might reasonably be expected to occur in undamaged, properly installed loops, without producing a false output or change in sensitivity.

5. Each unit or detection channel shall be capable of operation in one of the following two modes which shall be front panel switch selectable:

   a. Pulse mode: A vehicle passing over a loop shall cause a programmable output pulse of from 75 to 150 millisecond duration. In this mode, the detector shall rephase two seconds after initiation of the above described output pulse. The rephase sequence shall allow for detection of the smallest detectable vehicle within a maximum of 4 minutes subsequent to detection of a stopped vehicle in the loop field.

   b. Presence mode: Continuous output based on continuous occupancy of the loop field. Minimum hold time for the smallest detectable vehicle shall be four minutes and no more than 120 minutes with a 3-turn compact loop and minimum cable lead-in.

6. Each channel of the units shall have three modes of operation; delay, extension and normal that is neither delay nor extension.

   a. In the delay mode, delay the channel output for the time set. If a vehicle departs before the time set, an output shall not occur and the timer is reset. The delay time shall be settable in the range from 0 to 30 seconds. Settability shall be within one second in the 0-15 second range and within two seconds in the 16-30 second range.

   b. In the extension mode, extend the channel output after the vehicle departs the zone of detection for the time set. If a new vehicle arrives before the extension timer times out, the timer shall be reset, the output shall be maintained and the timer shall resume timing when the vehicle departs. The extension time shall be settable in the range from 0 to 7-1/2 seconds. Settability shall be within 1/2 second.

7. Should continuous detection exceed the presence time programmed, the sensor unit shall retune to the current environment. Operation of a detection channel shall not terminate if the loops are defective through either single point leakage to ground or short to ground. Circuitry in the detection channel shall be such that output response to an open loop is selectable as either a detection or no detection.

8. Provide means to ensure no detection channel adversely interacts with any other channel installed in the same cabinet.

9. Provide an overcurrent protection device on all sensor units. For shelf-mounted, case-contained units, the circuit breaker shall be accessible from the front or back of the unit. Other overcurrent protection devices may be mounted internally for shelf-mounted units. Lightning protection shall be as specified in ITE ST-017B.

10. Grounding of all sensor units and cables shall be as specified in the NFPA 70 and UL 467.

11. Equip each sensor unit with an indication light or meter for each output circuit to identify when the detector unit is sensing a vehicle. Provide a sensitivity control for each detection channel with a minimum of three sensitivity selections for each channel. All controls and indicators shall be readily accessible from the front panel.

C. Detector Loop Lead-in Cable

1. Induction loop lead-in cable shall consist of two NEC No. 14 AWG stranded tinned copper conductors insulated with 0.030-inch minimum high molecular weight, heat stabilized, color polyethylene insulation, conforming to both ASTM D 1248, Type I, Class B, Grade 4 and IMSA Standard 50-2.

2. Twist the conductors together at the rate of seven turns per foot. Use non-hygroscopic fillers to form a firm compact cylindrical core. Provide a non-hygroscopic core tape with aluminum or copper shield and a ground drain wire.

3. The outer jacket shall consist of an extruded, black, polyethylene jacket, conforming to both ASTM D 2308 and IMSA Standard 50-2.

D. Inductance Loop Wire

1. Inductance loop wire shall be single conductor No. 14 AWG; polyethylene insulated stranded copper with a 600-volt rating, and shall conform to the requirements of IMSA Standard 51-7. Mark the exterior jacket of the wire at regular intervals with the proper type letter or letters, the manufacturer's name or trademark, the AWG size and the maximum rated voltage.

   a. Protect the loop wire by a continuous flexible polyethylene tubing of 0.184-inch minimum inner diameter, 0.031-inch minimum wall thickness, and 0.26-inch maximum outer diameter, having a smooth bore. The tubing shall be highly abrasion resistant and shall remain flexible from minus 22 degrees F to plus 212 degrees F (minus 30 degrees C to plus 100 degrees C).

E. Loop Embedding Sealer

1. Provide detector loop sealer to encapsulate traffic signal loop wires embedded in roadway. The sealer shall be cold applied and may be a one- or two-component system, the viscosity of which shall be sufficient to allow the material to be either poured or placed under pressure and to fully encapsulate the loop wire. The sealer shall be curable at temperatures of 40 degrees F (4 degrees C) and above.

   a. When the sealer is bonded to common paving material, it shall have sufficient strength and resiliency to withstand stresses due to vibrations and differences in expansion and contraction as a result of temperature changes or traffic conditions and shall be compatible with the sheathing or covering of inductance loop wires.

   b. Cured sealer shall be resistant to most chemicals and solvents, including salts, acids and hydrocarbons. Packaged stability of the components in original unopened containers, stored in temperatures from 32 degrees F to 100 degrees F (0 degrees C to 38 degrees C) shall be a minimum of six months.

PART 3. EXECUTION

3.01 PREPARATION

A. Before manufacture or procurement of equipment, submit detailed specifications, Catalog Cuts and Shop Drawings outlining the construction and operation details of all equipment for prior Engineer approval as specified in 1.07. Do not procure equipment until the Engineer has given written approval.

3.02 INSTALLATION

A. Saw cut a rectangular shaped channel of the dimensions shown on the Contract Drawings with an access channel from each loop to the edge of the roadway. Cut the corners of the channels diagonally to assure a clean smooth radius.

B. Blow channel free of debris and moisture after the trench has been cut. If the loop is not immediately installed, install a backer rod filler to prevent the channel from collapsing. At curbs, if any, install a suitable conduit through the curb below the roadway level and terminate in the access channel.

C. Locate the sensor loop(s) connected to the detector unit input terminals at the zone(s) of detection as shown on the Contract Drawings. Connect the sensor loops to the detector sensor units by means of lead-in cable.

D. Install the loop detector wire in its polyethylene tubing continuous without splices, joints, kinks or curls, and no straining or stretching of the tubing around the corners of the channel or junction box. Use a wooden or plastic tool with rounded corners to seat the tubing in the bottom of the channel. After the wire is in place, recheck for slack, raised portions and tightness. If any of the foregoing is found, they shall be corrected. Twist the lead-in wires together with a minimum of seven turns per foot from the loop channel to the nearest junction box.

E. Extend the twisted loop wire from the channel to the nearest junction box. At this point connect to the detector lead-in cable. Install detector lead-in cables continuously without splices from the cabinet housing the sensor electronics to the junction box nearest the loop. Make connection of the lead-in cable to the loop wire with a compression solder-less connector secured mechanically and electrically with the proper tool as per ITE ST-017B. Clean the conductor with a minimum of insulation removed. Insulate all joints with a resin splicing kit.

F. Lead-in Detector Cable

1. Terminate the lead-in cable inside controller cabinet at a surge voltage protected terminal strip. Provide an excess of 18 inches of lead-in cable in each cabinet. Group and tag terminations with cable identification tags that show the loop designations shown on the Contract Drawings. Secure the conductors to the cable racks using nylon cable ties. Maximum lead-in cable length, unless otherwise shown on the Contract Drawings, shall be 850 feet from field junction box to controller cabinet.

2. Provide induction loop detector leads slack of five feet in rectangular junction boxes and three feet in circular junction boxes. Secure all slack cable at the bottom of the boxes with nylon cable ties. Form the slack cable and wires around the interior of the junction box.

G. After successful testing of the loop in accordance with 3.03 A.1, seal the channel with a joint sealant mixed and applied in accordance with manufacturer's instructions. Completely fill the channel with the joint sealant with no air bubbles below the surface. The loop sealer shall be flush with the roadway. Remove joint sealant that is accidentally applied to the roadway surface. Allow the joint sealant to sufficiently harden before allowing traffic to move over the area.

1. At sloping roadway apply the joint sealant in a manner that prevents the joint sealant from running out of the trench and onto the roadway.

3.03 FIELD TESTS

A. Perform initial installation test in accordance with 1.05 E.

1. Prior to installation of loop sealer, test each loop with a 500-volt megohmmeter. The tested resistance from each loop lead to ground shall be a minimum of 50 megohms. Test each loop for continunity with an ohmmeter. End-to-end resistance shall not exceed five ohms.

2. Perform an inductance test to determine the inductance of the loop. Submit in writing a tabulation of all test results for all loops. Provide a loop inductance meter to perform the inductance tests. If the loop inductance does not conform to the requirements shown on the Contract Drawings, adjust the number of turns of wire in the trench and retest the inductance of the loop.

END OF SECTION

SECTION 16680

INDUCTIVE DETECTION CABLE AND DETECTOR SENSOR UNIT

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings: A complete set of detailed drawings including reproducible Shop Drawings on Mylar, from which clear prints can be made. Included within this documentation shall be electrical wiring diagrams defining terminal identification number assignment.

B. Catalog Cuts and Data Sheets: Complete manufacturer's data including chemical resistance, material properties and test methods for loop embedding sealer and characteristics of detector sensor, loop and loop lead-in.

END OF APPENDIX "A"

SECTION 16680

INDUCTIVE DETECTION CABLE AND DETECTOR SENSOR UNIT

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

1.03 B	Specify number of dual-channel detector units, if required.
2.01 A	Specify wiring used in accordance with the requirements of the NFPA 70 National Electrical Code.
2.01 B.2	Specify either shelf- or rack-mounted detector sensor units.
3.02 A	Specify saw cut dimensions and shape.
3.02 C	Specify the sensor loop(s) that are connected to the detector unit input terminals.
3.02 F.1	Specify maximum lead-in cable length if greater than 850 feet from field junction box to controller cabinet.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16710

VEHICLE DETECTION LOOP

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for vehicle detection loop(s).

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

	American Society for Testing and Materials (ASTM)
ASTM B 8	Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard or Soft
ASTM D 2802	Ozone-Resistant Ethylene-Propylene Rubber Insulation for Wire and Cable
	Insulated Cable Engineers Association (ICEA)
ICEA S-68-516	Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC 8)
	National Fire Protection Association (NFPA)
NFPA 70	National Electrical Code
	Underwriters Laboratories, Inc. (UL)
UL 44	Rubber-Insulated Wires and Cables
UL 854	Service-Entrance Cables

1.03 QUALITY ASSURANCE

A. Wires and cables that have been manufactured more than two years prior to installation shall not be used.

B. Sealer shall be within the manufacturer's established shelf life and shall be dated by the sealer manufacturer to so indicate.

C. Sawcutting equipment shall be capable of sawcutting concrete and asphalt pavement to depths of two inches.

D. Air compressor shall be capable of providing the pressure and volume of air sufficient to clear loop sawcut slots of moisture and debris.

1.04 DELIVERY, STORAGE AND HANDLING

A. Deliver materials and components in manufacturer's original, unopened, protective packaging.

B. Store materials and components in a clean, dry space and protect them from weather.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MATERIALS

A. Loop Wire

Detection loop and lead-in wire shall be copper, #14 AWG, concentric-lay-stranded, conforming to ASTM B 8, Class B. Insulation shall be 600-volt, Type USE ethylene-propylene-rubber with heavy-duty thermosetting chloro-sulphonated polyethylene or neoprene jacketing, conforming to ASTM D 28027 NFPA 70, UL 44, UL 854 and ICEA S-68-516.

B. Loop Sealer

Vehicle detection loop sealer shall be flexible embedding sealer used to encapsulate traffic signal loop wire embedded in highway materials. The sealer shall be one part liquid consisting of a synthetic resin base. A specific reaction initiator may be added to accelerate the sealer cure and the amount to be added shall be dependent on the pavement. The sealer shall be curable at temperatures of 32 degrees F and above, and shall be self-leveling. Cured sealer shall be resistant to most chemicals and solvents, including salts, acids, hydrocarbons, etc., and shall be as specified on the Contract Drawings.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install vehicle detection loops as shown on the Contract Drawings and in accordance with the requirements of NFPA 70.

B. Vehicle loop saw cuts shall be cleaned free of moisture and debris before loop wires are installed.

C. Loop wire shall be installed in a continuous length of wire. No splicing shall be permitted.

D. Loop wires shall be tamped to the bottom of saw cut with a wooden or plastic tool, Contractor shall take care not to nick or abrade the wire insulation prior to installation of loop sealer.

E. Prime the prepared sawcut slot to ensure self-leveling flow of the loop sealer, and total encapsulation of the loop wires.

F. Install small wooden or plastic wedges in sawcut to prevent loop wires from floating up in sawcut during loop sealer curing time.

G. Loop sealer shall be flush with roadway surface. Clean up any spillage of sealer on roadway.

3.02 TESTING

A. Testing of vehicle detection loops shall be done PRIOR TO THE INSTALLATION OF THE LOOP SEALER, in the presence of the Engineer. Written notice of the testing shall be given the Engineer at least 5 days prior to testing.

B. The tested insulation resistance from each loop lead wire to ground shall be a minimum of 50 megohms, using a 500-volt megohm-meter.

C. End-to-end continuity of each vehicle detection loop shall not exceed 5 ohms, when tested using an ohm-meter.

END OF SECTION

SECTION 16710

VEHICLE DETECTION LOOP

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Detailed wiring diagrams for system using vehicle detection loops.

B. Catalog Cuts

1. Wires and Cables
2. Loop Sealer
3. Sawcut Equipment Specifications
4. Air Compressor Specifications

END OF APPENDIX "A"

SECTION 16710

VEHICLE DETECTION LOOP

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show:

(2.01 B)	The specific brand of loop sealer desired (Preco-Gold Seal Flex 45, Type C, or approved equal).
(3.01 A)	Installation details of vehicle detection loop(s)

END OF INSTRUCTIONS

DIVISION 16

SECTION 16711

PREFORMED VEHICLE DETECTION LOOP

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for preformed vehicle detection loops.

1.02 QUALITY ASSURANCE

Preformed vehicle detection loops, wires and cables that have been manufactured more than two years prior to installation will not be accepted.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials and components in manufacturer's original, unopened, protective packaging.

B. Store materials and components in a clean, dry space, and protect them from weather.

C. Handle in a manner to prevent damage to finished equipment.

1.04 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with the requirements of this Section, provide preformed vehicle detection loops of one of the manufacturers specified on the Contract Drawings.

2.02 MATERIALS

A. General

1. Location, types, and sizes of preformed vehicle detection loops are shown on the Contract Drawings.

B. Tie Wraps

Tie-wraps shall be of the non-metallic type.

C. Connectors

Connectors to splice loop tail, to loop lead-in cable shall be uninsulated indenter, or crimp, type compression butt connectors,

D. Heat Shrinkable tubing

Heat shrinkable tubing shall be either irradiated modified polyvinyl chloride or irradicated polyolefin.

E. Solder

1. Solder shall be 50 Tin/50 Lead.
2. Flux shall be non-corrosive and non-acid type.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install loops in locations shown on Contract Drawings as per the manufacturer's written instructions, which generally include the following steps:

1. Layout loop in its rectangular form.
2. Slide expansion/contraction sleeves into place over fold joints.
3. For loops installed in wet concrete, inject silicon sealer into the center hole of the expansion/contraction sleeves until sealer extrudes from both ends.

B. No splices shall be permitted on the continuous length of loop tail.

C. Secure loops to concrete slab or roadway rebars, as applicable, using tie wraps. Loops shall be secured to prevent movement during placement of the roadway.

D. Secure loop 'tail' to concrete slab using tie-wraps.

E. Provide connections from each loop to external equipment in accordance with details shown on the Contract Drawings.

1. Where shown on the Contract Drawings, loop lead-in cable shall extend directly to the external equipment.
2. Where shown on the Contract Drawings, the connection between loop 'tail' and loop lead-in cable shall be mechanically crimped and hot soldered to insure a low resistance, corrosion-free joint. The connector and wiring shall be reinsulated with heat shrinkable tubing, after completion of the physical joint.

3.02 FIELD TESTS

Perform test of preformed vehicle detection loops in the presence of the Engineer prior to the placement of the pavement material.

A. The tested insulation resistance from each loop lead wire to ground shall be a minimum of 50 megohms, using a 500 Volt Megohmmeter.

B. End-to-end continuity of each preformed vehicle detection loop shall not exceed 5 ohms, when tested using an ohmmeter.

END OF SECTION

SECTION 16711

PREFORMED VEHICLE DETECTION LOOP

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

Wiring, fabrication, and installation drawings for preformed vehicle detection loops

B. Catalog Cuts

Preformed Vehicle Detection Loop, including loop lead-in cable.

END OF APPENDIX "A"

SECTION 16711

PREFORMED VEHICLE DETECTION LOOP

INSTRUCTIONS TO SPECIFIERS

A. Contract Drawings

Ensure that the Contract Drawings show:

(2.01 A) The mfg. and model no. of all acceptable preformed vehicle detection loops (from at least two manufacturers).

(3.01 A.) Specify the location, type, size, number of turns, and other installation details for preformed vehicle detection loops.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16720

FIRE ALARM SYSTEMS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for Fire Alarm Systems.

1.02 REFERENCES

The following is a listing of publications referenced in this Section:

Building Officials and Code Administrators, Inc. (BOCA)

National Electrical Manufacturers Association Standards (NEMA)

National Fire Protection Association (NFPA)

NFPA 70	National Electrical Code.
NFPA 72	National Fire Alarm Code.
NFPA 90A	Installation of Air Conditioning and Ventilating Systems.
NFPA 13	Installation of Sprinkler Systems.
NFPA 92A	Smoke Control Systems.

Underwriters Laboratories, Inc. (UL)

UL 268	Smoke Detectors for Fire Protective Signaling Systems.
UL 1971	Notification Appliances for Fire Protective Signaling Systems.
UL 864	Control Units for Fire Protective Signaling Systems.

American National Standards Institute (ANSI)

ANSI 117.1	Elevator Operation.

Americans with Disabilities Act, PL 101-336 (ADA)

New York City Building Code NYCBC.

New York City Electrical Code NYCEC.

New York City Fire Prevention Code and Directives.

1.03 QUALITY ASSURANCE

A. Qualifications

1. The entity performing the Work of this Section shall have successfully completed at least three (3) installations for fire alarm system work of similar type, size and complexity, as the Fire Alarm System described in this Specification and the Contract Drawings. Said Installations shall have been in satisfactory operation for a period of not less than one (1) year, and shall have included at least one contract for the installation of a Fire Alarm System in an existing occupied building. The entity shall be licensed to perform this type of Work in the jurisdiction of said Work. Licensure shall be evidenced by a submission from the entity of the following: a copy of the entity's current license, business permit and certifications. The entity performing the Work of this Section shall be an authorized installer approved by the System manufacturer. Proof of such authorization shall be provided to the Engineer prior to the commencement of any Work.

2. System Manufacturer: The System manufacturer shall be one of established reputation and experience in the fire alarm industry. The manufacturer shall have been in business a minimum of five (5) years, show substantial involvement in the development and manufacture of systems similar to the one specified in this Contract and have a minimum of (3) three qualified factory authorized full line distributors and or branch offices within fifty (50) miles of the System location. The manufacturer shall also have an in-house technical support staff accessible to the Authority for technical assistance over the phone, offer detailed technical training courses both on site and at the manufacturer's facility, and be ISO-9001 certified.

3. System Vendor: If other than the System manufacturer, shall be an authorized distributor of the System manufacturer. The distribution agreement by the manufacturer to the vendor must be one that includes full authority to distribute, sell, certify, program and maintain the manufacturer's complete product line whether included in this project or not. Service only, or sales only, System vendors will not be considered as meeting these requirements. The System vendor shall also maintain an in-house engineering department capable and experienced in the preparation of drawings, sketches, calculations and submittals which are required as part of this Contract. The System vendor shall have successfully completed at least three installations, which have included fire alarm system work, of similar type, size and complexity as described in this Specification and the Contract Drawings. Said installations shall be in satisfactory operation for a period of not less than one year, and shall have included at least one contract for the installation of a fire alarm system in an existing occupied building. The System vendor shall also maintain an in-house technical service department staffed with at least three field technicians factory trained and certified by the manufacturer to install, operate, certify and maintain the system to be installed.

4. System Maintainer: For the maintenance of Fire Alarm System required in 3.05 herein, the System maintainer may also be the System manufacturer, the System vendor, or a vendor authorized and certified by the manufacturer to perform testing and maintenance services on the System installed under this Contract. The System maintainer shall maintain an in-house technical service department staffed with at least three (3) field technicians factory trained and certified by the manufacturer to install, operate, certify and maintain the system to be installed. The System maintainer shall be licensed and/or certified to perform fire alarm system maintenance, as required by the jurisdiction where the installed system is located. The System maintainer must maintain a 24 hr. Emergency Field Service Staff, an Inventory of Parts to support the installed system and shall respond at the installed system site within 4 hours of a call for service.

B. Codes and Standard Requirements

1. Conform to the requirements of NFPA 70, all applicable local codes and all other publications referenced in 1.02 herein.

2. All fire alarm equipment, materials, devices and assemblies used on this Contract shall be listed and/or labeled by Underwriter's Laboratories, Inc. (UL), and by other Local jurisdiction as required, for the specific purpose for which they are used. The Contractor shall not alter, install or modify such equipment in any way so as to alter or void the listing or label.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in manufacturer's original unopened protective packaging.

B. Store materials in a clean, dry space and protect same from damage.

C. Handle in a manner to prevent damage. Damaged equipment shall be replaced.

D. Where possible protective coverings shall be installed to prevent equipment damage, and shall be remain in place until final testing and commissioning is completed.

E. Touch up damage to finishes to match adjacent surfaces, including recoating of galvanized or plated surfaces where damaged, cut or drilled.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with the requirements of this Section, including but not limited to 1.03 A, provide fire alarm systems of manufacturers as shown on the Contract Drawings.

2.02 GENERAL

A. The System shall consist of those components as shown on the Contract Drawings, including but not limited to Fire Alarm Control Panel(s), Annunciator(s), Initiating Devices, Notification Appliances, Auxiliary and Accessory Devices, Test and Programming software, firmware and hardware, and all wiring and wiring methods as shown on the Contract Drawings and as specified in this Section.

B. Provide a fully operational Code compliant system. Only current equipment manufactured within six (6) months of the installation date shall be utilized.

2.03 MATERIALS

A. Addressable Fire Alarm Systems

1. Addressable Fire Alarm Systems, where required on the Contract Drawings, shall provide discreet identification and status information of system modules and devices via an alphanumeric visual display and hardcopy printer. The system shall be microprocessor based and user software programmable.

2. Fire Alarm Control Panel(s)

a. Fire Alarm Control Panel(s) shall be of the type shown on the Contract Drawings.

b. Panel(s) shall have active zones/loops/circuits as required. The spare capacity for zones/loops/circuits shall be at least 20%, or as otherwise shown on the Contract Drawings. Initiating and notification circuit loading shall be limited to 80% of the maximum specified by the manufacturer for the design configuration, with the maximum to comply with code requirements or as specified in the Contract Documents, whichever is more stringent. In no case shall the circuits be loaded as to impede proper system operation.

c. Panel(s) shall be of modular construction using only solid state components and modules. Panels(s) shall contain all of the necessary components and modules to provide a complete operational code and specification compliant system, including spare capacity, as called for in the Contract Drawings.

d. All Panel Door(s) shall be painted except those as specified otherwise. All System controls shall reside behind a key locked steel door provided with viewing windows made of any material other than glass accepted as part of the product listings.

e. The System shall be programmable via an IBM compatible laptop computer and manufacturer-supplied software. The System shall be fully field programmable utilizing the laptop computer via an onboard system programming port with the System fully powered and in operation. Shutdown of the System, loss of System operation, or removal of the System memory chips shall not be acceptable as part of the normal programming method. The System program shall be stored onboard utilizing non-volatile memory IC(s). Upon power up from complete shutdown, the System shall automatically reboot using the last stored program. Operator intervention or reprogramming shall not be required.

f. The System shall provide a text area for each addressable module or device, designated as a "Custom Message Field" which shall be reserved for the Authority's use. The "Custom Message Field" shall be capable of displaying any character of the English alphabet in both upper and lower case and any Arabic numeric digit. The character capacity of the "Custom Message Field" shall be as specified in the Contract Drawings.

g. The System shall incorporate an automatic "watchdog" feature that will reboot the System in any event where the operating system or processor halts. Operation of the watchdog feature shall be both visually displayed and printed at the time of occurrence.

h. The System power supply shall be provided with two (2) sources of energy. The primary supply shall be 120 VAC single phase commercial power. The secondary supply shall be either an emergency standby generator(s) qualified as an emergency power supply for fire alarm systems of the type specified in this Contract or emergency standby batteries of the size and capacity required to meet the standby requirements of the System specified in this Contract. The system power supply shall automatically transfer between the primary and secondary power and vice versa. The power supply shall be monitored for integrity as required by applicable codes, standards and listings for the intended use.

i. The Panel(s) shall be UL listed as a test instrument for the measurement of the sensitivity of connected intelligent ionization and photoelectric smoke detectors to comply with the testing requirements of NFPA 72.

The fire alarm control panel shall provide a display and a printed list of these sensitivity measurements as a permanent record of the required sensitivity testing.

The fire alarm control panel shall be programmed and the connected ionization and photoelectric light refracting smoke detectors shall be capable of self adjustment to compensate for the accumulation of contaminants that would change the detector sensitivity in either a more or less sensitive direction. The adjustment shall keep the relationship between the sensing chamber and the programmed alarm threshold voltage constant to prevent false indications of the failure to alarm in the presence of smoke.

The fire alarm control panel shall annunciate a trouble condition when any smoke detector approaches 80% of its alarm threshold due to gradual contamination, signaling the need for service and eliminating unwanted alarms. The trouble report shall annunciate the specific location of the smoke detector requiring service.

3. Initiating Devices - Pull Stations

Provide manual fire pull stations where indicated on the Contract Drawings. Stations shall be painted red. Where specified on the Contract Drawings the station shall also include either an integral white stripe or an accessory backing plate with white stripe. The white stripe shall be (1) one-inch wide and placed diagonally from top left to bottom right of the station. The stripe shall not obscure the stations operating instructions. The station shall be operable without the use of a special key or other device not part of the station, except in the case of resetting. The station shall be constructed of materials specified in the Contract Drawings. All stations shall be single action unless otherwise specified. The device shall be field programmable.

4. Initiating Devices - Open Area Detectors

Provide automatic detection devices where indicated on the Contract Drawings. All automatic detection devices shall be resettable from the control panel. Detectors shall include the use of a separate base assembly. The base assembly shall not include detection electronics which shall be housed in the detector. The detector shall be removable from the base assembly without the use of tools and without disturbing wiring connections. The device shall be field programmable.

5. Initiating Devices - Duct Detectors

a. Provide automatic detection devices where indicated on the Contract Drawings. All automatic detection devices shall be resettable from the control panel. Detectors shall include the use of a separate housing assembly. The housing assembly shall not include detection electronics that shall be housed in the detector. The housing assembly may contain an auxiliary local relay. The detector shall be removable from the housing assembly without the use of special tools and without disturbing wiring connections. The device shall be field programmable.

b. Detectors used in air duct applications shall be listed for this use. The air velocity ratings of the housing, sampling tubes or detector shall not be less than the air velocities expected to occur in the air handling system duct at the point of insertion. Duct Housings shall be installed to avoid undesirable flow restrictions and turbulence according to the manufacturer's installation instructions.

c. Duct detection devices shall have provisions for the use of a remote location indicator.

6. Initiating Devices - System Interfaces

a. Provide System interface modules where indicated on the Contract Drawings. System interfaces shall allow for the monitoring of conventional dry contact inputs to the System. The Interface shall supervise the dry contact inputs through use of an end of line device (EOL). EOL devices shall be placed across the contacts being monitored and not at the interface. The device shall be field programmable.

b. The System Interface Modules shall be available in the following versions:

Dual Input
Single input
Single Input and Single Form C Contact Output

7. Notification Appliances

a. Provide system notification appliances where indicated on the Contract Drawings. System notification appliances shall provide either audible, visual or combination audible and visual indication as indicated on the Contract Drawings. Notification appliance field wiring connection shall be accomplished using an integral terminal strip with screw & binding plate fasteners. Each appliance terminal position shall permit (2) single conductor # 14 stranded or solid wires to be attached without the use of wire loops, wire nuts, wire terminals or other methods other than a straight in connection. Appliances employing "pigtail" or "flying lead" field connections shall not be used.

Appliance source voltages shall be 24VDC for visuals, 24 VDC for coded and non-coded bells, and horns, and either 25VAC or 70.7VAC, based on system platform, for voice/tone speaker appliances. All appliances shall be UL Listed and UL Cross-listed for the Base System utilized. Appliances shall be red in color unless otherwise specified on the Contract Drawings.

b. The system notification appliances shall be available in the following versions:

(1) 4", 6", 10", 12" Motor or ElectroMechanically Operated Bells.

(2) 4", 6", 10", 12" Motor or ElectroMechanically Operated Bells with 15, 30, 15/75, 75, 110 Candela Strobe Lights.

(3) Single and Multitone Electronic Horns.

(4) Single and Multitone Electronic Horns with 15, 30, 15/75, 75, 110 Candela Strobes.

(5) Electronic Strobes, 15, 30, 15/75, 75, 110 Candela Outputs.

(6) Speakers, 25VAC or 70.7VAC MultiTap Wall and Ceiling-Mounted.

(7) Speakers, 25VAC or 70.7VAC MultiTap Wall-Mounted with 15, 30, 15/75, 75, 110 Candela Strobes.

(8) Accessory mounting plates, boxes, trim rings and guards.

B. Conventional Fire Alarm Systems

1. Conventional (Non-Addressable) Fire Alarm Systems, where required on the Contract Drawings, shall provide area or zone type identification of system devices. The visual display may consist of either an LED lamp display, an LED segmented display or a combination of both.

2. Fire Alarm Control Cabinet(s)

a. Fire Alarm Control Panel(s) shall be of the type shown on the Contract Drawings.

b. Panel(s) shall have active zones/loops/circuits as required. The spare capacity for zones/loops/circuits shall be at least 20%, or as otherwise shown on the Contract Drawings. Initiating and Notification Circuit loading shall be limited to 80% of the maximum specified by the manufacturer for the design configuration, with the maximum to comply with code requirements or as specified on the Contract Drawings whichever is more stringent. In no case, shall the circuits be loaded as to impede proper system operation.

c. Panel(s) shall be of modular construction of only solid state components and modules. Panels(s) shall contain all of the necessary components and modules to provide a complete operational code and specification compliant system, including spare capacity as called for in the Contract Drawings.

d. All panel door(s) shall be painted red, except those as specified otherwise. All System controls shall reside behind a key locked steel door provided with viewing windows made of any material other than glass accepted as part of the product listings.

e. The system power supply shall be provided with two (2) sources of energy. The primary supply shall be 110 VAC single-phase commercial power. The secondary shall be either an emergency standby generator(s) qualified as an emergency power supply for fire alarm systems of the type specified in this Contract or emergency standby batteries of the size and capacity required to meet the standby requirements of the System specified in this Contract. The System power supply shall automatically transfer between the primary and secondary power and vice versa. The power supply shall be monitored for integrity as required by applicable codes, standards and listings for the intended use.

3. Initiating Devices - Pull Stations

Provide manual fire pull stations where indicated on the Contract Drawings. Stations shall be painted red. Where specified on the Contract Drawings the station shall also include either an integral white stripe or an accessory backing plate with white stripe. The white stripe shall be (1) one inch wide and placed diagonally from top left to bottom right of the station. The stripe shall not obscure the stations operating instructions. The station shall be operable without the use of a special key or other device not part of the station, except in the case of resetting. The station shall be constructed of materials specified in the Contract Documents. All stations shall be single action unless otherwise specified.

4. Initiating Devices - Open Area Detectors

Provide automatic detection devices where indicated on the Contract Drawings. All automatic detection devices shall be resettable from the control panel. Detectors shall include the use of a separate base assembly. The base assembly shall not include detection electronics that shall be housed in the detector. The detector shall be removable from the base assembly without the use of tools and without disturbing wiring connections.

5. Initiating Devices - Duct Detectors

a. Provide automatic detection devices where indicated on the Contract Drawings. All automatic detection devices shall be resettable from the control panel. Detectors shall include the use of a separate housing assembly. The housing assembly shall not include detection electronics that shall be housed in the detector. The housing assembly may contain an auxiliary local relay. The detector shall be removable from the housing assembly without the use of special tools and without disturbing wiring connections.

b. Detectors used in Air Duct Applications shall be listed for this use. The air velocity ratings of the housing, sampling tubes or detector shall not be less than the air velocities expected to occur in the air handling system duct at the point of insertion. Duct housings shall be installed to avoid undesirable flow restrictions and turbulence according to the manufacturer's installation instructions.

c. Duct detection devices shall have provisions for the use of a remote location indicator.

6. Notification Appliances

a. Provide system notification appliances where indicated on the Contract Drawings. System notification appliances shall provide either audible, visual or combination audible and visual indication as indicated on the Contract Drawings. Notification appliance field wiring connection shall be accomplished using an integral terminal strip with screw and binding plate fasteners. Each appliance terminal position shall permit (2) single conductor # 14 stranded or solid wires to be attached without the use of wire loops, wire nuts, wire terminals or other methods other than a straight in connection. Appliances employing "pigtail" or "flying lead" field connections shall not be used.

Appliance source voltages shall be 24VDC for visuals, 24 VDC for coded and non-coded bells, and horns, and either 25VAC or 70.7VAC, based on system platform, for Voice/Tone Speaker appliances. All appliances shall be UL listed and UL cross-listed for the base System utilized. Appliances shall be red in color unless otherwise specified on the Contract Drawings.

b. The system notification appliances shall be available in the following versions:

(1) 4", 6", 10", 12" Motor or ElectroMechanically Operated Bells.

(2) 4", 6", 10", 12" Motor or ElectroMechanically Operated Bells with 15, 30, 15/75, 75, 110 Candela Strobe Lights.

(3) Single and Multitone Electronic Horns.

(4) Single and Multitone Electronic Horns with 15, 30, 15/75, 75, 110 Candela Strobes.

(5) Electronic Strobes, 15, 30, 15/75, 75, 110 Candela Outputs.

(6) Speakers, 25VAC or 70.7VAC MultiTap Wall and Ceiling Mounted.

(7) Speakers, 25VAC or 70.7VAC MultiTap Wall-Mounted with 15, 30, 15/75, 75, 110 Candela Strobes.

(8) Accessory mounting plates, boxes, trim rings and guards.

PART 3. EXECUTION

3.01 EXAMINATION

Inspect all system equipment and accessories prior to installation. Replace any damaged items.

3.02 PREPARATION

A. Field verify dimensions and coordination of conduit entry and all other mounting conditions with the entity manufacturing the equipment.

B. Arrange for the entity manufacturing the equipment to provide on-site technical supervision during installation and interconnection of the system equipment. Said supervision is to ensure the proper installation and operation of the System equipment, prior to the installed System beginning the final acceptance test.

C. After the System has been delivered, an on-site inspection will be made by the Engineer. If any equipment has been damaged or for any reason does not comply with the requirements of this Section, the Contractor shall be required to replace the equipment at no additional cost to the Authority, even though the equipment has been previously inspected, tested and approved for shipment. After such satisfactory replacement, the System shall be installed.

3.03 INSTALLATION

A. Install all materials in accordance with the codes and standards referenced in 1.02 and in accordance with the Specifications, Contract Drawings and approved plans, shop drawings and other submittals.

B. Air duct detectors shall be installed in air handling units downstream of filters and shall be provided with a pair of sampling tubes of the length recommended by the manufacturer, for proper sensitivity and operation.

C. Wiring

1. All fire alarm cables shall be type FPLP-UL (fire alarm approved cable), twisted pair #14 gauge (unless otherwise shown on the Contract Drawings), solid copper, 200° C, 600V, shielded (or unshielded as required), insulated conductors, with FEP insulation, and conductors colored black and red. All wiring, raceways, fittings, connectors and enclosures shall be UL Listed for the intended use. Conductor terminations shall be by methods as approved by the Engineer, and as indicated on the Contract Drawings.

2. All fire alarm control and power wiring shall be in hot-dipped galvanized steel (thick wall) conduit, or as specified on the Contract Drawings.

3. Wiring for device circuits, signaling circuits, and indicating appliance circuits shall be power-limited type. System wiring shall not be mixed in raceways with other wiring. Power-limited and non-power-limited circuits shall be run in separate raceways.

4. Minimum conduit size shall be provided as required by NFPA 70, or any other local codes, using the actual cross-sectional area of the wiring to be installed. Unless otherwise noted, minimum conduit size shall be 3/4".

5. All junction boxes, pull boxes, or other appurtenance which permits entry into the conduit system shall be painted red. Insulation or covering of wires and cables shall be factory color coded by use of color compounds. The color code shall be consistent throughout the performance of the work. Each pair of wires shall have a black and a red colored insulated conductor. Red shall be used for circuits with a positive (+) potential and black shall be used for circuits with a negative (-) potential.

6. All wires shall be identified with flame-retardant, low profile, labels as specified on the Contract Drawings.

D. Grounding

1. Install grounding bushings on all conduits penetrating fire alarm enclosures. Ground all equipment, wireways, enclosures and circuits as shown on the Contract Drawings. Measure, record and report shield/drain resistance utilizing an insulation resistance test meter. Submit a copy of the original test report to the Engineer for approval.

3.04 TRAINING

Operation and training for the system shall be a half-day seminar provided to Authority designated personnel through the means of practical demonstrations, technical literature and other related teaching procedures unless otherwise shown on the Contract Drawings. The training shall be conducted at the construction site.

3.05 MAINTENANCE

Furnish full preventive and remedial maintenance service for the fire alarm system, including all labor, parts, materials and supplies until the issuance of the Certificate of Final Completion. The Contractor shall respond to service calls by responding at the site within four hours of the call 24 hours a day, 7 days a week, including holidays.

3.06 FIELD TESTING

A. No system devices, modules, or other system electronics shall be connected to any circuit, prior to or during testing. Any equipment damaged due to testing shall be replaced by the Contractor at no additional cost to the Authority.

B. All wiring not supplied as part of the manufactured control panel shall be tested by the Contractor in accordance with the test criteria listed on the test reports specified in the Section entitled "Field Testing of Wiring". Prior to testing, field wiring shall not be connected to any equipment except external terminal blocks.

C. All testing prescribed by, and within, the test reports shall be accomplished in the presence of the Engineer only after all wiring work is completed. Conduit, condulet, pull box and junction box terminations shall be completed prior to testing. Once testing has been completed, the tested wiring shall not be disturbed. Any connection or wire that must be reworked shall be re-tested. Any conduit that has its contents modified in any way shall have all of its circuit conductors re-tested.

D. Test instruments (Meggers, Volt/Ohm Meters, etc.) used for testing as part of this Contract shall have been tested and calibrated within the last twelve (12) months and shall be evidenced by a certificate. A copy of the calibration certificate for each instrument used shall be submitted.

E. Field Wiring Test Reports shall be submitted, in duplicate, to the Engineer for approval. One copy shall be the original and one copy a photocopy. The reports shall be legibly handwritten. Typewritten reports will not be acceptable.

F. Field wiring will only be connected to the fire alarm equipment and devices once the test reports have been approved by the Engineer. Field wiring shall only be connected to the fire alarm panel(s) in the presence of a factory-trained technician acceptable to the System manufacturer and the Engineer, unless otherwise indicated on the Contract Drawings.

G. All fire alarm equipment, panels, detectors, signals etc. shall be fully pre-tested and shall have passed a 30-day operational test prior to presentation for final acceptance test. All Punch List items, defective or damaged equipment or backordered items shall be replaced, installed and or completed prior to the pre-test and final acceptance test. Upon satisfactory completion of the pre-test, the Engineer shall be notified in writing that the pre-test has been completed and that the system is in full conformance with the Contract Documents and ready for the final acceptance test.

H. The final acceptance test of the fire alarm system shall be performed by the System manufacturer's authorized technicians in the presence of the Engineer and shall consist of but shall not be limited to all fire alarm System panels, notification appliances, initiating devices, interface modules, off premise monitoring, and auxiliary functions. The Engineer will also witness the test. It shall be the sole responsibility of the System vendor to supply, and prepare any and all resources necessary to conduct and document the final acceptance test as prescribed by these Specifications, the Contract Drawings and NFPA 72.

END OF SECTION

SECTION 16720

FIRE ALARM SYSTEMS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Layout drawings with dimensioned locations and quantities of each device.
2. System riser drawings detailing system equipment location and type, and reference notation to each drawing.
3. Wiring and conduit details indicating numbered wires and terminals, and size and routing of each conduit and wire.
4. System calculations detailing system power requirements, battery standby calculations, voltage drops, resistance, and capacitance limits as set by the manufacturer and wiring size as set by the manufacturer.

B. Catalog Cuts and Installation Sheets

1. Manufacturer's current catalog cut and installation sheet for each product utilized in the System specified including:
   a. Fire Alarm wires.
   b. Speakers.
   c. Horns.
   d. Strobes.
   e. Strobe/horn units.
   f. Pull station.
   g. Power wiring.
   h. Warden telephones.
   i. Standpipe phone jacks.
   j. Air duct detectors.
   k. Heat smoke detectors.
   l. Supervisory switches.
   m. Conduits, fittings, boxes, terminal strip cabinets.
   n. Cutout switch.
   o. Relays.
   p. Interface modules.

q. Fire alarm command station.

r. Fire alarm control panel.

s. Computers and components.

t. Fire alarm accessory equipment.

u. Wire labeling system.

2. Copies of all UL listing documents, as provided by the manufacturer, for each product utilized in the System.

3. Copies of all NYC/MEA listing documents and resolutions (report of Material and Acceptance Test Division), as provided by the manufacturer, for each product utilized in the System.

a. System circuit test results.

b. Factory test reports.

C. Spare Parts

Submit a complete list of recommended spare parts, which shall include those spare parts required to be furnished in compliance with the requirements of this Section for approval by the Engineer.

D. Test Plans

Prepare and submit to the Engineer for approval a performance testing plan for the entire system a minimum of 30 days in advance of the earliest, approved, scheduled inspection and test date. The system shall be divided into the following stages:

1. Inspection upon arrival at the construction site.

2. On-site inspection and test immediately following the complete installation of the system to demonstrate compliance with the requirements of this Section.

3. A 30-day operational test commencing with the successful completion of the on-site inspection and test.

E. Training

Prior to the on-site inspection and test of the system, prepare and submit to the Engineer for approval a fire alarm system curricula, in accordance with the requirements of this Section.

END OF APPENDIX "A"

SECTION 16720

FIRE ALARM SYSTEMS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in this Section:

(1.02)	Define System as addressable or conventional.
(2.02 A.2.h)	Pertaining to New York City applications, the primary supply shall be a three (3) wire 120VAC circuit. This circuit shall be fed via a fuse cutout connected on the line side of the emergency electrical service.
(2.02.3)	Pull stations shall be made of metal when utilized in New York City. Pull stations, in New York City, of a Fire alarm system connected to a Central Monitoring System shall be painted with a white stripe.
(3.01 A)	Final connections shall be by others, or as directed by the maintenance group at the facility, when working on an existing active system.
Other	Specify proper taps for fire alarm speakers.

B. Other Items

1. Spare Parts: The entire fire alarm system shall be furnished with at least 10% spare capacity (and 20% zones/loop/circuits spare capacity), or as required by the facility maintenance group. These spare parts shall match installed products exactly, be packaged with protective coverings, and be clearly identified. The spare parts shall include, but not be limited to the following: speakers, strobes, strobe lamps, smoke detectors and bases, combination strobe/horn units, pull stations, warden telephones, standpipe phone jacks, interface modules, batteries, power supplies, internal boards and cards, and computer hardware.

2. If a maintenance agreement is required (after final completion), use separate maintenance agreement format (see Contract Engineer).

3. Specify the size, in number of hours, of the battery backup system. The size should be based upon the applicable codes at the facility.

4. For addressable fire alarm systems, ensure that the System source code be placed in an escrow account to ensure accessibility to the Authority. The details of the escrow agreement must be approved by the law department, and incorporated in the Division 1 portion of the Contract book.

5. Specify the number of training courses requiring based on the facility maintenance group.

6. Review the test report requirement and modify as required.

7. Specify the "Custom Addressable Message", if the fire alarm panel is addressable.

C. Submittals: Specify required submittals by editing Appendix "A" - "Submittals".

END OF INSTRUCTIONS

DIVISION 16

SECTION 16766

TOLL BOOTH AM/FM RADIO

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies requirements for AM/FM Radio Systems in toll booths.

B. Each toll booth system shall include one AM/FM Radio Receiver, two Speakers, one Antenna, and one power supply.

1.02 DELIVERY, STORAGE, AND HANDLING

A. Deliver system components and accessories in manufacturer's original, unopened, protective packaging.

B. Store system components and accessories in a clean, dry space and protect them from weather.

C. Handle in a manner to prevent damage to finished surfaces.

D. Where possible, maintain protective coverings until installation is complete and remove such coverings as part of final cleanup.

E. Touch up damage to finishes to match adjacent surfaces.

1.03 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 AM/FM RADIO RECEIVER

The AM/FM radio receiver shall be an electronically tuned receiver with no tape cassette player, Blaupunkt Model "Frankfurt SQM36", or approved equal.

2.02 SPEAKERS

A. The AM/FM radio system shall have two speakers, one each defined as left and right. The speakers shall be "Minimus - 7", 40 watt speakers, black in color, Radio Shack No. 40-2030, or approved equal.

B. The mounting brackets for the speakers shall be Radio Shack No. 40-2031, or approved equal.

2.03 AM/FM RADIO ANTENNA

The AM/FM radio antenna shall be a universal pillar mount, three-section whip, adjustable from 19-1/2 inches to 51 inches, Radio Shack No. 12-1320, or approved equal.

2.04 POWER SUPPLY

The AM/FM radio power supply shall be a regulated high performance 12 Volt DC power supply capable of providing 3.3 amps of output current at 55 degrees C, with regulation of 0.005%, Acopian No. A12MT400, or approved equal.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install system components in locations shown on the Contract Drawings, in accordance with manufacturer's instructions and approved Shop Drawings.

B. Wiring and interconnections between system components shall be done in accordance with manufacturer's instructions and approved Shop Drawings.

C. Make the necessary interconnections between the AM/FM radio system and the toll booth intercom system as shown on the Contract Drawings.

D. Align the antenna so that maximum reception of signal is achieved. Demonstrate overall satisfactory performance of the AM/FM radio system to the Engineer.

END OF SECTION

SECTION 16766

TOLL BOOTH AM/FM RADIO

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Wiring and installation drawings.
2. System Block and Wiring Diagrams.

B. Catalog Cuts

1. Equipment.
2. Wires and Cables.
3. Accessories.

END OF APPENDIX "A"

SECTION 16766

TOOL BOOTH AM/FM RADIO

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(3.01 A) Locations of system components.

(3.01 B) Interconnections between Toll Booth AM/FM System and Toll Booth Intercom System.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16782

CLOSED CIRCUIT TELEVISION (CCTV) SYSTEM

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for a Closed Circuit Television (CCTV) System.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

	Electronic Industries Association (EIA)
EIA-170	Electrical performance Standards - Monochrome Television Studio Facilities
EIA-232	Interface between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange
EIA-250	Electrical Performance Standards for Television Relay Facilities
EIA-422	Electrical Characteristics of Balanced Voltage Digital Interface Circuits
	National Fire Protection Association (NFPA)
NFPA 70	National Electrical Code
	New York City Building Code (NYCBC)
	New York City Electrical Code (NYCEC)

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. Unless otherwise specified on the Contract Drawings or in this Section, the Closed Circuit Television System, hereinafter referred to as the "System," manufactured, supplied, and installed shall conform to the requirements of NFPA 70, all local codes, all other publications referenced in Article 1.02 herein.

B. The electrical and electronic hardware, structural materials, and equipment housings, required for fully operational, integrated, real-time System shall operate on a twenty-four (24) hour per day, seven (7) day per week basis with high system reliability of 99.7 percent and shall conform to the requirements of this Section.

C. The System shall be composed of all items of hardware necessary to generate, transmit, and effect the display of changeable message text on fiberoptic sign panels as specified herein and as shown on the Contract Drawings. In general, the System shall consist of readily available, reliable and proven hardware, software, and firmware elements which fully comply with the requirements of this Section and the Contract Drawings. All of the Work of this Section shall be coordinated with the current operation of the facility.

D. Provide video communications between the points of surveillance and the location(s) of the CCTV monitor(s) specified on the Contract Drawings.

1. Cameras: The number of CCTV cameras to be supplied shall be as shown on the Contract Drawings.

2. Monitors: The number of CCTV monitors to be supplied shall be as shown on the Contract Drawings.

3. Configuration: Unless otherwise specified on the Contract Drawings, the configuration of the CCTV system shall conform to EIA-250, with 1 volt peak-to-peak across 75 ohms.

4. Distribution: Baseband, DC to 6 MHz.

1.04 QUALITY ASSURANCE

A. Qualifications

1. Contractor: Demonstrate a minimum of five (5) years experience and technical expertise in performing contracts comparable in size and complexity, and that the work was performed skillfully in a satisfactory manner and on time. Submit a complete list, which shall consist of a minimum of three (3) installations, one (1) of which shall be located in the United States, which shall have included work, comparable in type, size, and complexity as described herein under Article I "Introduction." Said installations shall be in satisfactory operation for the last three consecutive years, minimum.

2. System Integrator: The system and its components shall be supplied by one System Integrator of established reputation and experience who shall have furnished and provided technical assistance and shall have performed systems integration for the installation of CCTV Systems for that last three consecutive years and shall demonstrate prior experience on at least two projects of similar size and complexity to what is required under this Contract.

3. Equipment: CCTV equipment shall have been satisfactorily used in projects of similar size and complexity for not less than two years.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in manufacturer's original, unopened, protective packaging.

B. Store materials in a clean, dry space, protected from weather.

C. Handle in a manner to prevent damage to finished surfaces.

D. Where possible, maintain protective covering until installation is complete and remove such coverings as part of final cleanup.

E. Touchup damage to finishes to match adjacent surfaces, including recoating of galvanized or plated surfaces where damaged, cut, or drilled.

1.06 SPARE PARTS

A. The Contractor, or his authorized representative, shall confirm that there are a minimum of three (3) established agencies within the Port Authority District, which stock a full inventory of spare parts for the system supplied. In the event that there are not three (3) sources of supply, the Contractor warrants that all system components will be made available by the Contractor for a period of ten (10) years from the date of acceptance of the system.

1.07 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with the requirements of this Section, provide the following of one of the manufacturers specified on the Contract Drawings:

1. CCTV Cameras
2. CCTV Monitors
3. CCTV Camera Mounts
4. CCTV Camera Enclosures
5. CCTV Camera Lenses
6. CCTV Video Switchers
7. CCTV Video Motion Detectors
8. Video Distribution Amplifiers
9. Audio Distribution Amplifiers
10. Time-Lapse Video Cassette Recorders
11. Video Copy Processors

2.02 EQUIPMENT

A. General

1. All electrical materials and equipment for which there are established UL standards shall bear the UL label.
2. The CCTV equipment operating voltages shall be as specified on the Contract Drawings.

B. Camera(s)

1. Unless otherwise specified on the Contract Drawings, all cameras shall be enclosed in a protective or environmental housing. Housings shall be complete with all accessories as specified on the Contract Drawings.

2. Unless otherwise specified on the Contract Drawings, all cameras shall be monochrome, high performance, high resolution cameras with 2/3" format frame transfer image sensor and high sensitivity.

3. Unless otherwise specified on the Contract Drawings, each CCTV camera shall come with zoom lenses having automatic iris, which have focal lengths and apertures as specified on the Contract Drawings. The field of view shall be adjusted to the satisfaction of the Engineer.

C. Mounts

1. Fixed camera mounts shall provide a non-vibrating, adjustable support for camera and enclosure.

2. Pan and tilt mounts, for direct control, shall be the heavy-duty type and shall be 100% compatible with the video switcher furnished by the Contractor.

D. Monitors: Unless otherwise specified on the Contract Drawings, all CCTV monitors shall be monochrome, high performance raster scan displays with an average mean-time-between-failure (MTBF) of 50,000 hours, and meeting the following criteria, minimum:

Maximum Resolution:	1000 TV lines at center 800 TV lines at corner
Bandwidth:	30 MHz
Horizontal Frequency:	15.5 - 16.0 kHz
Vertical Frequency:	50 - 70 Hz
Power:	90-270 VAC, 50/60 Hz
User Controls:	Power On/Power Off Horizontal Position Adjustment Vertical Position Adjustment Vertical Size Contrast Brightness VTR Switch A/B Switch
Inputs:	A/B BNC with loop-through, auto terminating
Mounting Type:	as specified on the Contract Drawings

PART 3. EXECUTION

3.01 EXAMINATION

A. Inspect all System equipment, and accessories prior to installation. Replace any damaged items.

B. Ensure that the spaces where any electronic equipment is to be stored and/or installed is completely free from any foreign substances, such as concrete dust, water, or any other material that may otherwise be harmful to electronic equipment and connections. No allowances shall be made to the Contractor for equipment damage, or delays due to environmental/security damage.

3.02 PREPARATION

A. The Contractor shall be responsible for field verification of dimensions and coordination of conduit entry and all other mounting conditions with the entity manufacturing the equipment.

B. The entity manufacturing the equipment shall provide on-site technical supervision and assistance during installation and interconnection of the system equipment installed by the Contractor. Said supervision is to insure the safety of the proper installation and operation of the system equipment, prior to the installed system beginning the 30-day operational test.

C. After the system equipment has been delivered, an on-site inspection will be made by the Engineer. If any equipment has been damaged or for any reason does not comply with the requirements of this Section, the Contractor will be notified in writing, and shall be required to replace the equipment at his own cost and expense, even though the equipment has been previously inspected, tested, and approved for shipment. After such satisfactory replacement, the system shall be installed by the Contractor.

3.03 INSTALLATION

A. Install all System equipment in accordance with the manufacturer's written instructions in the locations shown on the Contract Drawings.

B. All control power and data communications wire shall be wired and harnessed within the equipment enclosures shown on the Contract Drawings.

C. All wiring shall be clearly labeled with function and wire identification number corresponding to the manufacturer's wiring diagrams and/or approved Shop Drawings.

D. Where external circuit connections are required, terminal blocks shall be provided and the manufacturer's drawings must clearly identify the interconnection requirements including wire type to be used.

E. All wiring required to externally connect equipment lineups shall be installed by the electrical contractor.

F. Contractor interconnection wiring requirements shall be clearly identified on the "AS-BUILT" system drawings.

3.04 FIELD TESTS

A. After installation, the equipment shall be tested to show compliance with this Section. The Contractor shall submit the proposed testing procedure to the Engineer for approval two weeks prior to proposed start of test. Said testing shall continue until the results are satisfactory to the Engineer. Any repairs, construction, or modifications as required to comply with this Section shall be performed by the Contractor without additional cost to the Authority.

B. After satisfactory completion of testing, a 30-day operational test shall commence. The Contractor shall correct any malfunctions as they occur, said malfunctions including, but not being limited to, equipment failure or failure of the System to comply with this Section. After the Contractor corrects a malfunc-tion, at no cost to the Authority, the 30-day test shall restart, at day one, and shall continue until the results are satisfactory with written approval of the Engineer.

C. The Contractor shall completely check out, calibrate and test all connected hardware and software to insure that the system performs in accordance with the requirements of this Section and sequences of operation submitted.

D. The Contractor shall submit a test report detailing compliance with the requirements of item B and item C above.

E. 30-Day Operational Test

1. Testing shall be performed to verify compliance with the requirements of this Section and shall be performed in accordance with the approved testing plan. Correct any malfunctions as they occur, said malfunctions shall include, but not be limited to, equipment failure or failure of the System to comply with the requirements of this Section. After corrections have been made, the 30-day operational test shall restart and shall continue until the results are satisfactory to the Engineer for a period of 30 consecutive days.

2. Maintain a log during all operational testing. Include a narrative description of corrective measures required and items required or replaced.

END OF SECTION

SECTION 16782

CLOSED CIRCUIT TELEVISION (CCTV) SYSTEM

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

1. Estimated progress schedule of dates for the Work to include (but not necessarily be limited to) the following:
   a. Project start
   b. Shop drawing submittal
   c. Shop drawing approval
   d. On-site rough-in start
   e. Training Curricula submittal
   f. Training Curricula approval
   g. On-site rough-in completion
   h. Recommended spare parts list
   i. Proof of performance testing
   j. Acceptance testing
   k. Completion/Resolution of all submittals and/or punch list items
   l. Record documents submittal
   m. Final Acceptance
2. Complete Bill of Materials.
3. Shop Drawings
   a. System Block Diagram
   b. Detailed System Wiring Diagrams, indicating all field terminal block numbers
   c. Complete, comprehensive, single-line diagrams, including all equipment, devices, and cabling completely identified.
   d. System Logic Program
   e. Details of Proposed Computer Screen Displays, including descriptions of interactive screen features.
   f. Command Description and Language
   g. Wire
   h. Enclosures and all Devices

4. Catalog Cuts

   a. CCTV Cameras

   b. CCTV Monitors

   c. CCTV Camera Mounts

   d. CCTV Camera Enclosures

   e. CCTV Camera Lenses

   f. CCTV Video Switchers

   g. CCTV Video Motion Detectors

   h. Video Distribution Amplifiers

   i. Audio Distribution Amplifiers

   j. Time-Lapse Video Cassette Recorders

   k. Video Copy Processors

   l. Wire and Cable associated with the installation of the CCTV system

   m. Cable connectors

5. Samples

   a. Color printouts of all workstation screen graphics

6. Spare Parts: Submit a complete list of recommended spare parts, which shall include those spare parts required to be furnished in compliance with the requirements of this Section, for approval by the Engineer.

7. Performance Testing Plan: Prepare and submit to the Engineer for approval a performance testing plan for the entire system a minimum of 30 days in advance of the earliest, approved, scheduled inspection and test date. The system test plan shall be divided into the following stages:

   a. Inspection of the System upon arrival.

   b. On-site inspection and test immediately following the complete installation of the system, to demonstrate compliance with the requirements of this Section.

   c. A 30-day operational test commencing with the successful completion of the on-site inspection and test, approved by the Engineer.

8. Record Documents: Prior to the issuance of the Certificate of Final Completion, deliver to the Engineer the following:

   a. One (1) reproducible set of the Contract Drawings and Shop Drawings, which reflect actual locations and actual wiring details of system equipment and all revisions to the Work of this Section. In addition, nine (9) sets of prints of said Contract Drawings and Shop Drawings shall be supplied to the Engineer. Three (3) copies of said drawings shall be marked to the attention of the Facility Supervisor of Electrical Maintenance.

b. System Documentation

The following shall be included in the complete documentation package on the system which shall be furnished at the time of delivery of the System.

(1) Software Documentation

Three complete sets of documentation shall be submitted, explaining all system capabilities and options, including system set-up, operation, and maintenance (software manuals shall be supplied in hard copy only).

(2) Hardware Documentation

(a.) Three complete sets of system manuals shall be submitted explaining all system capabilities and options, including but not limited to the installation, set-up, operation, and maintenance of all equipment furnished.

(3) Operational Documentation

Twelve complete sets of system operations manuals shall be submitted which shall consist of the following:

(a.) Operations Run Book (To be supplied in hardcopy only)

(b.) Detailed description of normal system operation

(c.) Error and Alarm handling Procedures

(d.) System Start up and Shutdown Procedures

(e.) Use of Various Logs and Output Data by Operator to Improve System Efficiency

(f.) Description of Operating Procedure and Troubleshooting Procedures for each subsystem

(g.) System Backup Procedures

(4) Test Procedures

Recommended system test procedures shall be no less than thirty days prior to scheduled factory test date.

Test shall include the following:

(a.) Factory test of system as witnessed by the Authority.

(b.) Field test of system prior to connection to substation components as witnessed by the Authority.

(c.) 30 day field performance test in which system shall operate without failure. If a failure is encountered, the 30-day test shall be restarted from the beginning.

END OF APPENDIX "A"

SECTION 16782

CLOSED CIRCUIT TELEVISION SYSTEM

INSTRUCTIONS TO SPECIFIERS

A. Contract Drawings

Ensure that the Contract Drawings show:

(1.03 A)	On plan drawings, all CCTV cameras to be installed, orientated to show the location to be surveilled. On plan and/or elevation drawings, all CCTV monitors to be installed, including a description of the CCTV video to be displayed on each monitor.
(2.01 A.1)	Specify the mfg. and model no. of all acceptable CCTV cameras, including all accessories, i.e. lenses, mounts, sealed, pressurized environmental enclosures. Specify at least two manufacturers (Cohu and Burle).
(2.01 A.2)	Specify the mfg. and model no. of all acceptable CCTV monitors. Specify at least two manufacturers (Cohu and Electrohome).
(2.01 A.6)	Specify the mfg. and model no. of all acceptable CCTV video switchers. Specify at least two manufacturers (American Dynamics and Javelin).
(2.01 A.7)	Specify the mfg. and model no. of all acceptable CCTV video motion detectors. Specify at least two manufacturers.
(2.01 A.8)	Specify the mfg. and model no. of all acceptable video distribution amplifiers. Specify at least two manufacturers.
(2.01 A.9)	Specify the mfg. and model no. of all acceptable audio distribution amplifiers. Specify at least two manufacturers.
(2.01 A.10)	Specify the mfg. and model no. of all acceptable time-lapse video cassette recorders. Specify at least two manufacturers.
(2.01 A.11)	Specify the mfg. and model no. of all acceptable video copy processors. Specify at least two manufacturers.
(2.02 A.2)	Specify the CCTV equipment operating voltages, or, specify what voltages will be supplied at each equipment location.
(2.02 B.1)	Specify the type of housings for CCTV cameras (usually with Cohu cameras, they must be the sealed, pressurized environmental type).
(2.02 B.2)	Specify the type of CCTV camera if the design requires a type not specified in this Section.
(2.02 B.3)	Specify the type of lenses if the design requires a type not specified in this Section.
(2.02 D.)	Specify the type of CCTV monitors if the design requires a type not specified in this Section.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16858

ELECTRIC HEATING CABLES

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for self-limiting and mineral insulated electric heating cables and accessories.

1.02 REFERENCE

The following is a listing of publications referenced in this section:

	National Fire Protection Association (NFPA)
NFPA 70	National Electrical Code
	National Electrical Manufacturer's Association (NEMA)
NEMA 250	Enclosure for Electrical Equipment (1000 Volts Maximum)
	Underwriters Laboratories, Inc. (UL)
UL 718K	Pipe Heating Cable
UL 877Z	De-icing and Snow-melting Equipment

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

The electric heating cable shall be designed, manufactured and installed in accordance with the latest revision of applicable standards NEMA, NFPA and UL. In case of conflicts between various standards, the more stringent requirements shall apply.

1.04 QUALITY ASSURANCE

Electric heating cable and accessories, of the type required, shall have been successfully used for purposes similar to those intended herein for not less than five years.

1.05 DELIVERY, STORAGE AND HANDLING

A. Deliver material in manufacturer's original unopened protective packaging.

B. Store materials in original packaging in a manner to prevent soiling, damage, wetting or corrosion prior to installation.

1.06 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide electric heating cable and accessories of the manufacturers listed on the Contract Drawings.

2.02 CONSTRUCTION FEATURES

Unless otherwise shown on the Contract Drawings, furnish materials and products in accordance with the following requirements:

A. Self Limiting Electric Heating Cable

1. The electric heating cable shall consist of an assembly of irradiated self-limiting resistive core material between two parallel circuit conductors, insulating primary jacket, insulated monitor wire (when shown on Contract Drawings), tinned copper protective braid and outer fluoropolimer jacket.
2. Cable shall be suitable for 120, 240 or 277 Volt single phase operation; voltage, length, type and wattage rating shall be as shown on the Contract Drawings.
3. For snow melting application the electric heating cable shall be U.L. approved for direct burial.
4. Cable lengths shall be confirmed by field measurements prior to purchase and installation of cable.

B. Mineral Insulated Electric Heating Cable

1. The mineral insulated electric heating cable shall be factory fabricated and shall consist of a heating section of specified length, joined to a cold section of required length connected to the branch circuit and controls in junction boxes located as shown on Contract Drawings.
   a. Heating section shall consist of two conductor alloy resistance wire, insulated with compressed magnesium oxide, and covered by metallic sheath.
   b. Cold section shall consist of two conductors mineral insulated, metallic sheathed cable with a current carrying capacity in accordance with NFPA 70.
   c. The sections shall be joined by a metallic sleeve, silver soldered or brazed to both cable sheaths. The conductors shall be butted together and silver soldered. The end cap on the hot sections shall be silver soldered or brazed to the cable sheath. The lead end shall be supplied with minimum 9-inch long high temperature leads, silver soldered to the cold section conductors, and enclosed in a sleeve fitting silver soldered to the cold section sheath.
   d. The metallic sheath shall be seamless, high thermal conductivity, high temperature corrosion resistant and flexible, such as stainless steel or copper.
   e. Cable gland end fitting shall be compatible with the cable sheath, and shall be furnished with the cable.
2. Cable shall be rated 300 Volts, minimum for 120, 208, 240 or 277 Volt single phase operation and rated 600 Volts for 480 Volt, single phase operation. The operating voltage, type, length and wattage rating shall be as shown on the Contract Drawings.

3. For snow melting application the electric heating cable shall be U.L. approved for direct burial.

4. Cable lengths shall be confirmed by field measurements prior to purchase and installation of cable.

2.03 ACCESSORIES

A. Thermostat(for pipe heating and freeze protection applications)

1. Thermostat shall be complete with a 10 foot length of stainless steel capillary tube and temperature sensitive bulb (for pipe temperature sensing), or with fluid filled ambient probe (for ambient temperature sensing). The contacts shall be single pole double throw, heavy duty, with a maximum non- inductive current interrupting capacity of 22 Amps, 120 Volt AC or as shown on the Contract Drawings.

2. For freeze protection of outdoor water lines the thermostat setting shall be fixed, non-adjustable set point of 40 degrees F with a differential of 3 degrees F and a set point accuracy of ±4 degrees F, used.

3. For pipe heating applications, unless shown on Contract Drawings, the thermostat shall have an adjustable set point, with a non-adjustable differential of 5-8 degree F and a set point accuracy of ±6 degree F. The thermostat range of operation shall be 0-100 degree F, with the set point as shown on the Contract Drawings.

4. The thermostat shall be housed in a die cast watertight NEMA 4 box.

B. Snow Detector (for snow melting applications)

When a snow detector is required and/or shown on the Contract Drawings, it shall be specifically designed for detection of snow condition, and shall be selected by the electric heating cable manufacturer for use in the intended snow melting application.

C. Indication Light

When an indication light monitoring the heating cable continuity is required and/or shown on the Contract Drawings, it shall have a red lens and be mounted in copper-free cast aluminum box. This light shall be suitable for cable voltage shown on the Contract Drawings and shall be manufactured by the selected system manufacturer or approved equal.

D. Monitoring Panel

Where shown on the Contract Drawings, a monitoring panel shall have six, twelve, or 24 pilot lights, as required , mounted in a heavy duty sheet metal NEMA 12 (indoor use) or NEMA 4x (outdoor use) enclosure, with a remote alarm module per cable and a Test/Reset switch. Function of the panel or what it is monitoring shall be as shown on the Contract Drawings.

E. Contactor

Where shown on the Contract Drawings, the contactor shall be rated 50 Amperes, 3-pole, 600 Volt with 120 VAC coil and shall include a Hand-Off-Auto selector switch.

F. Power Connections

The self-limiting electric heating cable shall be connected to the source of power by a Power Connection Kit, approved by the manufacturer for that particular application.

G. End Seal, Splice, and Expansion Joint Kits

All necessary electrical components required to complete a particular heating cable installation, such as end seals, splice, and expansion joint kits, etc. shall be as approved by the manufacturer of the cable for that particular application.

H. Pipe banding strap shall be stainless steel.

PART 3. EXECUTION

3.01 EXAMINATION

A. Verify that electrical installations, structural, mechanical and other related work satisfy the requirements for performance of the work for this Section in accordance with the Contract Documents.

B. Report immediately to the Engineer any electrical, structural or related construction defects in areas where electric heating cables are to be installed, and do not attempt to rectify any defect unless specifically instructed to do so by the Engineer.

C. Inspect all connections to electric heating cables.

3.02 PREPARATION

Before installation of the electric heating cables, the Contractor shall investigate the site condition to determine, what preparatory work, if any, will be needed.

3.03 INSTALLATION

A. General

1. Install electric heating cable system in accordance with the Contract Drawings, or approved shop drawings, and the requirements of this Section.
2. Determine the exact location of the power connection and termination of each heating section.
3. Field verify and coordinate the exact mounting location of the electric heating cable.

B. Pipe Heating Applications

1. Electric heating cable shall be installed in such a manner as to permit equipment servicing and removal without disturbing the cable on the pipe line. Follow typical installation procedures provided by the cable manufacturer.
2. The thermostat sensing bulb shall be located on the lowest part of the line to be protected and shall be secured with fiberglass tape.
3. In no case shall the thermostat sensing bulb touch the electric heating cable or be located at a point where performance will be influenced by the proximity of flanges, valves or other objects of high heat loss.

4. If an ambient temperature sensing thermostat is used in a freeze protection application, it shall be installed in a location where the lowest ambient temperature is expected, and there is no external sources of heat in the proximity of the sensing bulb.

5. Splice electric heating cable in accordance with manufacturer's recommendation. Cable shall not be spliced without the specific approval by the Engineer.

6. Install caution labels on pipe line insulation at five feet intervals.

C. Snow Melting Applications.

1. Electric heating cable shall be installed in concrete or asphalt paving and secured in place at 3-foot intervals, to maintain spacing and depth, as shown on the Contract Drawings.

2. To prevent damage during installation and paving, electric heating cable shall be installed with a minimum radius of bends as recommended by the manufacturer. Cables shall not be installed through expansion or score joints. Cable sections shall not intersect.

3. Junction boxes shall be located indoors if possible, or if outdoors, must be NEMA 4X weather tight construction and mounted a minimum of 18 inches above grade.

3.04 FIELD TEST

A. Electric heating cable and accessories shall be tested in accordance with manufacturer's start-up and field test instructions and requirements of this Section:

1. The electric heating cable shall be subjected to high potential testing per manufacturer's recommendation.

2. For pipe heating applications, the cable shall be tested before and after pipe insulation is applied.

3. For snow melting applications where electric heating cable is embedded in concrete or pavement, the cable shall be tested before (concrete or pavement) surface is applied, after surface is applied but before it has hardened, and after surface hardening.

B. All tests shall be performed in the presence of the Engineer. Reports of all tests made on the electric heating cable and accessories shall be submitted to the Engineer.

C. The Contractor shall correct any deficiencies discovered during the tests.

END OF SECTION

SECTION 16858

ELECTRIC HEATING CABLES

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

1. Shop Drawings

   Entire electric heating cable system, including:

   a. Size, length and dimensional heating cable layout (including pipeline if pipe heating application), total electrical loading, with all connection details and complete list of parts with full identification.

   b. Complete details of construction, wiring diagrams and schematics, connection details and interconnection requirements and parts identification of any electromechanical (control) devices, such as monitoring panels, contactors, if required to be furnished as part of the electric heating cable system.

2. Catalog Cuts

   a. Electric Heating Cable

   b. Power Connection Kit

   c. Splice Kit

   d. End Seal Kit

   e. Expansion Joint Kit

   f. Pipe Straps

   g. Thermostat

   h. Snow Detector

   i. Signal Light

   j. Warning Sign

   k. Monitor Panel

   l. Contactor

3. Submit 12 copies of field test reports.

END OF APPENDIX "A"

SECTION 16858

ELECTRIC HEATING CABLE

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in this section:

(2.01) List of manufacturers of electric heating cable and accessories (minimum - three)

1. Suggested list:

   a. Self Regulatin g Cable and Accessories:

      Thermon
      Nelson Electric, division of General Signal Corporation
      Raychem Corporation

   b. Mineral Insulated Cable and Accessories:

      Chromalox, E.L. Wiegand Division, Emerson Electric
      Nelson Electric, division of General Signal Corporation
      Easy Heat-Wirekraft Co.

      Manufacturers of equal qualifications to the above listing will be acceptable if approved by the Engineer.

(2.02) Include the name of materials and products other than specified
(2.02 A.1) Monitor wire, if required
(2.02 A.2) Cable voltage, length and wattage rating
(2.02.B.2)
(2.02.B.1) Branch circuit and controls in junction boxes
(2.04.A.1) Electrical rating of thermostat if other than specified
(2.04.A.2) Thermostat set point
(2.04.A.3)
(2.04.B) Snow detector
(2.04.C) Ind ication light
(2.04.D) Monitoring panel with required number of pilot lights and items to be monitored.
(2.04.E) Contactor
(3.03.A.1) Installation instructions
(3.03.C.1) Spacing and depth of installation of electric heating cable in the paving (for snow melting application)

2. Ensure that the following sections are included in the Contract Book:

   Section 16110 "RACEWAYS"
   Section 16120 "WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS)"
   Section 16135 "BOXES AND FITTING"

END OF INSTRUCTIONS

DIVISION 16

SECTION 16859

ELECTRIC HEATING CABLES (SELF-LIMITING TYPE)

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for self-limiting type electrical heating cables and accessories.

1.02 REFERENCES

The following is a listing of publications referenced in this Section:

National Electrical Manufacturer's Association (NEMA)

NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum).

National Fire Protection Association (NFPA)

NFPA 70 National Electrical Code.

Underwriters Laboratories Inc. (UL)

UL 718K Pipe Heating Cable.

UL 877Z Deicing and Snow-Melting Equipment.

1.03 QUALITY ASSURANCE

Heat tracing cables and accessories, of the type required, shall be of the type which have been successfully used for purposes similar to those intended herein for not less than five years.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver material in manufacturer's original unopened protective packaging.

B. Store materials in original packaging in a manner to prevent soiling, physical damage, corrosion, wetting or weather damage prior to installation.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with the requirement of this Section, provide self-limiting type electrical heating cable and accessories of one of the following system manufacturers, or approved equal:

Raychem Corporation
Nelson Electric
Thermon

2.02 CONSTRUCTION FEATURES

A. Heat Tracing Cable

1. The heat tracing cable shall consist of an assembly of irradiated self-limiting resistive core material between two parallel circuit conductors, and insulating primary jacket, insulated monitor wire (where shown on the Contract Drawings), tinned copper protective braid and an outer fluropolymer jacket.
2. Cable shall be suitable for 120, 220 or 227 Volt single phase operation; voltage, length and wattage rating shall be as shown on the Contract Drawings.
3. Cable lengths shall be confirmed by field measurements prior to purchase and installation of cable.

B. Thermostat

1. Thermostat shall be complete with a 10-foot length of stainless steel capillary tube and temperature-sensitive bulb. The contacts shall be single pole, double throw, heavy duty, with a maximum non-inductive current capacity of 22 amps, 120 volt AC.
2. Thermostat setting shall be fixed, non-adjustable set point of 40 degrees F with a differential of 3 degrees F and a set point accuracy of $\pm$ 4 degrees F, used on outdoor heat traced water lines.
3. The thermostat shall be housed in a die cast watertight NEMA 4 box.

   Thermostat shall be type "AMC-F5" as manufactured by Raychem Corporation, or approved equal.

C. Power Connection

The self-limiting, heat-tracing cable shall be connected to the source of (cold) power by a Power Connection Kit approved by the manufacturer for that particular application.

D. Indication Light

When an indication light monitoring the heating cable integrity is required and/or shown on the Contract Drawings, it shall have a red lens and be mounted in a copper-free cast aluminum box.

1. This light shall be suitable for cable voltage operation shown on the Contract Drawings and shall be as manufactured by the selected system manufacturer, or approved equal.

E. Monitoring Panel

When a monitoring panel is required and/or shown on the Contract Drawings, it shall be 6, 12, or 24 pilot lights, as required, mounted in a heavy-duty sheet metal NEMA 12 (indoor use) or NEMA 4X (outdoor use) enclosure, with a remote alarm module and a Test/Reset switch. Panel shall be as manufactured by Nelson Electric, or approved equal.

F. Contactor

When a contactor is required and/or shown on the Contract Drawings for an installation of multiple heat-tracing cable sections controlled by a single thermostat, the contactor shall have a Hand-off-Auto selector switch and be similar to Type E304 as manufactured by Raychem Corporation.

G. End Seal, Splice, and Expansion Joint Kits

All necessary electrical components required to complete a particular heating cable installation, such as end seal, splice, and expansion joint kits shall be as approved by the manufacturer of the cable for that particular application.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install heat tracing cable system in accordance with the Contract Drawings, or approved Shop Drawings, and the requirements of this Section.

B. The Contractor shall determine the exact location of the power connection and termination of each heating section.

C. The Contractor shall verify in the field the exact mounting location of the heat-tracing cable.

D. Heat-tracing cable for pipe heating system shall be installed in such a manner as to permit equipment servicing and removal without disturbing the heat tracing cable on the pipeline. Follow typical installation procedures provided by the cable manufacturer.

E. The thermostat-sensing bulb shall be located on the lowest part of the pipeline to be protected.

F. In no case shall the temperature controller touch the heat tracing cable or be located at a point where performance will be influenced by the proximity of flanges, valves or other objects of high heat loss.

G. Splice heat-tracing cable in accordance with manufacturer's recommendation.

H. Secure cables in place with fiberglass tape at 18-inch intervals.

I. Install caution labels on pipeline insulation at five feet intervals.

3.02 FIELD TESTS

A. All tests shall be performed in the presence of the Engineer.

B. Heat tracing cable shall be tested in accordance with manufacturer's start-up and field test instructions:

1. For pipe heating applications, cable shall be tested before and after insulation is applied.

2. For snow melting applications where heat tracing cable is embedded in concrete or pavement, cable shall be tested before (concrete or pavement) surface is applied, after surface is applied but before it has hardened, and after surface hardening.

END OF SECTION

SECTION 16859

ELECTRIC HEATING CABLES (SELF-LIMITING TYPE)

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

Entire heat tracing cable system (only when shop drawings are required by the Contract Drawings), including:

1. Size, length and dimensional heating cable layout (including pipeline if pipe heating application), with all connection details and a complete list of parts with full identification.
2. Complete details of construction, wiring diagrams and schematics, connection details and interconnection requirements and parts identification of any electromechanical (control) devices, such as monitoring panels, contactors, if required to be furnished as part of the heat tracing system.

B. Catalog Cuts

1. Heat tracing cable.
2. Power connection kit.
3. Splice kit.
4. End seal kit.
5. Expansion joint kit.
6. Pipe straps.
7. Thermostat.
8. Signal light.
9. Caution labels.

END OF APPENDIX "A"

SECTION 16859

ELECTRIC HEATING CABLES
(SELF-LIMITING TYPE)

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in this Section:

(2.02 A.1)	Monitor wire, if required.
(2.02 A.2)	Cable voltage, length and wattage rating.
(2.02 B.1)	Thermostat and associated controls.
(2.02 B.2)	Set point range.
(2.02 D)	Indication light.
(2.02 E)	Monitoring panel with required number of pilot lights and wired as required.
(3.01 A)	Installation of heat tracing cable system.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16860

ELECTRIC HEATERS

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies requirements for electric heaters.

B. Types of electric heaters specified in this Section are:

1. Horizontal unit heaters
2. Fan forced wall heaters
3. Wall mounted explosion resistant convectors
4. Baseboard heaters

1.02 REFERENCES

American National Standard Institute (ANSI)

American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)

National Electric Code (NEC)

National Fire Protection Agency (NFPA)

Occupational Safety & Health Association (OSHA)

Occupational Safety & Health Association (OSHA)

Anti-Friction Bearing Manufacturers Association (AFBMA)

Anti-Friction Bearing Manufacturers Association (AFBMA)

American National Standard Institute (ANSI)

Air-Conditioning and Refrigeration Institute (ARI)

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. The electric heaters shall be designed, manufactured and installed in accordance with the latest revision of applicable standards referenced in 1.02. In case of conflict between various standards, the more stringent requirement shall apply.

B. Design and performance requirements of electric heaters shall be as specified in the "Electric Heater Schedule", shown on the Contract Drawings.

1.04 QUALITY ASSURANCE

A. Electric heaters of type and sizes required, shall have been satisfactory used for the purposes similar to those herein, for not less than three years.

B. Electric heaters shall be subject to factory inspection prior to shipping.

1.05 DELIVERY, STORAGE AND HANDLING

A. Deliver heaters with factory-installed wooden skids and lifting lugs; pack components in factory-fabricated protective containers.

B. Handle heaters carefully to avoid damage to components, enclosures and finish.

C. Store heaters in clean dry spaces and protect them from weather.

D. Touch up any damage to finishes to match adjacent surfaces.

E. Comply with the manufacturer's instructions for unloading and moving heaters to their final locations for installation.

1.06 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide electric heaters of the manufacturers listed on the Contract Drawings.

2.02 CONSTRUCTION FEATURES

A. General

Electric heaters shall consist of casing, electric heating elements, fan, motor and drive (if required), control equipment, power and control wiring, enclosures, pedestal legs, discharge grille, blank section and accessories etc., as specified herein and as shown on the "Electric Heater Schedule" shown on the Contract Drawings.

B. Horizontal Unit Heaters

1. The cabinet shall be made of 18-gauge die formed, furniture grade steel. The housing shall include individual adjustable louvers with 30 degree downward stops shall be furnished to provide desired control of discharge air. All metal surfaces of the casing shall be phosphate coated to resist corrosion and finished in baked enamel. Mounting brackets designed for ceiling mounting shall be furnished.

2. Heaters to be of the draw-through air flow design to eliminate hot spots and extend design life.

3. For safety, the electric heating bank shall consist of metal sheath heating elements. The elements shall have a copper clad steel sheath for strength and corrosion resistance and aluminum fins for faster heat transfer. Automatic reset thermal overheat protection shall be of the linear capillary type wired for instantaneous de-energizing in case of thermal overload. Heating bank to have protective air inlet louvers.

4. Motors shall be of the totally enclosed, continuous heavy-duty all-angle operation equipped with built-in thermal overload protection.

5. Fans shall be aluminum and with fan delay, directly connected to fan motor, designed specifically for unit heater application.

6. Low voltage control transformer and thermostat shall be provided, for more precise temperature control.

7. All horizontal unit heaters shall be provided with factory installed disconnect switches.

C. Fan Forced Wall Heaters

1. The cabinet shall be made of heavy-duty, 16-gauge steel bar grille with bronze brown baked enamel finish and aluminum frame.

2. The electric heating elements shall be steel finned metal sheath with low sheath temperatures. Built-in power disconnect switch shall be provided for added safety during maintenance.

3. Heater shall be wired with standard 60 degree C (166 degree F) wire.

4. Automatic reset thermal overheat protector disconnecting power in event of overheating due to accidental blockage shall be provided.

5. Heater shall be equipped with integral thermostat for quick installation. Tamper-resistant, adjustable through the front bar grille of heater.

6. Fan shall be aluminum, directly connected to fan motor. Motor shall be permanently lubricated and totally enclosed, for long life and low maintenance.

7. Built-in fan delay switch energizes fan motor only after the element are heated. When heat shuts off, the fan delay switch de-energizes fan motor after residual heat gas been dissipated.

D. Wall-Mounted Explosion-Resistant Convector

1. The housing shall be made of heavy-gauge steel with baked neutral gray enamel finish and integral mounting brackets.

2. The heating element shall be long, low-watt density element with steel sheath and brazed steel fins, supported by sturdy steel framework.

3. An explosion-resistant external wiring connection for 3/4" conduit shall be furnished within the convector enclosure.

4. A separate, wall mounted explosion resistant thermostat (40°F-80°F range) shall be provided.

E. Electric Baseboard Heaters

1. Heaters shall be low profile and available in lengths from 28 inches through 10 feet.

2. Heating elements shall be made of aluminum. Low-density elements shall be installed side-by-side on the same horizontal plane to uniformly warm all incoming air. Elements shall be center-anchored and shall float freely on each end through nylon bushings.

3. Built-in controls shall include thermostats, disconnect switch, transformer relay and power relay. The thermostat shall be capable of controlling multiple units on a pilot duty circuit. Thermostat adjustment shall be with thin bladed screwdriver through the discharge louvers and shall be tamper-resistant.

4. An automatic reset thermal overheat protector shall run the full length of the heater and shall turn off heating elements, should overheating occur at any point along heating length. Overheat protector shall restore operation automatically when the cause of overheating is removed.

5. Heaters shall be designed with a built-in pre-wired raceway to enable multiple-unit wiring from one feeder source.

6. Enclosures shall be 14-gauge aluminum with reinforced, all welded construction designed to withstand heavy-duty commercial and institutional use, with extruded aluminum pedestal legs.

7. Top discharge grille shall be extruded aluminum with anodized finishes. Heaters shall be designed so that front covers can be easily removed for individual servicing in a wall-to-wall run.

8. A 1/4-inch mesh aluminum screen shall be installed beneath the discharge grille to deter the insertion of foreign objects.

9. Back panel shall be one-piece painted steel, completely finished, and shall be suitable for mounting in front of a glass curtain wall.

10. Heaters and blank sections shall be designed so they can be butted together with use of splice plates.

11. Accessories shall include end caps, blank sections and splice plates. Blank sections shall be completely enclosed to enable the installer to pull standard wiring from heater to heater through the accessories.

2.03 SHOP TEST

Verify that manufacturer has tested each electric heater and certified its rating and its completeness.

PART 3. EXECUTION

3.01 EXAMINATION

Report immediately to the Engineer any electrical, structural or related construction defects in areas where electric heaters are to be installed. Do not attempt to rectify any defect, unless specifically instructed to do so by the Engineer.

3.02 PREPARATION

Before installation of electric heaters, the Contractor shall investigate the site condition to determine, what preparatory work, if any, will be needed.

3.03 INSTALLATION

A. Install electric heaters in accordance with manufacturer's installation procedures, as shown on the Contract Drawings and in accordance with the following:

1. Fan forced wall heaters shall be installed a minimum of 12" from floor or 8" from adjacent wall surface, behind door, upside down or side-up, in floor, ceiling or closet.

2. Wall-mounted explosion-resistant convectors shall be installed a minimum of 24 inches above finished floor.

3. Horizontal unit heaters shall be mounted a maximum of 20 feet above finish floor.

B. Coordinate all trades to ensure that the installation of the units is not in conflict with the work performed by other trades.

C. Verify the electrical wiring installation is in accordance with manufacturer's submittal and in accordance with the installation requirements of other electrical Section(s) of the Specifications.

3.04 FIELD TEST

Start up, test and adjust units in presence and to the satisfaction of the Engineer.

END OF SECTION

SECTION 16860

ELECTRIC HEATERS

APPENDIX "A"

SUBMITTALS

A. Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples", Division 1 - GENERAL PROVISIONS:

1. Shop drawings.
   - a. Layout drawings layout, type and locations of electrical heaters.
   - b. Electrical and control wiring diagram.
2. Catalog cuts, which shall include but not be limited to the following:
   - a. Design and performance data for heating capacity;
   - b. Electrical characteristics;
   - c. Accessories.
   - d. Unit construction components, materials and gauges.
   - e. Control equipment data.
   - f. Installation procedures.

B. Calculations

Submit calculations for the room heating requirements

C. Shop test data

Submit 12 copies of shop test data and manufacturer's certification.

Submit 12 copies of operation and maintenance manuals including replacement and spare parts list.

END OF APPENDIX "A"

SECTION 16860

ELECTRIC HEATERS

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in this section:

(2.01) List of manufacturers of electric heaters (minimum - three)

1. Suggested list:

a. Horizontal unit heaters, fan-forced wall heaters, explosion-resistant convectors:

QMark, Division of Marley Electric
Chromalox, Wiegand Industrial Div., Emerson Electric Co.
Reznor/Thomas & Betts

b. Electric Baseboard Heaters

QMark, Division of Marley Electric
Brasch Manufacturing Co. Inc.
Edvards Engineering Corp.

Manufacturers of equal qualifications to the above listing will be acceptable if approved by the Engineer.

(1.03.B) (2.02.A) Electric Heater Schedule

c. Include the following:

Electric Heater Designation
Type
Location
Heating element power requirements
Fan motor (if any) power requirements
Heater mounting (wall, ceiling, etc.)
Remarks

(3.03.A) Installation of electric heaters

END OF INSTRUCTIONS

DIVISION 16

SECTION 16861

ELECTRIC BASEBOARD HEATERS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for electric baseboard heaters.

1.02 REFERENCES

A. American National Standard Institute (ANSI).

B. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).

C. National Electric Code (NEC).

D. National Fire Protection Agency (NFPA).

E. Occupational Safety and Health Association (OSHA).

F. Underwriters Laboratories Inc. (UL).

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

Design and performance of components and methods specified herein shall comply with the applicable provisions of the codes and standards, and shall be as shown on the Contract Drawings.

1.04 QUALITY ASSURANCE

Electric baseboard heaters of the manufacture, type, and size required shall have been installed in similar applications to those intended herein for not less that three years.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Handle heaters carefully to prevent damage to finished surfaces.

B. Store heaters in accordance with the manufacturer's instructions in clean, dry spaces and protect them from weather.

C. Comply with the manufacturer's instructions for unloading and moving heaters to their final location for installation.

1.06 SUBMITTALS

See Appendix "A" for submittal requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with the requirements of this Section, provide electric baseboard heaters as manufactured by one of the following companies, or approved equal.

Q Mark Electric Heating Products; Division of Malley Electric Heating
Brasch Manufacturing Co. Inc.
Vulcan Radiator Corp.

2.02 MATERIALS

A. Electric Heating Elements

1. Elements: Aluminum.
2. Bushings: Nylon.

B. Enclosures

1. Front and Side Panel: Aluminum.
2. Back Panel: Steel.
3. Pedestal Legs: Extruded aluminum.
4. Grille: Extruded aluminum.
5. Screen: Aluminum.

2.03 CONSTRUCTION FEATURES

A. General

Electric baseboard heaters shall consist of electric heating elements, control equipment, power and control wiring, enclosures, pedestal legs, discharge grille, blank section and accessories as specified herein and as shown on the "Electric Heater Schedule" shown on the Contract Drawings.

B. Electric Baseboard Heaters

1. Heaters shall be low profile and available in lengths from 28 inches through 10 feet.
2. Heating elements shall be made of aluminum. Low-density elements shall be installed side-by-side on the same horizontal plane to uniformly warm all incoming air. Elements shall be center-anchored and shall float freely on each end through nylon bushings.
3. Built-in controls shall include thermostats, disconnect switch, transformer relay and power relay. The thermostat shall be capable of controlling multiple units on a pilot duty circuit. Thermostat adjustment shall be with a thin-bladed screwdriver through the discharge louvers and shall be tamper-resistant.

4. An automatic reset thermal overheat protector shall run the full-length of the heater and shall turn off heating elements, should overheating occur at any point along heating length. Overheat protector shall restore operation automatically when the cause of overheating is removed.

5. Heaters shall be designed with a built-in pre-wired raceway to enable multiple-unit wiring from one feeder source.

6. Enclosures shall be 14-gauge aluminum with reinforced, all welded construction designed to withstand heavy-duty commercial and institutional use.

7. Top discharge grille shall be extruded aluminum with anodized finishes. Heaters shall be designed so that front covers can be easily removed for individual servicing in a wall-to-wall run.

8. A 1/4-inch mesh screen shall be installed beneath the discharge grille to deter the insertion of foreign objects.

9. Back panel shall be one-piece painted steel, completely finished, and shall be suitable for mounting in front of a glass curtain wall.

10. Heaters and blank sections shall be designed so they can be butted together with use of splice plates.

11. Accessories shall include end caps, blank sections, and splice plates. Blank sections shall be completely enclosed to enable the installer to pull standard wiring from heater to heater through the accessories.

2.04 SHOP TESTS

Manufacturer shall test each electric heater and certify its rating and its completeness.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install units in accordance with the manufacturer's installation instructions.

B. Coordinate all trades to ensure that the installation of the units is not in conflict with work performed by other trades.

C. Verify that the electrical wiring installation is in accordance with the manufacturer's submittal and the installation requirements of this Section.

3.02 FIELD TEST

Start up, test and adjust units in presence and to the satisfaction of the Engineer.

END OF SECTION

SECTION 16861

ELECTRIC BASEBOARD HEATERS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

Electrical and control wiring diagrams.

B. Product Data

1. Performance operating data for heating capacity, power and electrical characteristics.
2. Unit construction components materials.
3. Electrical operation heating element data.
4. Control equipment data.
5. Installation procedures.

C. Schedules

Electric heater schedules.

D. Maintenance Manuals

Submit 12 copies of operation and maintenance manuals including replacement and spare parts list.

END OF APPENDIX "A"

DIVISION 16

SECTION 16935

SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEM (FOR POWER MONITORING APPLICATIONS)

PART 1. GENERAL

1.01 SUMMARY

This Section specifies requirements for a supervisory control and data acquisition (SCADA) system for power monitoring applications.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

	American National Standards Institute (ANSI)
ANSI C37.90	Relays and Relay Systems Associated with Electric Power Apparatus
ANSI C62.41	Guide for the Surge Voltages in Low-Voltage AC Power Circuits
	Electronic Industries Association (EIA)
EIA-485	Standard for Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems
	National Fire Protection Association (NFPA)
NFPA 70	National Electrical Code
	New York City Building Code (NYCBC)
	New York City Electrical Code (NYCEC)
	Underwriters Laboratories (UL)
UL 497	Protectors for Paired Conductor Communication Circuits
UL 508	Industrial Control Equipment

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. General

1. All SCADA system equipment manufactured, supplied, and installed shall comply with the requirements of NFPA 70, all local codes, and all other publications referenced in Article 1.02 herein.

2. Provide a complete and fully operational SCADA system, hereinafter referred to as the "System," complying with the requirements of this Section. All of the Work of this Section shall be coordinated with the current operation of the facility.

3. The System shall consist of power monitor modules (PMM's), of the quantity shown on the Contract Drawings, integrated on a high-speed communications network encompassing the locations shown on the Contract Drawings. The PMM's shall transmit the information specified in this Section to a remote workstation running standard, off-the shelf power monitoring and control software, furnished and installed in accordance with the requirements of this Section.

4. The System shall provide the operator at the remote workstation with all information available at each PMM. All data and event information shall be displayed and logged automatically and at user-configurable intervals.

5. A standard, high speed, industrially proven Local Area Network (LAN) shall be used to connect all PMM's that support direct connection of multiple remote workstations anywhere on the network.

6. Each remote workstation connected to the LAN shall have equal access to information provided by the PMM's for centralizing data display, data logging, alarming, event recording, and other power monitoring operations.

7. Unless otherwise specified on the Contract Drawings, the System shall consist of all components specified in this Section, and as required to make the System operate in accordance with the requirements of this Section.

B. Power Monitor Module (PMM)

1. Power Monitor Modules (PMM's) shall be installed in circuit breaker enclosures, as shown on the Contract Drawings.

2. Each PMM, within a switchgear line-up, shall be daisy-chained to the PMM in the adjacent circuit breaker enclosure. The daisy chain shall begin at the "head-end" of each switchgear line-up, where it shall be connected to the interface modules for data communication with the remote workstations.

3. Unless otherwise shown on the Contract Drawings, the interface between "head-end" interface modules, within a substation, shall be via a local area network.

4. Where shown on the Contract Drawings, connect the interface module to a telephone modem. Install empty conduit, as shown on the Contract Drawings, at each location to allow leased, dedicated, voice-grade, dial-up type telephone lines to be installed from the telephone interface points to the modems. Telephone service shall be installed by others.

5. Signals sent over the telephone lines shall be received via a modem at the remote workstation located as shown on the Contract Drawings. The remote workstation shall monitor; control, except closing circuit breakers; and receive alarms and data from all PMM's.

C. The remote workstation software shall process the data received from the PMM's and generate CRT display screens showing the data in both graphic and tabular forms.

D. Design Requirements

1. Application software and/or firmware for remote workstations, programmable logic controllers (PLC's), and PMM's shall be provided in accordance with the requirements of this Section.

2. Networking Requirements

a. All data stored in the power monitor modules shall be accessible to external devices by means of serial communications interfaces comforming to EIA-485 standards.

b. The System shall have sufficient telecommunications capacity that 32 PMM's may be connected to form a continuous communications link extending up to 4,000 cable feet at 19,200 Baud. Communications links shall be compatible with the EIA-485 multi-drop communications standards.

c. Communication rates on the links shall be adjustable (preconfigured) up to 19.2K baud to provide acceptable throughput of PMM data.

d. It shall be possible to program up to 99 sites that can be automatically polled at user-defined intervals or schedules, in addition to on-demand monitoring and polling.

e. The high speed, industrially proven, network bus shall form the basic structure for all System communications by linking equipment lineups to the modem output for communication to the remote workstations. All components shall function together in an integrated data communications network.

f. The high-speed network shall operate at speeds of up to 500K baud to provide adequate data throughout; speed shall be adjustable.

g. The high-speed network shall consist of network interface modules that allow man-machine interfaces, remote workstations, programmable logic controllers, and other higher level or sub-networks to access the data being gathered by the PMM's, Electric Trip Units, and Transformer Temperature Monitors, as shown on the Contract Drawings.

h. The network bus shall be wired in accordance with the manufacturer's written instructions.

i. The network interface modules shall be modular in design to allow for easy future expansion or modification of the System.

j. Each network interface module shall allow for the connection of at least 32 PMM's and one local System display unit or other network compatible devices such as programmable logic controllers, remote workstations, etc.

k. It shall be possible to connect at least 100 network interface modules together in a LAN of up to 15,000 cable feet in length to form the high-speed communications network.

l. Modems shall be furnished and installed as shown on the Contract Drawings. Auxiliary hardware, required to interface the modem to the PLC, shall be provided, as required, to make the System operational, in accordance with the requirements of this Section. Use of modems shall be transparent to the System software and PMM's.

m. Modems shall conform to the following:

(1) Protocol - asynchronous

(2) Speed - 9600bps in V.32 mode

(3) Operation - Full duplex over 2-wire dedicated lines

(4) Interface - RS232, CCITTV.24, V.28

(5) Power - 115 VAC, 60 Hertz

E. Remote Workstation Requirements

1. Unless otherwise shown on the Contract Drawings, the System shall include a remote workstation, complete with the required System Application Software, furnished and configured in accordance with the requirements of this Section. The System shall be preconfigured with all software, configuration files, and screen drawings by the System Integrator and ready to connect and operate when delivered to the site.

2. The remote workstations shall display and store all information from the PMM's. It shall be possible to operate more than one remote workstation on the network with each one working independently from the others and having complete access to all information. Each remote workstation shall be based on high performance, graphics terminals using a Windows-NT protocol that allows any terminal to communicate with the PMM's.

3. The System shall be a multi-user system, which shall simultaneously perform program development and process applications. It shall be a priority-scheduled, event driven System with priority and activities assignable such that process activities determine the level of service required. Real-time application functions shall be serviced in accordance with their priority.

4. Data integrity and System availability shall be ensured by both hardware and software protection mechanisms. On-line diagnostics, error detection and logging shall be provided to verify System integrity. Automatic System recovery shall be provided in the event of power failure or hardware or software failure.

5. The System shall be both flexible and expandable. A virtual memory operating system shall be provided to allow large programs to execute in both large and small memory configurations without program modification or definition of overlays. The command language shall allow for easy modification and/or extension of command repertoire and allow applications to present their own command interface to the user.

6. At the remote workstation, the software shall be configured to permit an operator to view only. Operator shall not be able to change or modify any settings or run any non-programmed reports. All alarm and alarm reports shall remain in place.

7. The remote workstation hardware to be furnished and installed shall be as shown on the Contract Drawings.

8. Monitors

   a. Each monitor shall be sized at 21 inches. The autoscanning color monitor shall have a resolution of 1280H x 1024V pixels, display up to 256 colors and utilize the MOTIF graphic user interface to display process and System data.

   b. The Windows-NT display terminal shall provide a resolution of 1280 H x 1024V pixels and up to 256 colors and utilizes the MOTIF graphic user interface to display process and System data. The remote workstation shall use a natural, operator-friendly interface for process monitoring and supervisory control and for engineering-programming and tuning the distributed process controllers. The window display shall allow simultaneous observation of multiple process graphics displays with dynamic update of process data. All remote workstations shall be configured identically.

c. On all high resolution graphic displays, it shall be possible, by menu selection, to ZOOM IN, ZOOM OUT, ZOOM TO, PAN and SET ZOOM SCALE to allow the operator to amplify selected screen sections.

9. Internal Hard Disk: The remote workstation shall be provided with 1 high-capacity high-performance SCSI Winchester disk drive. The disk drive shall be a 3-1/2" device and shall incorporate 48-bit error correction code (ECC). The formatted capacity of the disk drive shall be a minimum of 1 gigabyte, expandable to 9.5 gigabytes. Average seek time shall be no greater than 14 milliseconds with a maximum seek time of 20.8 milliseconds. Peak transfer rate shall be at least 3.1 Mbytes per second (to bus). Mean time between failure (MTBF) shall be at least 250,000 hours. For improved fault isolation, 90% on board diagnostic coverage shall be provided on power-up. Additionally, to insure data integrity write as well as read diagnostics shall be performed at startup. All errors, hard and soft, shall be reported to the System to aid in monitoring drive condition. The Winchester disk drive shall be installed in the System box of the remote workstation computer. Winchester drive storage unit shall be as shown on the Contract Drawings.

10. Magnetic Tape Unit: A 4 mm digital audio tape (DAT) drive shall be provided with the remote workstation. The capacity of the DAT drive shall be at least 4 Gbytes (with data compression) per cartridge. The DAT drive shall be installed in the CPU enclosure of the remote workstation computer. The DAT tape drive shall be as shown on the Contract Drawings.

11. Communication Interface Device

a. A multi-channel communication multiplexer shall be provided as the interface to the communication System. Communication data rates shall be programmable.

b. The communication interface between the PMM and remote workstation shall be via a communications gateway processor connecting directly to the System LAN. An Ethernet gateway device shall be the Peripheral Processor Unit (PPU). The PPU shall support up to 16 individual channels, operating at data rates from 4.8Kb/sec to 115Kb/sec.

c. PPU gateway devices shall be industrial computers resident on an Ethernet LAN. The motherboard of the PPU shall be a complete Pentium-based personal computer. It shall contain a complete AT kernel with processor, 4MB DRAM and peripheral drivers. On board it has two serial ports, one parallel port, a watchdog timer, keyboard interface, hard disk IDE controller and floppy disk controller. The motherboard shall drive a six-slot passive ISA IEE P996 backplane. The addition of the 40MB 3.5" hard disk, 1.44MB 3.5" floppy drive and an optional monochrome graphics adapter shall make for a complete PC compatible computer capable of local man-machine interface (MMI).

12. Printers

a. Heavy-duty printers shall be used for System alarm logging, event logging and report printing. Printers and other serial devices shall be served by a terminal server interface unit connected to the LAN or via a SCSI multiplex unit directly connected to the remote workstation. All printers may substitute for another printer's functional assignment. Printers shall be equipped with color ribbons to allow alarm messages to be printed in color, capable of producing color character based screen copies only.

b. Unless otherwise shown on the Contract Drawings, a total of 4 printers shall be provided. Two at each workstation location, one providing alarm logging and the other event and report printing.

c. Printers shall be provided that are designed for heavy-duty cycle operation in a continuously powered ON mode. They shall be of the impact printing type with full upper/lower case ASCII character set with a minimum of 94 printing characters. Print speed shall be, as a minimum, 240 cps. They shall have adjustable tractor type form feed for up to 14-7/8 inch continuous multi-part forms.

d. A keyboard printer shall be provided as a System console device, logger and CRT hard copy device.

e. A read only printer shall be provided as a System/ alarm logger, report printer, and as a CRT hard copy device.

f. The printer shall have a built-in test & setup routine to verify proper operation. In the event the device goes off-line or can not print, the System shall re-direct printing to the alternate printer (HP Deskjet 500 or compatible).

g. The printer shall be as specified on the Contract Drawings.

F. Software Requirements

1. Application Software Description

a. The PMCS shall be supplied with user friendly application software suitable for operation on computer workstations that serve as central control stations by monitoring the devices in the System, recording events, indicating alarm conditions, and displaying and logging device data.

b. The software shall be configured to accommodate new monitoring devices that may be added to the System later. The user shall be able to add these new devices or make other changes necessary to reflect changes to the electric plant without programming or making extensive changes to configuration files.

c. Any software keys or programming tools the user may need to change the software displays, one-line diagrams, or accommodate new monitoring devices shall be furnished.

2. The System manufacturer shall supply application software which provides the operator user friendly access to all power monitor module data, breaker/contactor/switch status and manual control, communication alarms, captured waveforms and logged data.

3. The software shall be a standard "off-the-shelf" control & automation product capable of being configured and modified to perform the functionality specified in this Section.

4. The remote workstation software shall not be able to perform any control function that shall be accomplished through the software with the appropriate security clearance. (Administrator and Integrators only!)

5. The remote workstation shall, via software commands, be capable of being taken off/on-line without affecting the operation and status of the System. Once off-line, the software on the remote workstation shall alterable and/or upgradable without disrupting normal System operation.

6. The software shall provide four levels of security defined as follows.

   a. User: Can operate software and access and view information, can not acknowledge or control equipment.

   b. Operator: Allows user with valid password to acknowledge indications and alarms, can not control equipment.

   c. Administrator: Allows access to all System functions and control, adding notes, etc.

   d. Integrator: Allows user to actually modify System graphics and logic.

7. Provisions shall be included to allow the following number of the types of users identified above:

   a. Users: Unlimited, no restriction

   b. Operators: 20

   c. Administrators: 5

   d. Integrators: 3

8. The software shall communicate, control, and display all information provided by the PMM's.

9. Application Software shall be supplied to support System configuration, monitoring of the devices, data logging, alarming, and other operations associated with the PMM's.

G. Data Presentation Format

1. Shall support an unlimited number of System devices, and poll all as required.

2. Shall display information for the System real-time data table format. Shall display status of digital status inputs.

3. The software environment shall be the following:

   a. The Operating System - Windows NT, or approved equal

   b. Networking Software - TCP/IP

   c. Graphic User Interface - Windows-NT/OSF Motif

   d. Programming Languages - C and Fortran-77.

4. The database shall be stored in main memory and in disk resident files. Data required for real-time rapid response such as point parameters, control setpoints, etc. shall be stored in tables in memory. Data, used only when requested by an operator or other non-real-time information (history, picture templates, point descriptions, etc.), shall be stored in disk files. The main memory data base shall consist of a number of global data partitions that shall be sized and configured for a specific subsystem application. Partitions (databases) may be simple tables, vectored (variable length entries), keyed (hash-coded table lookup) and/or pooled. Time critical partitions shall be locked in memory while all other shall be disk-resident and paged into memory as required. Size of the databases shall be limited only by available disk storage.

5. The disk database shall be a collection of disk files that shall be either in formatted edit mode for operator creation and modification or direct access, unformatted for fast access. The files shall contain several types of general information.

   a. Information on points, groups of points, or RTU's/PLC's

   b. Text formats for messages, reports, or displays

   c. Messages for logging

   d. Menus for MMI display keys

   e. Process history

   f. Data processing results

6. All data required to define the System shall be entered on-line using a generalized data base entry/modification program from the console device. New data bases for specific applications shall be created off-line using a screen editor. The off-line data base shall then be loaded into the on-line data base structures. Databases shall be automatically saved from memory to disk and from processor to processor as changes are made.

H. Data Acquisition and Communications

1. The data acquisition subsystem shall consist of a general-purpose network interface processor that shall communicate over Ethernet with the front-end processor (PPU). The protocols and data processing required by specific data acquisition and control hardware shall be resident in the PPU.

2. Three color-coded alarm levels shall be supported. Alarms shall be user-defined pickups and dropouts. The user shall be able to select indication including visual, audible, and/or required acknowledgement. Alarms shall be reported by exception.

I. Man-Machine Interface

1. All interaction between the operator and the workstation shall be controlled by the man-machine interface (MMI) environment. All activities initiated at the workstation shall be subsystems under the control of a process dedicated to the workstation.

2. All communications from the keyboard to the CPU shall be funneled through the MMI environment. The MMI environment shall provide the following services:

   a. Processing of all inputs from console

   b. Clock updates

   c. Command line processing

   d. Background process activation

   e. Screen copy functions

   f. Function key processing

   g. Alarm banner line updates

3. The Man-Machine Interface process shall provide the operation with a fully interactive set of facilities to perform all monitoring, display, control and reconfiguration activities.

J. System Security Subsystem - MMI processes and pictures available to an operator can be made a function of the password level to ensure process and data base security. In addition, the ability to control or modify points or other database items can be made a function of the categories assigned to operators.

K. Point Definition and Control

1. Provide functions to allow the operator to manipulate the point database. These shall include functions to view and modify point values and attributes, to list points according to operator-defined point groups, to load the data base into memory, and create new data base input files from the current, on-line database.

   a. Data Base Loading: The System data base (point descriptions, calculations, etc.) shall be loaded through interactive CRT screens.

   b. Point Control: To examine a point more closely, send output control to a point, or enter data to a point, the operator shall simply poke the point value or graphic symbol on any picture or table. All operational information on the point shall then be displayed at the top of the screen allowing direct operator interactions.

   c. Database Editor: The database editor function shall allow the user to add, delete and modify database points on line. The program shall consist of display formats for each point type. The MMI shall be designed for easy modification of any of these items, as well as point addition and deletion.

L. Point Display and Definition Subsystem

1. In addition to the display and control points via graphic displays, the Point Log subsystem shall provide tabular lists of points selected from various user-defined groups. Group listings can be based on any criteria such as alarms disabled, points in hand mode and control inhibited points. The user may control any point from these lists, as from a graphic display by poking its entry on the list.

2. Any selected list of points may also be sent to the printer.

M. Point Groups: Point groups shall allow the user to deal with more than 1 point in a convenience manner such as the display and modification of points, alarm summaries, and the use of points as input to an application program.

N. Alarm and Event Logging

1. All messages shall be managed by message spooling. The message subsystem shall receive requests to print a message from a message template file. All messages shall be written at high speed to a large circular spool file and shall be printed on the appropriate printers at full printer speed.

2. Alarm events shall be time stamped when first processed and the full messages text shall be placed in the alarm table by the message subsystem.

O. Report Generator

1. Report formats shall be a full 132 columns by 66 lines report format by selection of 1 of 4 quadrants on the 80 column screen. Calculations may be specified on report tables for summing, averaging, etc. of rows and columns. Minimum, maximum and other data along with text may also be integrated into the report format.

2. The Report program shall be scheduled to generate and print a report, preventative maintenance work requests, etc. on a periodic basis. Scheduler options shall include immediate print, add/change/ delete report, time of next printing, repeat frequency, and output device(s).

3. All reports shall be printed by the report spooling module.

P. Historical Data Recording

1. Software shall include a history editor for editing history files.

2. Provide a function to display the status of the history System and all data entries in the history files. The history data files shall be archived to magnetic tape under operator control.

Q. Data Presentation and Trending

1. Process data may be presented from both the real-time and historical databases.

2. Real-time data shall be displayed on the color CRT in stripchart (value vs. time), scatter plot (value 1 vs. value 2), or histograph (sample count vs. value) mode. The stripchart shall display up to 4, 8 or 16 analog variables as vertical barcharts with alarm levels indicated.

3. Historical information shall be obtained from either the on-line disk files or from the data archived on magnetic tape.

4. Trends shall be displayed on the CRT or printed on a graphic printer. Tabular data shall be output to a CRT or any printer.

5. Statistical routines shall be available for analysis of regular data (e.g., hourly or daily averages) such as x-y correlation, log normal distribution, and least squares curve fitting.

6. Frequently used trends shall be pre-formatted and obtained from poke points on a graphic trend menu display. These trends may be modified and presented in different formats by on-line editing of the various parameters.

R. Workstation CRT Data Display

1. Screen Information

a. The information displayed on the CRT shall be developed based upon the information contained in this specification and on the contract documents. Where graphics are specified they shall be patterned after the plans or similar documents that will be furnished to the contractor by the Authority.

b. There shall be a minimum of 350 display screens developed which shall contain the following information:

(1) An overall site plan shall show the entire boundary of the facility with the location of each substation clearly indicated. The level of detail of this screen shall be equal to that shown on the Contract Drawings.

(2) There shall be one substation screen for each substation shown on the Contract Drawings to indicate the number and designation of each cubicle within each substation. Each circuit breaker shall be identified by its respective designation. The level of detail of these screens shall be as shown on the Contract Drawings and as directed by the Engineer.

(3) There shall be a minimum of 12 single line diagram screens to indicate the circuit breakers contained in each switchboard assembly. The single line diagrams for each of these screens shall be developed from information and plans furnished by the Authority. A single line diagram of each substation shall be included.

(4) Data and report screens shall be formatted to present all data derived from each PMM.

(5) Additional report screens shall be formatted to summarize all available data in spreadsheet and graphical presentation format.

c. All screens shall include information or graphics that shall be shaded or less dense in appearance to allow the Authority to highlight the important areas of the screen to the user.

d. A notepad window shall be available for the Administrator to provide notices. The window shall call up a text file and display its contents. Text file shall be limited by the available storage space connected to the computer. This window shall not lock out notices of change of state and alarms. Upon changes of state and alarm conditions the screen shall be reset tot the overall System layout. There shall be 2 types of notes. One shall be associated with each substation, the other shall be general to be used as a general bulletin board.

e. Each device being monitored shall have its name tag information stored in a relational database. A sub-database shall have provisions to link maintenance information such as date, type of maintenance performed, by whom, and notes.

f. Provisions shall be made to have attached to each device a window with warning messages. Upon selection of the device, or activation of any alarm condition involving the device, if there is information present in the warning "window", it shall also be brought to the forefront.

g. Only Administrators and Integrators shall be allowed to enter and modify warning messages.

h. Provisions shall be made to have a procedure screen attached to each alarm condition associated with each particular device.

i. All monitored characteristics shall have 2 setpoints. These setpoints shall be user configurable. In addition, voltage shall have 2 additional set points for a total of 4 user-configurable set points.

j. The System software shall communicate and control PMM's from the following vendors:

Siemens Energy & Automation
Power Measurement Limited
Square D

k. All System data shall be logged to the hard disk at user specified intervals. Data logs shall be saved on a per month basis. At the end of the month, all data shall be saved to a file identifying the respective month and year. The System software shall store at least 12 months of data on the workstation hard disk. Overflows shall be written to tape. The System software shall provide the ability for the System administrator to save data files to tape both manually and automatically on a periodic interval selected by the user.

2. System Operation and Screen Interaction

a. There shall be programmed into the System screen interaction that allows the user to go from one screen to another by the use of a mouse or the keyboard.

b. The final screen interaction shall be as defined by the Authority.

c. Location of pop-up windows shall be configurable by user with appropriate security clearance (Integrator).

d. Acknowledgement of alarms, warnings, notices, etc., shall be user and password protected (available only to Operators and Administrators).

e. After 1 minute of inactivity, the screen shall refresh to the overall System layout. This default to the overall System layout may be defeated with appropriate security clearance (Operators and Administrators only).

f. Energized equipment shall be shown in red. Equipment that is open or not energized shall be shown in green. Grounded equipment shall be shown in yellow.

g. Insertion and operation of the Ground and Test Device shall be indicated by identifying the equipment grounded in the color yellow.

h. Control of equipment shall be by the selection and activation method. Equipment to be controlled must first be selected by either the mouse or through the keyboard. Upon selection, the System shall ask for confirmation that the equipment selected is correct. Once confirmation is received, a pop-up window shall be shown with the control options available. Once a control option is selected, the System shall ask the operator for confirmation of the action to be performed. Upon receiving confirmation, the System shall execute the desired control function. Pressing the "Esc" key at any time during the process shall nullify all previous selections and return the System to its default state.

i. Each alarm condition shall have an associated procedure file that shall be accessed by pressing the appropriate function key. After 1 minute of inactivity, the procedure file shall close and the display shall return to the alarm annunciation until acknowledged.

j. Context sensitive help shall be provided at any point by pressing an associated function key.

k. The substation distribution system shall be shown in two views. Layout, as previously described, and in a single-line format. An associated function key shall enable the user to toggle from one view to the other.

l. Upon activation of an alarm condition, the System shall be capable of directly displaying the affected substation via an assigned function key. Operation shall be based on the last alarm or through selection of a specific alarm listed on the alarm window.

m. Two keys shall be assigned to allow "upward" and "downward" movement in the distribution system. For example, pressing the "downward" key from the overall substation layout will bring up the layout of the substation presently selected. Pressing the "upward" key will return the operator to the previous display. In addition, the System shall be capable of going directly to any view via the program's function menu.

n. All electrical data for each device shall be displayed in real-time in either view (layout, or single line). Selection of the data to be displayed shall be configurable by Administrators and Integrators only.

o. The System shall have a summary log for each device that will maintain cumulative information such as number of operations, number of hours on-line, number of hours off-line, number of alarms. In addition to the cumulative, all of this information shall be stored and reported on a monthly basis.

p. A printout shall be made of all System operations, alarms, warnings, etc., as they occur. The printout shall include the date and time (hour, minute, second), equipment ID, and a description of the event. The System shall monitor and retain the abnormal condition for as long as it exists. Monthly reports shall be available that identify the alarm condition, date, time, duration, and who acknowledged the alarm.

q. The remote disabling switch at each substation shall be monitored. Upon disabling remote control of the respective substation, a visual indication shall be provided for as long as remote control is disabled.

3. Screen Development

a. During the shop drawing phase of the project, allow 40 hours of interaction with the Authority's representative (at the location designated by the Authority) to develop screen graphic and data display concepts and general configuration. These interactions shall be at the Authority's designated location and time.

4. Automatic Control

a. Data pertaining to the automatic control system shall be transmitted via the System network to the remote workstation (for circuit breaker tripping only).

b. At a minimum the application software at the remote workstation shall provide the following:

(1) Interactive color-graphics one-line of automatic control system (breaker status, relays status, etc.).

(2) All automatic control operations (open breaker, relay operation, etc.) shall be date/time stamped and recorded in an event log.

(3) Setup and display alarm conditions for automatic control operations shall be possible with each alarm condition entered in the event log.

(4) Manual operator intervention via the keyboard or interactive one-line graphics shall be provided such that any point in the process may be controlled.

(5) Manual intervention shall be password protected to prevent inadvertent or unauthorized override of the control scheme.

(6) Protective relaying functions, anti-paralleling interlocks, or load limits shall not be defeatable.

S. Uninterruptible Power System

1. Provide at each workstation, in Building #14, an uninterruptible power system (UPS) to maintain power to the remote workstation in the event of a short power outage.

2. The UPS shall be an on-line system having the following characteristics:

   a. Lightning and Surge Protection: In accordance with ANSI/IEEE C62.41, categories A and B.

   b. Spike Attenuation: 2000 to 1.

   c. Galvanic Isolation: Complete from line. Output neutral bonded to ground.

   d. Noise (RF) Isolation: 120 dB common-mode, 60 dB normal-mode.

   e. Input: 120V: 96 VAC - 138 VAC.

   f. Output Voltage: 120 VAC.

   g. Regulation: ±3%.

   h. Output Waveform: Pure sine-wave, less than 5% THD.

   i. Efficiency: 85% to 92% on line.

   j. Operating Environment: 0° to 40° C (32° to 104° F), 0 to 95% relative humidity (non-condensing).

3. The UPS shall be as shown on the Contract Drawings.

T. Transient Voltage Surge Suppressors (TVSS)

1. Provide, as shown on the Contract Drawings, transient voltage surge suppressors for telephone lines.

2. Telephone transient voltage surge suppressors shall conform to the requirements of UL 497.

3. Telephone TVSS shall have a clamping voltage of 200V peak ±10%, response time of 1 picosecond, and peak transient input voltage of 12KV, microseconds. Input shall be via RJ11 modular jack; output shall be via RJ11 modular plug. Unit shall be as shown on the Contract Drawings.

U. Transducers

1. Provide current transducers as shown on the Contract Drawings. Transducers shall have a 0-5 ampere ac input and 4-20mA output. Transducers shall be as shown on the Contract Drawings.

1.04 QUALITY ASSURANCE

A. The System manufacturer and the System integrator, if applicable, performing the work specified in this Section, and as shown on the Contract Drawings, shall be business entities that are substantially engaged in the type and scope of work specified in this Section, and shall demonstrate that they have been designing SCADA systems, for power monitoring purposes, for that last three consecutive years and shall demonstrate prior experience on at least two projects of similar size and complexity to what is required under this Contract.

B. The System manufacturer and the System integrator, if applicable, shall have authorized maintenance personnel and resources available within the Port Authority District, as demonstrated by existing contracts, to provide maintenance for systems comparable to the System furnished in accordance with the requirements of this Section.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in manufacturer's original, unopened, protective packaging.

B. Store materials in a clean, dry space, protected from weather.

C. Handle in a manner to prevent damage to finished surfaces.

D. Where possible, maintain protective covering until installation is complete and remove such coverings as part of final cleanup.

E. Touch up damage to finishes to match adjacent surfaces, including re-coating of galvanized or plated surfaces where damaged, cut, or drilled.

1.06 SPARE PARTS

A. The Contractor, or his authorized representative, shall confirm that there are a minimum of three (3) established agencies within the Port Authority District, which stock a full inventory of spare parts for the system supplied. In the event that there are not three (3) sources of supply, the Contractor warrants that all system components will be made available by the Contractor for a period of ten (10) years from the date of acceptance of the system.

B. Submit to the Engineer a priced parts list, with the System manufacturer's recommendations of the type and quantity of spare parts to be stocked for a 20-year design life of equipment. Include names and telephone numbers of the nearest sources of supply for each item.

1.07 MAINTENANCE OF THE SYSTEM

Furnish full preventive service and remedial maintenance of the system including all labor, parts, material, and supplies for one year from the rendering of the Certificate of Final Completion. The Contractor shall respond to a service call by traveling to the construction site within four (4) hours of the call, 24 hours per day, 7 days per week, including holidays.

1.08 SUBMITTALS

See Appendix "A."

PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with the requirements of this Section, provide SCADA system equipment of one of the manufacturers specified on the Contract Drawings.

2.02 MATERIALS

A. Power monitor modules (PMM's)

1. The power monitor modules (PMM's) shall be installed in the substation cubicle as shown on the Contract Drawings.

2. The PMM's shall provide true RMS quantities accurate for distorted, non sinusoidal wave shapes beyond the 30th harmonic (fundamental of 50 to 60 hertz). Each shall be equipped with integral data communications for integration into the System network.

3. Information provided by each power monitor module shall include frequency, current, demand current, voltage, real power, reactive power, apparent power, demand power, power factor, accumulated energy and accumulated reactive energy.

4. Each power monitor module shall retain historical circuit data, setup and configuration values, date and time of last power loss, and diagnostics data in the event of a control power failure.

5. Each power monitor module shall capture current and voltage waveforms that may be exported to computer workstations for viewing, storing and waveform analysis.

6. Voltage, current, status, relay and power inputs shall conform to ANSI/IEEE C37.90A-1989 surge withstand and fast transient test.

7. All PMM's shall be listed to UL 508.

8. Characteristics

   a. The PMM's shall accept inputs from industry standard instrument transformers (120 VAC secondary PT's and 5A secondary CT's).

      (1) PT primaries through 5 KV shall be supported.

      (2) CT primaries through 3 kA shall be supported.

   b. The current and voltage signals shall be digitally sampled at a rate high enough to provide valid data for waveform analysis and true RMS metering accurate beyond the 30th harmonic (fundamental of 60 Hz).

   c. The PMM's shall be listed to UL 508, industrially rated for an operating temperature range of 32° F to 122° F ambient, and have an overcurrent withstand rating of 500 amps for 1 second.

   d. All setup parameters required by the PMM's shall be stored in nonvolatile memory and retained in the event of a control power interruption.

   e. The power monitor module shall maintain in nonvolatile memory maximum and minimum values for each of the instantaneous values reported as well as the time and date that the minimum or maximum was set.

   f. The power monitor module shall be accurate to 0.2% for voltage and current metering and 0.4% for all power and energy functions. These accuracies shall be maintained for loads from 10-100% of full scale for power factors from 0.5-1.0.

   g. Any power monitor module shall be applicable in single phase, two or three wire configurations; or in three phase, three or four wire systems. In three phase configurations, a fourth CT input shall be available to measure neutral or ground current. If the fourth CT is not used, then it shall be possible to calculate a residual ground or neutral current by connecting the return phase CT's through the fourth current input.

   h. In 4 wire connections, the power monitor module shall utilize the circuit neutral common reference and not earth ground to provide metering accuracy.

i. The power monitor module shall be capable of being applied without modification at nominal frequencies of 60 hertz.

j. The power monitor module shall operate properly over a wide range of control power including 90-260 VAC or 70-260 volt DC.

k. Power Monitor Module Display

(1) The PMM's shall be equipped with an integral 6-digit LED display to provide local access to the following metered quantities as well as the minimum and maximum value since last reset of each quantity:

(a.) Current, per phase RMS

(b.) Voltage, phase to phase and phase to neutral

(c.) Real power, per phase and 3 phase total

(d.) Reactive power, per phase and 3 phase total

(e.) Apparent power, per phase and 3 phase total

(f.) Power factor, 3 phase total and per phase

(g.) Frequency

(h.) Demand current, per phase and three phase average

(i.) Demand real power, three phase

(j.) Demand apparent power, three phase

(k.) Accumulated Energy, (MWH and MVARH)

(l.) THD, current and voltage, per phase

(m.) k-factor, current, per phase

(2) Reset of the following electrical parameters shall also be allowed from the front of the power monitor module:

(a.) Peak demand current

(b.) Peak demand power (kW) and peak demand apparent power (kVA)

(c.) Energy (MWH) and reactive energy (MVARH)

(3) Setup for system requirements shall be allowed from the front of the power monitor module. Setup provisions shall include:

(a.) CT rating 3000:5, 2000:5, 1200:5, 600:5 as shown.

(b.) PT rating 2400:120

(c.) System type three phase 3 wire

(d.) Demand interval (5-60 min)

(e.) Watt hours per pulse

(4) All reset and setup functions shall have a means for protection against unauthorized/ accidental changes.

(5) Displaying each of the power monitor module quantities shall be accomplished through the use of scroll buttons that select the next quantity in the list programmed into the device.

(6) The power monitor module shall be installed so that it can only trip a circuit breaker.

l. The following instantaneous readings as well as their minimum and maximum readings since last reset shall be communicated by the power monitor module:

(1) Frequency

(2) Alternate, scaleable analog input

(3) Current, per phase RMS

(4) Current, 3 phase average RMS

(5) Voltage, phase to phase and phase to neutral

(6) Power factor, per phase

(7) Power factor, 3 phase total

(8) Real power, per phase and 3 phase total

(9) Reactive power, per phase and 3 phase total

(10) Apparent power, per phase and 3 phase total

(11) Demand Current, per phase and three phase average

(12) Demand real power, three phase average

(13) Demand apparent power, three phase average

(14) Accumulated energy, (MWH, MVAH and MVARH)

(15) Total Harmonic Distortion (THD), voltage and current, per phase

(16) K-factor, per phase

m. All power demand calculations shall be done by any one of the following calculation methods, selectable by the user:

(1) Thermal demand using a sliding window updated every 15 seconds. The window length shall be set by the user from 5 to 60 minutes in five minute increments.

(2) Block interval, with optional sub-intervals. The window length shall be set by the user from 5 to 60 minutes in five minute intervals. The user shall be able to set the sub-interval length from 5 to 30 minutes in 5 minutes intervals.

(3) External Pulse Synchronization, utilizing a synch pulse provided externally. An optional status input shall be used to sense the pulse.

(4) The following demand readings shall be reported by the power monitor module:

(a.) Average demand current, per phase

(b.) Peak demand current, per phase

(c.) Average demand for real power, reactive power, and apparent power

(d.) Predicted demand for real power, reactive power, and apparent power

(e.) Peak demand for real power, reactive power and apparent power

(5) The default demand calculation method shall be a 15-minute sliding window thermal demand.

n. Each power monitor module shall receive a broadcast message over the communications network bus that can be used to synchronize demand calculations by several power monitor module. This message need not be addressed specifically to any one power monitor module.

o. Each power monitor module shall be individually capable of operating an output relay to provide the master demand synch pulse for other metering devices.

p. The following energy readings shall be reported by the power monitor module.

(1) Accumulated energy

(2) Accumulated reactive energy

(3) Accumulated apparent energy

(4) For real and reactive energy reported values, separate totals for energy flow in each direction shall be kept, as well as an arithmetic sum.

(5) Each power monitor module shall operate a KYZ output relay to provide output pulses for a user definable increment of reported energy.

q. In addition to the standard power monitor module features previously indicated, all power monitor modules shall include waveform capture capability. Two types of waveform capture shall be supported. One shall record data for one (or more) cycles of input voltage and current (60-cycle nominal), the other shall record 12 cycles of data.

(1) Either type of waveform capture shall be initiated from the workstation running the appropriate System software. In addition, the 12-cycle waveform shall be initiated by an external trigger and/or on board high speed triggers. In the case of the external trigger, it shall be sensed and the waveform capture sequence shall be initiated within 1 millisecond. A user definable delay shall determine how many of the twelve cycles are shown before and after the trigger event.

(2) The power monitor module shall transmit the waveform samples over the network to the computer workstation for display, archival, and analysis.

(3) In the case of the 12 cycle capture, each voltage and current of all phases shall be sampled concurrently so that proper phase relationships are maintained, therefore, the effect of a disturbance can be observed on all phase voltages and currents.

(4) Harmonic analysis performed on the captured waveforms shall resolve harmonies through the 31st.

r. Data logging may be accomplished either within the power monitor module or at the workstation, or both. Each power monitor module shall be able to log data, alarms and events, and multiple waveforms. This information shall be communicated to the workstation upon demand. Logged information to be stored in each power monitor module includes:

(1) Up to 10 separate data logs shall be configurable by the user. Each log entry shall be date and time stamped. Each log entry shall be user configurable to consist from one to a maximum of 12 readings of instantaneous data. It shall be possible to set up each log to take data at a different user defined schedule interval. In addition, it shall be possible for a user to define an event or new min/max condition that will trigger log file entries.

(2) A Min/Max log file shall include the time, date, and value for the minimum and maximum of each metered value.

(3) An alarm and event log shall contain time, date, event information and coincident information for each user-defined alarm or event. This log shall have a capacity of up to 1,000 events.

(4) Waveform logs shall store captured waveforms, both 12 cycle and other as defined by the user. Waveform log entries shall be scheduled at a user-defined interval, externally triggered, or forced in response to a user defined event. Waveform logs shall be either Stop When Full or Circular (FIFO) as defined by the user.

(5) A simple user interface shall be provided to enable the user to allocate power monitor module memory to different log functions.

s. Power monitor module Input/Output (I/O) Options: Power monitor modules shall be equipped with the following I/O options as shown on the project drawings:

(1) Three output relays suitable for KYZ pulse initiation.

(2) Four digital inputs.

t. Alarm events shall be user definable. Alarm events shall include:

(1) The following classes of events shall be available as alarm events:

(a.) Over/under current

(b.) Over/under voltage

(c.) Current imbalance

(d.) Phase loss, current

(e.) Phase loss, voltage

(f.) Voltage imbalance

(g.) Over kVA

(h.) Over kW or kVAR into/out of load

(i.) Over/under frequency

(j.) Under power factor

(k.) Over THD

(l.) Over K factor

(m.) Over demand, current or power

(n.) Reverse power

(o.) Phase reversal

(p.) Status Input change

(2) For each alarm event, the user shall be able to define a pick-up, dropout, and delay.

(3) Indication of an alarm condition shall be possible to be viewed from the front panel.

u. Output Relay Control

(1) Relay outputs shall operate either by user command sent over the communication link, or set to operate in response to user defined alarm event.

(2) Output relays shall close in either a momentary or latched mode as defined by the user.

(3) Each output relay used in a momentary contact mode shall have an independent timer that can be set by the user.

(4) It shall be possible for individual relay outputs to be controlled by multiple alarms in a wired "OR" configuration.

2.03 SHOP TESTS

A. All System equipment, materials, hardware, software, and firmware to be furnished and all work to be performed in accordance with the requirements of this Section shall be subject to inspections and tests by the Authority.

B. No System equipment shall be delivered to the Authority until the system has been inspected, tested, and approved for shipment by the Engineer.

C. Unless otherwise directed by the Engineer, the System equipment shall be tested by the system manufacturer and/or the System integrator, and witnessed by the Engineer, in the place of manufacture.

D. Testing of the System shall be performed in accordance with the requirements of this Section, and shall continue until the results are satisfactory to the Engineer. Each item of System equipment shall be tested in its entirety with the use of simulated inputs and and simulated outputs, as required. All simulation equipment required for the test shall be furnished by the System manufacturer without additional compensation therefor. Any repairs, construction, or modifications required to comply with the requirements of this Section shall be performed by the System manufacturer without any additional compensation therefor.

E. When the manufacture of all System equipment is complete, the Contractor shall notify the Engineer by requesting, in writing, an inspection and test of said equipment. This written request shall be in the possession of the Engineer a minimum of fifteen (15) working days prior to the requested inspection and test dates.

F. Any approval by the Engineer, however, shall be construed merely to mean that at the time he knows of no good reason for objecting to any equipment, and no such approval shall release the Contractor from its obligation to comply with the requirements of this Section.

PART 3. EXECUTION

3.01 EXAMINATION

A. Inspect all System equipment, and accessories prior to installation. Replace any damaged items.

B. Ensure that the spaces where any electronic equipment is to be stored and/or installed is completely free from any foreign substances, such as concrete dust, water, or any other material that may otherwise be harmful to electronic equipment and connections. No allowances shall be made to the Contractor for equipment damage, of delays due to environmental/security damage.

3.02 PREPARATION

A. The Contractor shall be responsible for field verification of dimensions and coordination of conduit entry and all other mounting conditions with the entity manufacturing the system.

B. The entity manufacturing the system shall provide on-site technical supervision and assistance during installation and interconnection of the system equipment installed by the Contractor. Said supervision is to insure the safety of the proper installation and operation of the system equipment, prior to the installed system beginning the 30-day operational test.

C. After the system equipment has been delivered, an on-site inspection will be made by the Engineer. If any equipment has been damaged or for any reason does not comply with the requirements of this Section, the Contractor will be notified in writing, and shall be required to replace the equipment at his own cost and expense, even though the equipment has been previously inspected, tested, and approved for shipment. After such satisfactory replacement, the system shall be installed by the Contractor.

3.03 INSTALLATION

A. Install all System equipment in accordance with the manufacturer's written instructions in the locations shown of the Contract Drawings.

B. All control power, CT, PT, and data communications wire shall be wired and harnessed within the equipment enclosure.

C. All wiring shall be clearly labeled with function and wire identification number corresponding to the manufacturer's wiring diagrams.

D. Where external circuit connections are required, terminal blocks shall be provided and the manufacturer's drawings must clearly identify the interconnection requirements including wire type to be used.

E. All wiring required to externally connect equipment lineups shall be installed by the electrical contractor.

F. Contractor interconnection wiring requirements shall be clearly identified on the PMCS system drawings.

3.04 FIELD TESTS

A. After installation, the System shall be tested to show compliance with this Section. The PMCS manufacturer shall submit the proposed testing procedure to the Engineer for approval two weeks prior to proposed start of test. Said testing shall continue until the results are satisfactory to the Engineer. Any repairs, construction, or modifications as required to comply with this Section shall be performed by the PMCS manufacturer without additional cost to the Authority.

B. After satisfactory completion of testing, a 30-day operational test shall commence. The PMCS manufacturer shall correct any malfunctions as they occur, said malfunctions including, but not being limited to, equipment failure of failure of the System to comply with this Section. After the PMCS manufacturer corrects a malfunction, at no cost to the Authority, the 30-day test shall restart, at day one, and shall continue until the results are satisfactory with the written approval of the Engineer.

C. The PMCS manufacturer shall completely check out, calibrate and test all connected hardware and software to insure that the system performs in accordance with the approved specifications and sequences of operation submitted.

D. The PMCS manufacturer shall conduct a validation demonstration witnessed by the Engineer, which shall consist of, but not limited to:

1. Running each specified report.
2. Display and demonstrate each data entry template to show site specific customizing capability. Demonstrate parameter changes.
3. Execute menu tree.
4. Execute digital commands in English mode.
5. Display graphics.
6. Demonstrate all specified diagnostics.
7. Demonstrate scan, update, and alarm responsiveness.
8. Demonstrate and verify all monitoring and control functions in operation for each equipment item controlled and each point monitored.

E. The PMCS manufacturer shall submit a test report detailing compliance with the requirements of item C and item D above.

F. 30-Day Operational Test

1. Testing shall be performed to verify compliance with the requirements of this Section and shall be performed in accordance with the approved testing plan. Correct any malfunctions as they occur, said malfunctions shall include, but not be limited to, equipment failure or failure of the System to comply with the requirements of this Section. After corrections have been made, the 30-day operational test shall restart and shall continue until the results are satisfactory to the Engineer for a period of 30 consecutive days.
2. Maintain a log during all operational testing. Include a narrative description of corrective measures required and items required or replaced.

3.05 TRAINING

A. Operational and Maintenance Training for the System shall be provided to Authority-designated personnel through the means of practical demonstrations, seminars, and other related technical teaching procedures. The training shall be conducted at the site.

B. The operational training courses shall be conducted during the 30-day operational test. The training shall include but not be limited to "hands-on" operation of all System hardware, explanation of the complete repertoire of System commands, instruction of insertion and retrieval of data, and instruction on the use of reports and alarms. The Contractor shall conduct a minimum of two 8-hour training courses with up to 15 students per course. The Contractor shall provide one up-to-date operational training manual per student plus an additional 15 training manuals for Authority use in conducting future training courses. The operational training courses shall be scheduled to meet the requirements of the Authority.

C. The Maintenance training courses shall be given after the System has passed the 30-day operational test. The Contractor shall conduct a minimum of two 16-hour training courses with up to 8 students per course. The Contractor shall provide one, up-to-date maintenance training manual per student plus an additional 15 training manuals for Authority use in conducting future maintenance training courses. The training shall include, but not be limited to, description of all System equipment, equipment operation, and interfaces between System elements, procedures for System troubleshooting, equipment diagnostic procedures, recommended service and test procedures, and recommended preventive maintenance schedules.

3.06 MAINTENANCE

Furnish full preventive and remedial maintenance services for the System, including all labor, parts, material, and supplies for one year from the rendering of the Certificate of Final Completion. The Contractor shall respond to a service call by traveling to the site within four (4) hours of the call, 24 hours per day, 7 days per week, including holidays.

END OF SECTION

SECTION 16935

SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEM (FOR POWER MONITORING APPLICATIONS)

APPENDIX "A"

SUBMITTALS

A. Submittals

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

1. Estimated progress schedule of dates for the Work to include (but not necessarily be limited to) the following:

   a. Project start

   b. Shop drawing submittal

   c. Shop drawing approval

   d. Factory test procedure submittal

   e. Factory test procedure approval

   f. Factory test of the system

   g. On-site rough-in start

   h. Training Curricula submittal

   i. Training Curricula approval

   j. On-site rough-in completion

   k. Recommended spare parts list

   l. Proof of performance testing

   m. Complete system maintenance training

   n. Complete system maintenance training

   o. Operation and Maintenance Manual submittals

   p. Acceptance testing

   q. Completion/Resolution of all submittals and/or punch list items

   r. Record documents submittal

   s. Final Acceptance

      (1) Complete Bill of Materials

      (2) Shop Drawings

         (a.) Block Diagram

         (b.) SCADA Devices and Operating Manuals

(c.) Workstation Equipment

(d.) Complete Wiring Diagrams, indicating all field terminal block numbers

(e.) Complete, comprehensive, single-line diagrams, including all equipment, devices, and cabling completely identified

(f.) System Logic Program

(g.) Details of Proposed Computer Screen Displays, including descriptions of interactive screen features

(h.) Command Description and Language

(i.) Conduit and Raceways

(j.) Wire

(k.) Enclosures and all Devices

(3) Catalog Cuts

(a.) Power Monitor Module

(b.) Network hardware and software

(c.) Workstation Hardware and Software

(4) Samples

(a.) Color printouts of all workstation screen graphics

(b.) Report formats

(5) A detailed, written description of the function and operation of the SCADA System Software

(6) Spare Parts: Submit a complete list of recommended spare parts, which shall include those spare parts required to be furnished in compliance with the requirements of this Section, for approval by the Engineer.

(7) Performance Testing Plan: Prepare and submit to the Engineer for approval a performance testing plan for the entire system a minimum of 30 days in advance of the earliest, approved, scheduled inspection and test date. The system test plan shall be divided into the following stages:

(a.) Factory inspection and test of the System, performed by the Contractor and witnessed by the Engineer at the place of manufacture.

(b.) Inspection of the system upon arrival.

(c.) On-site inspection and test immediately following the complete installation of the system, to demonstrate compliance with the requirements of this Section.

(d.) A 30-day operational test commencing with the successful completion of the on-site inspection and test, approved by the Engineer.

(8) Training: Prior to the on-site inspection and test of the system, prepare and submit to the Engineer for approval a SCADA system user and maintenance training curricula, in accordance with the requirements this Section.

(9) Operation and Maintenance Manuals: Prior to the issuance of the Certificate of Final Completion, prepare and submit to the Engineer for approval Operation and Maintenance Manuals, in accordance with the requirements of Section 16001, entitled "OPERATION AND MAINTENANCE MANUALS."

(10) Record Documents: Prior to the issuance of the Certificate of Final Completion, deliver to the Engineer the following:

(a.) One (1) reproducible set of the Contract Drawings and Shop Drawings, which reflect actual locations and actual wiring details of SCADA system equipment and all revisions to the Work of this Section. In addition, nine (9) sets of prints of said Contract Drawings and Shop Drawings shall be supplied to the Engineer. Three (3) copies of said drawings shall be marked to the attention of the Facility Supervisor of Electrical Maintenance.

(b.) In addition to quantities of Operation and Maintenance Manuals specified in other Sections of this Contract, three (3) copies of said Operation and Maintenance Manuals shall be supplied to the Engineer and marked to the attention of the Facility Supervisor of Electrical Maintenance.

(c.) System Documentation

The following shall be included in the complete documentation package on the system which shall be furnished at the time of delivery of the System.

(d.) Software Documentation

Three complete sets of documentation shall be submitted, explaining all system capabilities and options, including system set-up, operation, and maintenance (software manuals shall be supplied in hard copy only).

(e.) Hardware Documentation

Three complete sets of system manuals shall be submitted explaining all system capabilities and options, including but not limited to the installation, set-up, operation, and maintenance of all equipment furnished.

(f.) Operational Documentation

Twelve complete sets of system operations manuals shall be submitted which shall consist of the following:

i. Operations Run Book (To be supplied in hardcopy only)

ii. Detailed description of normal system operation

iii. Error and Alarm handling Procedures

iv. System Start up and Shutdown Procedures

v. Use of Various Logs and Output Data by by Operator to Improve System Efficiency

vi. Description of Operating Procedure and Troubleshooting Procedures for each subsystem

vii. System Backup Procedures

(g.) Test Procedures

Recommended system test procedures shall be no less than thirty days prior to scheduled factory test date.

Test shall include the following:

i. Factory test of system as witnessed by the Authority.

ii. Field test of system prior to connection to substation components as witnessed by the Authority.

iii. 30-day field performance test in which system shall operate without failure. If a failure is encountered, the 30-day test shall be restarted from the beginning.

END OF APPENDIX "A"

SECTION 16935

SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEM (FOR POWER MONITORING APPLICATIONS)

INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

(1.03 A.3)	The quantity of power Monitor Modules required. The locations of all Power Monitor Modules.
(1.03 A.7)	Any components not covered in this Section.
(1.03 B.1)	The circuit breaker enclosures where Power Monitor Modules are to be installed.
(1.03 B.3)	The interface between "head-end" modules within a substation, if different than as specified in this Section.
(1.03 B.4)	All connections to modems.
(1.03 B.5)	The location of the remote workstation.
(1.03 D.2.g)	Network interface modules, connections to man-machine interfaces, remote workstations, PLCs, connections to other networks, electric trip units, and transformer temperature monitors.
(1.03 D.2.1)	Installation details of modems at the substations.
(1.03 E.1)	The number of remote workstations required, especially if more than one is required.
(1.03 E.7)	The mfg. and model no. of the remote workstation hardware, including all key components.
(1.03 E.9)	The mfg. and model no. of the remote workstation hard disk.
(1.03 E.10)	The mfg. and model no. of the digital audio tape drive.
(1.03 E.12.b)	The mfg. and model no. of the digital audio tape drive.
(1.03 E.12.g)	The mfg. and model no. of the printers
(1.03 R.1.b.21)	The presentation of the graphics screen showing the facility and identifying the locations of the substations.
(1.03 R.1.b.2)	The presentation of the graphics screen showing each electrical substation and identifying each circuit breaker cubicle.
(1.03 S.3)	The mfg. and model no. of the uninterruptible power system. Also specify its capacity.
(1.03 T.1)	The transient voltage surge suppressors.
(1.03 T.2)	The mfg. and model no. of the of the transient voltage surge suppressors.
(1.03 U.1)	The mfg. and model no. of the transducers.
(2.01)	The mfg. and model no. of all acceptable SCADA system equipment from at least two manufacturers.

END OF INSTRUCTIONS

DIVISION 16

SECTION 16998

MEDIUM VOLTAGE SYSTEM COMMISSIONING TESTS

PART 1. GENERAL

1.01 SUMMARY

This Section specifies the tests required for commissioning the medium voltage equipment shown on the Contract Drawings. These tests are to be performed in addition to the specified tests outlined in other sections of these Specifications.

1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

National Electrical Manufacturers Association(NEMA) Standard

National Electrical Testing Association (NETA) "Acceptance Testing Specifications for Electrical power Distribution Equipment and Systems", also Called - NETA ATS.

American National Standards Institute (ANSI)

Occupational Safety and Hazard Administration (OSHA) Safety Rules

Port Authority High Tension Safety Rules

American Society of Testing and Materials (ASTM)

ASTM D877	Test method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
ASTM D923	Method for Sampling Electrical Insulating Liquids
ASTM D924	Test Method for AC Loss Characteristics and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids

1.03 QUALITY ASSURANCE

A. The Contractor shall secure the services of qualified personnel to perform inspection and testing. The required qualifications include, but are not limited to a minimum of five years experience in testing of this type.

B. The Authority reserves the right to interview the actual personnel who will be assigned to perform the tests. The test personnel will be questioned to ascertain the level of experience attained. Only those personnel interviewed and authorized by the Authority may perform the testing.

If the finding of the panel selected by the Authority's Chief Electrical Engineer conducting the interview is that the personnel interviewed are not qualified, this shall be the cause for rejection.

1.04 SUBMITTALS

For Submittal Requirements, see Attachment "A".

PART 2. PRODUCTS

2.01 TESTING FIRMS

Subject to compliance with the requirements of this Section, provide the services of a Testing Firm selected from the list shown on the Contract Drawings or approved equal.

PART 3. EXECUTION (TESTS)

3.01 GENERAL

A. In addition to the tests outlined in Section 3.02 hereunder, perform all tests recommended by the manufacturer in manufacturer's instructions, shop drawings, as described in various sections of these Specifications and as outlined on the Contract Drawings.

B. All tests must be witnessed by the Engineer. A written notice, at least fourteen days prior to the tests shall be given to the Engineer.

C. Test values shall be considered acceptable as specified by the manufacturer and approved by the Engineer.

3.02 ELECTRICAL TESTS

A. General

1. Prior to the energization of any medium voltage equipment, all tests outlined in 3.01 above, and those outlined below in accordance with NETA ATS, shall have been performed by the Contractor and approved by the Engineer.

2. No voltage other than Megger output shall be applied to control voltage transformers during the performance of any tests, so that no high voltage can be induced on the primary of these transformers or into the high voltage system.

3. All safety precautions shall be exercised per OSHA and Port Authority High Tension Safety Rules to avoid personal injury and damage to equipment under test.

B. Medium Voltage Switchgear

1. Perform the following tests on all the Current Transformers including those located within the ground and test device. Readings are to be taken at each protective relay to confirm wiring connections.

a. Ratio test at all the taps with full primary current injection

b. Polarity test with inductive kick method

c. Measure secondary winding resistance

d. Megger secondary winding at 1000VDC

e. Perform magnetization curve test to the saturation voltage. Plot the curve and verify with the Accuracy Class claimed by the manufacturer.

2. Perform the following tests on all the Voltage Transformers:

   a. Ratio test.

   b. Polarity test

   c. Megger secondary winding at 500VDC.

   d. Over Potential test at voltage recommended by the manufacturer.

3. Perform the following tests on all the switchgear bus sections:

   a. All bus connections shall be inspected. Check for loose connections, missing or damaged components. Torque all connections and terminations to the manufacturer's specifications.

   b. The switchgear bus shall be given a phase-to-phase and phase-to-ground Megger test at 1000VDC, with all the breakers open and all potential transformer fuses removed.

   c. Perform phasing check to ensure proper bus phasing from each source.

   d. Perform an overpotential test on each bus section in accordance with manufacturer's instructions.

4. Perform insulation resistance test on control wiring. (Do not perform this test on wiring connected to solid state components).

5. Perform control wiring performance test. Use the elementary diagrams of the switchgear to identify each remote control and protective device. Conduct tests to verify satisfactory performance of each control and tripping function.

6. Perform current injection tests on the entire current circuit in each section of switchgear, including the ground and test device, to check in-zone and through-zone fault operation for differential protection.

7. Verify operation of the Directional Overcurrent relays to make sure that the relays trip only in the direction specified in the contract drawings.

8. Verify the proper output level and polarity at each transducer.

9. Confirm phasing receptacle connections by the battery pulse method from the primary of the voltage transformer.

10. Check all meters at mid-scale for accuracy. Verify multipliers.

11. All protective relays shall be tripped (either manually or electrically) to determine whether the proper breaker has functioned as intended and any device or devices (including alarm, horns) have also operated correctly.

12. Clean, calibrate and test all protective relays. All relay settings shall be in accordance with the values furnished and/or approved by the Engineer and/or the Authority.

13. Voltmeters shall be checked against potential transformer ratios. Pointers shall be set on zero scale. With no voltage, voltmeter reading shall be checked with test-voltmeter after energizing.

14. Watt meters and watt-hour meters shall be checked for proper current and potential transformer ratios. Pointers shall be set on zero scale with no load and energized to check for proper rotation of meter.

15. All test results shall be in accordance with the requirements of all applicable test standards.

16. All switchgear shall be given operational tests. This shall include mechanical operation as well as operation by control circuit relays and tripping devices. Operating voltage at closing and tripping coils shall be checked to determine that voltage is of proper value.

17. The Contractor shall adjust and set all overcurrent trip devices, shunt trip devices and alarm devices in accordance with values furnished by Engineer.

C. Medium Voltage Circuit Breakers And Ground & Test Devices

The following tests shall be performed on the Medium Voltage Circuit Breakers and Ground & Test Devices. The term "Breaker" in the following tests represents Medium Voltage Circuit Breakers and Ground & Test Devices.

1. Measure contact resistance by a Digital Low Resistance Ohmmeter (DLRO). Any contact resistance over 100 micro-ohms should be investigated and remedial action shall be performed.

2. Perform minimum pick-up voltage tests on the trip and close coils.

3. Each Breaker shall be given a Megger test in the racked-out and closed position. A 1000-Volt, motor-driven Megger shall be used. Megger tests shall be applied between each phase to ground, between phases and between Line and Load sides. All test readings shall be recorded.

4. Perform an Overpotential Test, at a voltage recommended by the Breaker manufacturer, in the closed position. Test each phase to ground with all other phases grounded and across open contacts of each phase.

5. Perform insulation resistance test at 1000 volts DC on the Breaker control wiring. (Do not perform the test on wiring connected to solid state components).

6. With the Breaker in the test position, perform the following tests:

   a. Trip and Close the Breaker with the control switch at least ten (10) times. All indication lights, annunciations, alarms and targets shall be observed to determine correct operation. The Breaker mechanism shall be observed for correct alignment, freedom of binding and good contact.

   b. Trip each Breaker by manually operating each of its protective relays.

   c. Test the Breaker antipump circuit as recommended by the manufacturer.

7. All Breakers shall be operated through at least three (3) Open-Close cycles in the Racked-in position by manual operation and via control circuits, from each control point. All indication lights, annunciations, alarms and targets shall be observed to determine correct operation. The Breaker mechanism shall be observed for correct alignment, freedom of binding and good contact.

D. Medium Voltage Liquid Filled Transformers

1. Perform insulation power factor test and excitation current test using the test procedures outlined by Doble Engineering or approved equal. Furnish values of the Power Factor, Capacitance, Excitation Current and Watt Loss.

2. Perform overpotential test in accordance with the applicable ANSI and NEMA standards.

3. Insulating liquid shall be sampled in accordance with ASTM D-923. Sample shall be laboratory tested for:

   a. Dielectric breakdown voltage

   b. Acid neutralization number

   c. Specific gravity

   d. Interfacial tension

   e. Color

   f. Visual condition

   g. Water content in PPM

   h. PCB content

4. Perform ratio, polarity, insulation resistance and magnetization curve tests on the bushing current transformers.

5. Perform ratio, polarity and insulation resistance on any voltage transformers installed on the transformer.

6. Check all the gauges and protective devices on the transformer for their intended functions.

7. Record Nitrogen pressure and verify with the manufacturer's recommended pressure.

8. Perform Turn-to-Turn ratio test on all the taps of the transformer.

9. Check the operation of the automatic tap changer.

10. Verify the terminal markings with the nameplate and the applicable ANSI standard.

E. Medium Voltage Disconnect Switches

1. Measure contact resistance with a Digital Low Resistance Ohmmeter. If the contact resistance is above 100 micro ohms, repeat the test after cleaning and re-adjusting the contacts.

2. Apply overpotential between each phase and ground with the switch in the closed position. The remaining two phases should be connected to ground while testing the third phase. Test across open contacts of each phase.

3. Apply overpotential between phases and between line and load sides of the switch with the switch in the OPEN position.

4. Operate the switch at least ten (10) times to check its mechanical operation.

5. Check the mechanical, electrical and key interlocking features between the subject disconnect switch, grounding switch and any upstream and downstream circuit breakers or disconnect switches.

6. Verify the fuse size and rating as per specifications and Contract Drawings.

7. Check the operation and intended purpose of the Blown Fuse Indicator.

8. Check the fuse for continuity and damage and check the fuse holder for adequate mechanical support for each fuse.

9. Check blade alignment and arc interrupter operation

F. Medium Voltage Dry Type Transformers

1. Perform insulation power factor test, following the procedures outlined by the Doble Engineering or approved equal. Furnish readings of the Insulation Power Factor, Capacitance, Excitation Current and Watt Loss.

2. Perform over potential test as approved by the manufacturer. Measure insulation resistance at intervals of 30 seconds, 1 minute and 10 minutes. Calculate Dielectric Absorption Ratio and Polarization Index.

3. Perform turn ratio test between windings at each available tap.

4. Verify the terminal markings with the nameplate and applicable ANSI standards.

5. Test the lightning arrestors

6. Measure core to ground resistance

7. Check the operation of the cooling fans.

8. Check the temperature control unit and set the unit for the operation of fans, initiation of alarms and trip functions. Verify each control function.

9. Check the ratio, polarity, insulation resistance and magnetization curves any current transformers installed inside or outside the transformer enclosure.

10. Check the ratio, polarity and insulation resistance of any voltage transformers installed inside or outside the transformer enclosure.

11. Perform winding resistance test for each winding at as found tap position.

G. Medium Voltage Insulated Power Cables

1. All medium voltage cables should be Hi-Potential tested by the following the method outlined herein at a voltage recommended by the manufacturer. It should be noted that these tests shall be performed with all safety precautions and proper preparation of the cable ends.

   "Each phase conductor of the cable shall be subjected to the Hi-Potential test to ground with the other two phases grounded together with the ground shields. Applied potential shall be increased in steps of 5KV by holding the voltage for one minute at each step. At the end of each minute, leakage current shall be recorded.

   After reaching the intended voltage level, the voltage shall be held for at least ten minutes and the leakage current shall be recorded at the end of each minute." If the test indicates excessive leakage current, discontinue the test and notify the Engineer. Discharge each cable of the capacitive charge by grounding the cable till the cable is completely discharged and remains discharged.

2. Check continuity of the cable shield and measure its resistance for the entire length of the cable.

END OF SECTION

SECTION 16998

MEDIUM VOLTAGE SYSTEM COMMISSIONING TESTS

APPENDIX "A"

SUBMITTALS

A. Submit the name of the NETA Certified proposed testing firm with the following information accompanied:

1. Company resume.
2. List of references.
3. List of testing work completed of similar magnitude.
4. Number of permanent employees with their employment duration.
5. List of test equipment owned or leased with their valid calibration certificates.

B. Submit a list of the proposed personnel with their resumes who shall perform the testing prior to the interview.

C. Submit a sample of test forms to be used for the testing for Engineer's approval. If not approved by the Engineer, the testing firm shall resubmit the forms, with the changes, for the Engineer's approval.

D. Submit test procedures, with sketches to illustrate how the test equipment will be connected to the equipment to be tested, for Engineer's approval. If not approved by the Engineer, the testing firm shall resubmit the test procedures, with the changes, for the Engineer's approval.

E. Once all of the above items A-D have been satisfied, the testing firm shall submit a schedule indicating when the tests shall be performed.

F. After the testing has been completed, submit three (3) copies of the test report for each unit within 15 calendar days of the completed testing to the Engineer for review. All test results and values shall be recorded on the forms approved by the Engineer.

The test sheet shall have all technical characteristics of the unit and all identification data including feeder name, building, substation, location, nameplate information, test date and name of tester. "As found" and "As left" relay settings shall be documented. All discrepancies encountered shall be itemized and clearly described on the test sheet. All tabulations of the test data shall be in the Microsoft Excel format and shall be supplied on a disk as well as two bound hard copies.

A report for each substation shall be provided indicating number of units tested, number of units not available to be tested, discrepancies found and cross references for more information to the specific test sheet. A summary of all reports along with the testing firm's recommendation shall be submitted.

END OF APPENDIX "A"

SECTION 16998

MEDIUM VOLTAGE SYSTEM COMMISSIONING TESTS

INSTRUCTIONS TO SPECIFIER

A. General

Define the scope of the Medium Voltage Commissioning Tests on the Contract Drawings.

B. If all of the distribution system equipment that is included in the Medium Voltage Commissioning Tests does not appear on the Contract Drawings, provide reference drawings or a list available drawings as required.

C. Ensure that the Contract Drawings show:

(2.01 A.1) A list of acceptable testing firms must be added to the Contract Drawings.

1. The following is a suggested list:

Eastern High Voltage, Inc., Robbinsville, NJ
Electro Power Management, Inc., Louis, MO
General Electric Corp., Parsippany, NJ
Advanced Testing Systems, Inc., New Fairfield, CT
American Power Technologies, Inc., Lake Success, NY
Tech Serv Division Of Welsbasch Electric Corp., L.I.C., NY
Westinghouse Electric Corp., Hillside, NJ
Scott Testing, Inc., Trenton, NJ

END OF INSTRUCTIONS