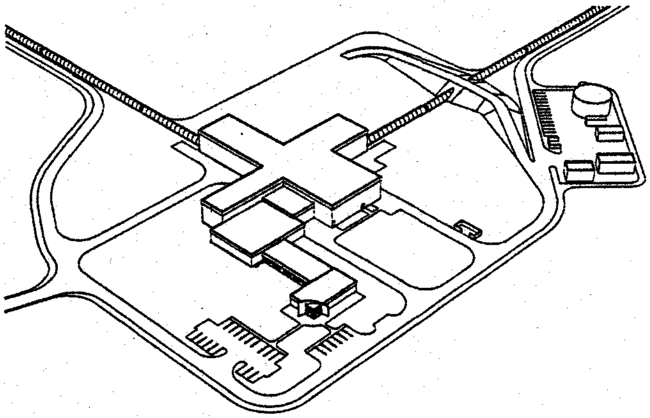
NOTE: - The enclosed draft specifications are generic to both the Hanford and Livingston Sites



Civil Construction

Preliminary Design Report -- Draft

Volume II-2 -- Construction Specifications

November 1, 1995

LIGO
Laser Interferometer Gravitational-Wave Observatory
California Institute of Technology
The Ralph M. Parsons Company
Contract Number: PP150969

LIGO Document	______
CDRL Number	**11 and 13**
DRD Number	**05**

APPROVAL STATUS

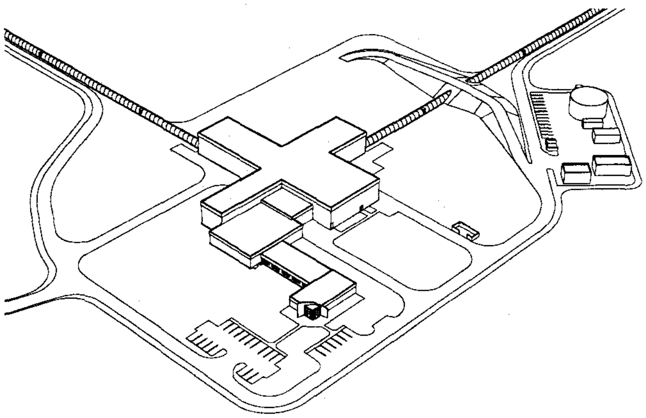
YES NO NOT REQUIRED

____
Project Manager, Parsons

____
Technical Representative, Caltech

Parsons–LIGO
Laser Interferometer Gravitational-Wave Observatory

NOTE: - The enclosed draft specifications are generic to both the Hanford and Livingston Sites



Civil Construction

Preliminary Design Report -- Draft

Volume II-2 -- Construction Specifications

November 1, 1995

LIGO
Laser Interferometer Gravitational-Wave Observatory
California Institute of Technology
The Ralph M. Parsons Company
Contract Number: PP150969

LIGO Document	______
CDRL Number	**11 and 13**
DRD Number	**05**

APPROVAL STATUS

YES NO NOT REQUIRED

Project Manager, Parsons

Technical Representative, Caltech

Parsons–LIGO
Laser Interferometer Gravitational-Wave Observatory

SECTION 06100

ROUGH CARPENTRY

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI B18.22.1	(1965; R 1981) Plain Washers

AMERICAN PLYWOOD ASSOCIATION (APA)

APA Form E30	(1990) Design/Construction Guide, Residential and Commercial

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 307	(1992) Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength
ASTM A 36	(1991) Standard Specification for Structural Steel
ASTM A 525	(1991b) Standard Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
ASTM D 2016	(1974; R 1983) Moisture Content of Wood
ASTM E 84	(1991a) Standard Test Method for Surface Burning Characteristics of Building Materials

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B18.2.1	(1981; R 1992) Square and Hex Bolts and Screws, Including Hex Cap and Lag Screws (Inch Series)
ASME B18.6.1	(1981; R 1991) Wood Screws (Inch Series)

AMERICAN WOOD-PRESERVERS' ASSOCIATION (AWPA)

AWPA A3	(1991) Determining Penetration of Preservatives and Fire Retardants
AWPA C1(1991)	All Timber Products - Preservative Treatment by Pressure Processes
AWPA C20	(1991) Structural Lumber - Fire-Retardant Treatment by Pressure Processes
AWPA C27	(1991) Plywood - Fire-Retardant Treatment by Pressure Processes
AWPA P5	(1991) Waterborne Preservatives

AWPA P8	(1991) Oil-Borne Preservatives

AMERICAN WOOD PRESERVERS BUREAU (AWPB)

AWPB LP 2	(1988) Softwood Lumber, Timber and Plywood Pressure Treated with Water-Borne Preservatives for Aboveground Use

FEDERAL SPECIFICATIONS (FS)

FS FF-B-588	(Rev D) Bolt, Toggle; and Expansion Sleeve, Screw
FS FF-N-105	(Rev B; Int Am 4) Nails, Brads, Staples, and Spikes: Wire, Cut, and Wrought
FS FF-S-325	(Int Amd 3) Shield, Expansion; Nail, Expansion; and Nail, Drive Screw (Devices, Anchoring, Masonry)
FS TT-W-571	(Rev J) Wood Preservation: Treating Practices

NATIONAL FOREST PRODUCTS ASSOCIATION (NFOPA)

NFOPA-03	(1988) Manual for House Framing

NATIONAL INSTITUTE FOR STANDARDS AND TECHNOLOGY (NIST)

NIST PS 1(1983)	Construction and Industrial Plywood
NIST PS 20	(1970; Rev 1986) American Softwood Lumber Standards

REDWOOD INSPECTION SERVICE (RIS)

RIS-01	(1987) Grades of California Redwood Lumber

SOUTHERN PINE INSPECTION BUREAU (SPIB)

SPIB 1001	(1991) Grading Rules

WEST COAST LUMBER INSPECTION BUREAU (WCLIB)

WCLIB Std 17	(1991) Standard Grading Rules for West Coast Lumber

WESTERN WOOD PRODUCTS ASSOCIATION (WWPA)

WWPA-01	(1991) Western Lumber Grading Rules 91

1.2 SUBMITTALS:The following shall be submitted in accordance with Sectio 01300,"Submittals," in sufficient detail to show full compliance with thespecification:

A. Certificates of Compliance shall be submitted for the following laboratory test reports.

1. Tests for Moisture Content of wood shall be in accordance with ASTM D 2016, [Method A, Oven Drying Method] [Method B,Electronic Moisture Meter Method]. Material tested shall be thesame material proposed for use in the project. Moisture test shall be dated

no earlier than 3 months prior to the delivery of lumber materials. An additional test report will be required if the materials species or stress grade changes.

2. Fire-Retardant-Treated Lumber Tests shall be according to the paragraph entitled, "Fire-Retardant-Treated Lumber," of this section.

3. Certificates of Compliance shall be submitted for the following items showing conformance with the referenced standards contained in this section. Certificates for wood-framing materials, shall include grade, species and moisture.

Wood-Framing Materials
Fasteners
Wood-Preservative Treatment

1.3 DELIVERY, HANDLING, AND STORAGE: Wood materials shall be securely bundled and shipped with adequate moisture-resistant covers to preclude damage by weather or handling during delivery, when stored, and during construction. Wood materials that must be stored outdoors before immediate use shall be placed in orderly piles and stored on blocks above ground.Lumber shall be stored in stacks with provision for air circulation within stacks. Material shall be protected from the elements with moisture-resistant covers.

PART 2 - PRODUCTS

2.1 WOOD MATERIALS

A. General Requirements:

1. Each piece of framing lumber, board lumber, and plywood shall bear the trademark and grade identification of the manufacturer's association or the authorized inspection bureau under rules of which the lumber is manufactured and graded.

2. Softwood lumber shall be seasoned S4S and kiln-dried or air-dried to the specified moisture content. Dressed sizes shall conform to NIST PS 20.

3. Moisture content shall conform to the rules of the lumber association or the inspection bureau under which the lumber is graded but shall not exceed 15 percent for boards and dimensional lumber 2 inches or less in thickness.

B. Lumber for Plates, Blocking, Cant Strips and Similar Applications shall be of one of the following species at the option of the Contractor:

Douglas fir, coast region; Western larch; hemlock, white fir, ponderosa pine, western red cedar	Standard grade, west coast	WCLIB Std 17 WWPA-01 Grading Rules
Sitka spruce, western red cedar	Standard grade	WCLIB Std 17
Redwood	Construction grade	RIS-01

C. Fire-Retardant-Treated Lumber: Lumber for wood plates shall be fire-retardant treated by means of an approved pressure impregnating process in accordance with AWPA C1, AWPA C20. Contractor shall submit reports of the results of retention-penetration test boring cores, and performance ratings. Treatment and performance inspection shall be performed by an independent, qualified test agency that establishes the performance rating.

1. After treatment, wood materials shall have a flame-spread rating not greater than 25, with no evidence of significant progressive combustion when tested for 30 minutes duration in accordance with ASTM E 84.Fuel contributed shall not exceed 15; smoke developed shall not exceed 5.

2. After treatment, solid lumber materials shall have a minimum penetration of 1/2 inch of fire retardant material when tested by a borer core in accordance with AWPA A3.Plywood materials shall have a minimum retention of 25 pounds per cubic foot when tested by weighing before and after treatment.

3. Approved fire-retardant materials shall bear identification showing the fire performance rating thereof issued by an approved testing agency.

4. After treatment, solid lumber shall be kiln-dried to reduce moisture to not more than 19 percent.Plywood shall be kiln-dried to reduce moisture to not more than 15 percent.

D. Preservative Treated Lumber:

1. The following wood members shall be pressure-preservative treated in accordance with FS TT-W-571 or AWPB LP 2.Each piece shall bear the AWPB stamp, indicating point of treatment, preservative symbol, symbol of standard, date of treatment, and moisture content after treatment:

Plates in contact with concrete
Roof cants

2. Preservative shall be water-borne conforming to AWPA P5. Wood treated with water-borne preservatives shall be air-dried or kiln-dried to reduce maximum moisture content to 15 percent. Treated wood exposed in the final structure shall be free from objectionable odors and shall not be harmful or corrosive to adjacent materials or anchorages.

2.2 ANCHORAGE AND FASTENER MATERIALS

A. Nails and Staples and tacks shall conform to FS FF-N-105. Nails for roof blocking, cants, and nailers shall be galvanized. Power-driven staples shall be galvanized Type III, Style 3.

B. Bolts, Nuts and Screws

1. Bolts and nuts shall be carbon steel, galvanized, conforming to ASTM A 307, Grade A.

2. Lag screws or lag bolts shall be commercial steel, galvanized, conforming to ASME B18.2.1.

3. Expansion shields, expansion nails, and drive screw devices shall conform to FS FF-S-325.

4. Toggle bolts shall conform to FS FF-B-588.

5. Washers shall be carbon steel, galvanized, general assembly purpose type, conforming to ANSI B18.22.1.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Washers shall be provided under bolt heads or nuts in contact with wood. Lumber shall be bored to receive bolts. Nailers, blocking, and furring shall be furnished in lengths that minimize joints.

B. Blocking, Cant Strips, and Nailers:

1. Nailing strips, blocking, cant strips, and sub fascia wood members shall be continuous, cut with square ends and in maximum practical lengths. For bolted connections, members shall be fastened to structural steel members or concrete with 1/2-inch bolts at a maximum spacing of 4 feet on center, one bolt near each end of the member. Bolt heads shall be countersunk flush with the surface of the wood. Sub fascia members shall be held to a tolerance of 1/8 inch in 10 feet.

2. Wood cant strips shall be not less than 4-inches long and set at projections through the roof deck, expansion joints, and fascias. Perimeter roof blocking, nailers, and cants shall be groove-cut to provide ventilation for insulation. Groove cuts shall be matched for continuity or new vent grooves cut when wide vents are built of more than one width of wood.

3. Bottom half of nailers shall be cut to provide a net open area equivalent to 10 percent of the edge face.

END OF SECTION

SECTION 06200

FINISH CARPENTRY

PART 1 GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A208.1	(1979; R 1986) Mat-Formed Wood Particleboard
ANSI B18.6.1	(1981) Screw, Wood

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 1037	(1993) Standard Test Method for Evaluating the Properties of Wood-Base Fiber and Particle Panel Materials
ASTM D 1760	(1986; Rev A) Standard Specification for Pressure Treatment of Timber Products
ASTM D 4689	(1990) Standard Specification for Adhesive, Casein Type

ARCHITECTURAL WOODWORK INSTITUTE (AWI)

AWI-01	(1986) Architectural Casework - General

FEDERAL SPECIFICATIONS (FS)

FS MMM-A-130	(Rev B; Int Am 3) Adhesive, Contact
FS MMM-A-181	(Rev D) Adhesives, Phenol, Resorcinol, or Melamine Base

HARDWOOD PLYWOOD MANUFACTURERS ASSOCIATION (HPMA)

HPMA HP-1	(1992) Standard for Hardwood and Decorative Plywood

NATIONAL ELECTRICAL MANUFACTURER'S ASSOCIATION (NEMA)

NEMA LD-3	(1991) High Pressure Decorative Laminates

NATIONAL INSTITUTE FOR STANDARDS AND TECHNOLOGY (NIST)

NIST PS 1	(1983) Construction and Industrial Plywood

WOODWORK INSTITUTE OF CALIFORNIA (WIC)

	(1994) Manual of Millwork

1.2 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Drawings: Submit for the following items, bearing the AWI or WIC Certified Compliance Grade Label.

1. Fabrication Drawings shall be submitted for Finish Carpentry Materials consisting of fabrication and assembly details to be performed in the factory.

2. Installation Drawings shall be submitted for the following items in accordance with Part 3, "Execution," of this section.

Hardwood Plywood Wainscots
Cabinets, Counters, and Caseworks
Wood Trim
Plastic Laminated Counter Tops, Edges and Backsplashes
Shelving
Steel backing plate or wood blocking locations required for anchoring of cabinets, casework, and other work of this section.

B. Data: Catalog data for each proposed cabinet hardware item.

C. Certificates: Submit as required in Article "Quality Assurance" above.

D. Samples: The following samples shall be submitted:

At least three sample flitches from each log for architectural-grade, Hardwood Plywood.

Wood Trim 12-inches.

Plastic Laminate 3 by 6 inches.

1.3 DELIVERY, HANDLING, AND STORAGE

A. Contractor shall protect materials from damage during delivery, when stored, and during construction. Damaged and defective materials shall be removed and replaced with new.

B. Trim, paneling, cabinet work, and other finish millwork items shall be delivered and brought into the building only after the building has dried out, following the installation of wet materials, and when there is no danger of damage to materials due to excessive moisture.

C. Wood paneling and particleboard shall be stored in accordance with manufacturer's directions for at least 48 hours in the room in which they are to be installed. Plywood paneling shall be removed from cartons and stacked flat, with 1-inch stripping under and between each pair of face-to-face panel. Face panels shall be separated by a slipsheet.

1.x QUALITY ASSURANCE:

A. Work of this section shall conform to either AWI 01, or the Manual of Millwork of WIC, grades as noted hereafter, except as modified by more stringent requirements herein. Prior to delivery to site, submit AWI or WIC Certified Compliance Certificates indicating each millwork product for the work and that all products will fully conform to AWI or WIC grades and other requirements shown and specified.

B. Fabricator and installer of work of this section shall have not less than five years local experience in commercial work of the complexity of this project. Furnish references showing not less than 10 such projects.

1.4 SITE CONDITIONS: Field measurements shall be taken before fabrication and installation of materials to verify and supplement the indicated dimensions.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Plywood Wainscot Paneling: Meet or exceed the requirements of HPMA HP-1, Grade A, with specialty grade characteristics as specified herein. Face veneers shall be manufactured with a 3-ply particleboard core or, at mill option, with a veneer core. Face veneer shall be plain sliced cherry, AWI or WIC Premium grade, and shall match approved samples.

1. Hardwood plywood panels shall be Type II bonded with water-resistant adhesives.

2. Moisture content of hardwood plywood paneling shall be certified not to exceed 12 percent at the time of mill shipment.

3. Panel veneers shall be book matched. Panel shall be attached to furring and wall framing by concealed mechanical fasteners with no exposed face nailing.

B. Plywood Shelving, Utility Usage shall be sanded interior grade plywood, 3/4-inch thick, graded "B-D Int-DFPA" in accordance with NIST PS 1, or shall be 3/4-inch thick particleboard conforming to ANSI A208.1, manufactured from wood flakes, particles, and shavings, and bonded with urea-formaldehyde resin.

C. Fasteners and Adhesives

1. Nails and Staples: All nails and staples, whether hand driven or mechanically driven, shall conform to FS FF-N-105.

2. Wood Screws shall be carbon steel or brass, conforming to ANSI B18.6.1. Wood screws exposed to view shall be brass with an oval head with cross recess drive.

D. Adhesives for interior millwork and trim shall be moisture-resistant type conforming to ASTM D 4689, Type II, water- and mold-resistant Glue shall be polyvinyl acetate type for casework.

F. Solid Wood: Exposed cherry trim shall be Premium Grade in accordance with the WIC or AWI-01 Standards. Trim shall be 300-S-4, milled to the indicated profile. Moldings, joint tolerances, miters, construction quality, and surface finish shall conform to AWI-01 requirements for "Standing and Running Trim & Rails." Material shall be furnished in the maximum practical length for the end use.

1. Material shall be kiln-dried. Moisture content shall not exceed 12 percent at the time of delivery to the building site.

2. Corners shall be mitered, tightly butted, and secured.

3. Wood trim shall be carefully selected to match hardwood plywood paneling.

4. Exposed nailing shall be countersunk finishing nails. Countersunk holes shall be filled with matching wood filler or putty.

5. Wood trim shall be hand sanded at the jobsite to a smooth clean finish, free of machine or tool marks, abrasions, raised grain, or similar imperfections.

G. Laminated Plastic: conforming to NEMA LD3-1980, manufactured by Formica, Micarta, Parkwood or WilsonArt, finishes and colors as selected from any of the listed manufacturers, grades as follows:

1. For shelves and other horizontal surfaces: Grade GP-50.
2. For cabinet doors, sides, backs and other vertical surfaces: Grade GP-28.
3. For countertops: High wear Grade HW-120.
4. For backing and concealed applications: Backing grade.
5. For insides of cabinets behind solid doors: Melamine cabinet liner.

H. Particleboard shall conform to CS236, Table 1, Class 1-B2, and as follows: minimum density 40 pounds per cubic foot; internal bond 80 psi., screwholding: face - 250 pounds; edge - 225 pounds. Submit certification of conformance with these requirements.

D. Fiberboard: Medite II, formaldehyde free, medium density fiberboard, or equal environmentally safe, plywood substitute, where feasible. Medite manufacturer: Medite, P.O. Box 4040, Medford OR 97501 (800) 676-3339 FAX (503) 779-9921. Medite distributors: California Panel & Veneer, P.O. Box 3250, Cerritos Ca. 90703 (213) 926-5834, and Royal Plywood, 14171 East Park Place, Cerritos Ca. 90701 (310) 404-2989.

E. All hardware shall have satin chrome plated finish.

1. Concealed Hinges: Stanley 1561-2, end mount.
2. Concealed Hinges: Stanley 1561-9X, center mount.
3. Door and Drawer Pulls: As selected by Architect.
4. Drawer Guides: Grant 3320.
5. Drawer Slides:
   a. Full Extension slides.
      (1) 75 pound capacity rated: Accuride No. 3800.
      (2) 100 pound capacity rated: Accuride No. 3017, 417, 439, 4037, Grant No. 329, 527, or KV No. 1429, 1460.
      (3) 150 pound capacity rated, Accuride No. 4437, Grant No. 555, or KV No. 8500.

2.02 MANUFACTURE

A. Laminated Plastic Finished Cabinets: WIC Section 15 "Custom" grade, with a high pressure laminated plastic for edge banding, white polyester overlay cabinet liner in cabinets with solid doors and drawers. Low pressure decorative polyester or melamine overlay is not permitted for other uses. Sides and backs of casework shall be fabricated of Medite. Use particleboard for incidental pieces only. Countertop backing and shelves shall be fabricated of plywood. Open cabinets and cabinets with glass doors shall have interiors finished to match exterior. Casework shall be Style A, frameless. Cabinet doors shall be as follows: flush doors Type A, glazed doors Type B with wood stop finished to match color and pattern of laminate. Construction shall be Type 2, single length for each unit, unless Type 1, self supporting units are detailed, or unless single lengths are not practicable for access to spaces.

B. Laminated Plastic Countertops: WIC Section 16 "Custom" grade, fabricated of plywood, covered with NEMA LD-3, 0.050" thick plastic laminate, with square butt joint backsplash and extend across the walls abutting ends of countertops. At sinks, provide no-drip tilt edge with self-edging. Seal the edges of sink and plumbing trim cut-outs with resin sealer. Make tops up to 12-foot length in one piece; for longer lengths, use not over two pieces, assembled with draw bolts and splines, jointed flush and smooth as shown on approved Shop Drawings. Splices shall not occur across sink cut-outs. Seal joints at splices with mastic.

PART 3 - EXECUTION

3.1 PREPARATION: Paneling and finished millwork items shall be installed only when temperature and humidity conditions approximate the interior conditions that will exist when the building is occupied. Relative humidity in the building at the time of installation of materials shall be within the limits recommended by the manufacturer.

3.2 PANELING INSTALLATION

A. Arrange each panel in the room immediately before installation for best color and grain pattern and identify each panel with a number on the panel back to ensure proper location when installed.

B. Panels shall be fastened to wall sheathing with contact cement without nails, in accordance with manufacturer's directions. Inside corners shall be butt joint, one panel scribed, the other butted. Joints shall be standard V joints. Trim shall be solid hardwood of same species as paneling.

C. Wood Trim shall be set straight, plumb and level, closely fitted, and rigidly fastened. Nail heads of exposed work shall be countersunk and the holes filled with matching wood filler. Joints shall be tight and formed to conceal shrinkage. Shop miters over 4 inches shall be glued and splined.

D. Furring and framing to receive paneling shall be checked for plumb and true plane surface. Adjustments shall be made before proceeding with the work.

3.3 SHELVING: Shelving shall be constructed and assembled in accordance with AWI-01, specified grade. Uprights and wall cleats shall be solid wood, 1 by 3-inch minimum size, or may be metal wall standards with heavy duty adjustable brackets.

3.4 CABINETS:

A. All installation work shall be done under the supervision, of a skilled cabinetmaker who can direct the installation in accordance with the true intent and meaning of drawings and specifications. He shall have had experience in fabricating and finishing of cabinetwork. All installation shall conform to standards as set forth in the WIC Manual of Millwork, Section 1.

B. Install cabinets and casework level, plumb, and tight against adjacent walls. Secure cabinets to walls with concealed toggle bolts, and secure top to cabinet with concealed screws. Make cutouts for fixtures to templates supplied by fixture manufacturer. Carefully locate cutouts for pipes so that edges of holes will be covered by escutcheons. All installation shall conform to the standards as set forth in Section 26 of the WIC Manual of Millwork.

C. Cabinet Hardware: Fit and install cabinet hardware at the shop. After cabinets are in place, readjust each hardware item and leave in correct working condition.

D. Countertops shall be set and secured to cabinets with concealed angles and wood screws. Provide all cutouts in countertops for sinks, sink trim and other devices as shown or required for complete installation. Cutouts shall be carefully made to be completely concealed by the standard escutcheon plate accompanying the trim or other device. Where field joints are made in tops, they shall be completely finished.

E. Cabinetwork installation shall be made complete with all required fastenings, clip angles, braces, anchors and other appurtenant fittings as required to render the work rigid and secure.

F. Hardware and Metal Work: Install all finish hardware and metal work for the cabinet and fixture work, including all items necessary for and incidental to a complete installation. All items of hardware shall be accurately and neatly fitted and installed and all operating parts inspected and adjusted for proper functioning by the Manufacturer.

END OF SECTION

SECTION 07270

FIRESTOPPING

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E 119

ASTM E 814

UNDERWRITERS' LABORATORIES, INC. (UL)

UL 1479

1.2 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data and Test Reports: Submit firestopping manufacturer's specifications for materials and application with copies of Code approvals and UL classifications. Upon completion, inspect the application and submit a written certification that all installed materials and workmanship conform to specifications and Code requirements, and as classified in UL Building Materials Directory.

B. Job Site Sample: Before proceeding with the work, install a sample of each typical condition at location as directed, showing proposed workmanship and application techniques. Make all adjustments in materials and workmanship required to obtain approval. The approved sample shall be the criterion for acceptance of all work.

1.3 QUALITY ASSURANCE: Firestopping shall conform to requirements of applicable building codes, insurance rating organizations, and all other authorities having jurisdiction.

A. Firestopping materials shall conform to flame and temperature ratings and hose stream test of ASTM E814 (UL 1479), and time/temperature requirements of ASTM E119. Flame and temperature ratings shall conform to the fire resistance rating of the assembly being penetrated, but not less than one hour.

B. Materials shall be listed by the International Conference of Building Officials (ICBO).

C. Applicator: Installer shall be certified by manufacturer and having not less than 5 years experience in firestopping installations of size and complexity required for the work. Submit qualifications of firm and superintendent or foreman of subcontractor for approval.

1.4 DESCRIPTION OF SYSTEM: Firestopping shall include sealing of openings and joints indicated, specified, and required to make the entire building resistant to the passage of temperature, flame smoke, water, and toxic fumes and gases. The following are examples of locations where firestopping is required:

A. Openings in fire-rated floors, walls and partitions, including openings for future items, and those accommodating penetrating items such as cables and wires, cable trays, conduits, pipes, ducts, structural elements and similar items.

B. Openings between walls and connecting floor and roof assemblies.

C. Penetrations of vertical service shafts.

D. All other openings, gaps and holes in fire resistance rated construction.

1.5 JOB CONDITIONS: Install temporary coverings and protection to prevent the material from contaminating adjoining surfaces and construction and to prevent damage or the creation of a public nuisance. Conform to requirements of governing public authorities.

1.6 DELIVERY AND STORAGE: Deliver to site in factory sealed containers, and store as recommended by manufacturer.

PART 2 - PRODUCTS

2.1 MATERIAL:

A. Acceptable Manufacturers: Subject to approval by regulatory authorities, products may be manufactured by any one of the following:

1. Bio Fireshield Inc., Damonmill Square, Concord, MA 01742 (617)369-7700.

2. Contractor Products Dept., 3M Center, St. Paul, Minn. 55144 (612)736-2911.

3. International Protective Coatings Corp., 725 Carol Avenue, Ocean Township, NJ 07712 (908) 531-3666 FAX (908) 531-5192.

4. GE Silicones, 1 Hudson River Road, Building 25/73, Waterford, NY 12188 (518) 235-2391

5. USG "Firestop Systems", Glendale, CA. (800) 964-4874.

6. Hilti Construction Chemicals, Inc., Tulsa, OK (918) 252-6901

7. Specified Technologies, Inc., 200 Evans Way, Suite 2, Somerville, NJ 08876 (908) 526-8000 FAX (908) 526-9623, represented by Construction Products Group, P.O. Box 849, Huntington Beach, CA 92648.

B. Materials shall be suitable for firestopping of penetrations made by copper, steel, glass, plastic and insulated pipe for the life of the building without adversely affecting the fire rating of the wall or floor.

C. On insulated pipe, the material shall be approved for use over the insulation.

D. Materials shall meet the fire rating classification of the assembly being penetrated, but not less than 1 hour.

E. Materials shall allow for normal movement of building structure and penetrating items without affecting the fire rating or structural integrity of the wall and floor system.

F. Materials shall be asbestos free, emit no toxic or combustible fumes, and shall be capable of maintaining an effective barrier against flame, smoke, water and toxic gases in compliance with referenced standards.

2.2 TYPES OF MATERIALS:

A. Firestopping Mortar: Single component Portland cement fly ash mortar, not requiring supports or anchoring devices to pass water hose stream test.

B. Firestopping Sealant: Single component intumescent or silicone type sealant, gun grade for walls and overhead application, and self-levelling type for floor applications. Sealant shall provide flexible, air-tight, waterproof seal and shall bond to building materials to be encountered.

C. Firestopping Wrap Strips: Flexible intumescent foil faced strips of com-pounded neoprene rubber, heat-expansive silicate and ceramic-based material to be used where plastic, insulated , glass or other combustible pipe or pipe wraps penetrate a fire resistive assembly. Wrap strip shall intumesce upon application of heat, totally filling all voids created by combustion of plastic or glass pipe or pipe insulation.

D. Firestop Compound: Use firestop compound as required by each approval rating.

E. Firestopping Sleeves: Prefabricated sleeve, consisting of steel collar lined with intumescent material, classified for both flame and temperature.

F. Firestopping Foam Sealant: Two part silicone foam sealant.

G. Collars (for plastic pipe): Types required for each condition of application.

H. Backing Material: Mineral wool weighing not less than 4 pounds per cubic foot, glass fiber or similar material acceptable to rating authorities.

I. Metal Components: Provide as required by manufacturer to meet fire test requirements.

PART 3 - EXECUTION

3.1 PREPARATION:

A. Clean surfaces and substrates of dirt, oil, loose materials and other foreign materials which may affect the proper bond or installation of firestopping materials.

B. Provide primers as required for the various substrates and conditions.

C. Surfaces which have been previously painted shall not be covered with firestopping unless tests are performed to indicate compatibility of materials.

3.2 APPLICATION:

A. Install firestopping materials in strict accordance with recommendations of manufacturer and with approved fire rating reports. Install so that flame and temperature resistance ratings equal to that of assembly being penetrated, but in no case less than one hour.

B. Provide or ensure that all anchoring devices, back-up materials, clips, sleeves, supports and other materials used in the fire tests are installed. Install temporary dams as required to retain material until initial cure.

C. Install firestops with sufficient pressure to fill and seal openings to ensure an effective fire and smokeseal and waterseal.

D. Tool or trowel exposed surfaces. Remove excess materials as work progresses. Keep adjoining surfaces free from firestopping materials.

3.3 CLEAN UP: Remove all temporary dams after initial cure of material. Remove stains and discoloring of adjacent surfaces. Remove all debris from site upon completion of installation.

END OF SECTION

SECTION 07410

METAL WALL PANELS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC S335	(1989) Specification for Structural Steel Buildings Allowable Stress Design and Plastic Design with Commentary

AMERICAN IRON AND STEEL INSTITUTE (AISI)

AISI SG-673	(1986; Errata 1990) Cold-Formed Steel Design Manual

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 123	(1989a; E1) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 36	(1991) Standard Specification for Structural Steel
ASTM A 366	(1991) Standard Specification for Steel, Sheet, Carbon, Cold-Rolled, Commercial Quality
ASTM A 525	(1991b) Standard Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
ASTM C 236	(1984) Steady-State Thermal Performance of Building Assemblies by Means of a Guarded Hot Box.
ASTM C 920	(1987) Standard Specification for Elastomeric Joint Sealants
ASTM D 1056	(1991) Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber
ASTM E 72	(1980) Strength Tests of Panels for Building Construction
ASTM E 84	(1994) Tunnel Test for Surface Burning Characteristics of Building Materials.
ASTM E 283	(1991) Rate of Air leakage Through Exterior Windows, Curtainwalls, and Doors.

ASTM E 330	(1990) Structural Performance of Exterior Windows, Curtainwalls, and Doors by Uniform Static Air Pressure Difference.
ASTM E 331	(1991) Water Penetration of Exterior Windows, Curtainwalls and Doors by Uniform Static Air Pressure Difference.

AMERICAN WELDING SOCIETY, INC. (AWS)

AWS D1.1	(1992) Structural Welding Code - Steel

ARCHITECTURAL ALUMINUM MANUFACTURER'S ASSOCIATION

AAMA 1502.7	(1981) Voluntary Test Method for Condesation Resistance of Windows, Doors and Glazed Wall Sections.

FACTORY MUTUAL (FM)

FM 4411	Series of Fire Tests.
FM 4880	50 ft. Corner Test for Unlimited Height Usage.

INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS (ICBO)

UBC 17-6	Multi-story Fire Evaluation Program by Southwest Research Institute.

UNDERWRITERS LABORATORIES, INC. (UL)

UL-02	(1992) Building Materials Directory

1.2 PERFORMANCE REQUIREMENTS

A. Structural Properties: Structural designs shall have been derived from witnessed structural tests for wind loads by Chamber Methods as outlined in ASTM E 72. Standard test design loading shall be 20 pounds psf, positive or negative wind load, and a deflection limit of L/180 under positive loading.

B. Water Penetration: No uncontrolled water penetration shall occur when the wall is tested in accordance with ASTM E 331. The differential static pressure difference used in test shall be 12.0 psi, 2.3 inches water gage, equivalent to a 69 mph wind velocity.

C. Air Infiltration: Air leakage rate shall be no greater than 0.04 cfm/sf of wall area. This performance must be met at a pressure differential of 6.24 psf, 1.2 inches water gage, equivalent to a wind velocity of 49.4 mph determined in accordance with procedures specified in ASTM E 283.

D. Thermal Performance: Thermal properties for 2" thick metal faced sandwich panels shall be U = 0.0 BTU/HR/ft2/degrees Farenheit for panels when tested in accordance with ASTM C 236.

E. Condensation: Panel shall have a minimum condensation resistance factyor of 85 +/-2 when tested in accordance with AAMA 1502.7.

F. Fire Performance Requirements: Fire performance tests for metal face sandwich panels shall consist of the following:

1. Underwriters Laboratories, Inc. Building Materials Directory, Building Units (BLBT), File R6896, UL 723 Test for Surface Burning Characteristics of Building Materials, ASTM E 84 Steiner Tunnel Test. Panel ratings shall not exceed the following:

Flame Spread 15
Smoke Developed 50 - 130

2. Factory Mutual Approval Guide, Building Insulation, Walls, Insulated Core, Fire Rated per FM 4411 Series Test resulting in a Class I rating.

3. Multi-Story Fire Evaluation Program, UBC 26-4 (17-6) by Southwest Research Institute. Result shall indicate no flame penentration to second floor, no significant flame propagation over the exterior face of the panels, and no lateral spread of flame.

4. FM 4880 Approval for Unlimited Height Application without Automatic Sprinklers. 50 ft. high wall-ceiling test shall be conducted. Flame or burn shall not reach the ceiling or ends of test walls.

G. Research Reports: International Conference of Building Officials Research Report No. PFC- 3820.

1.3 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Manufacturer's Catalog Data shall be submitted for the following items:

Steel Sheet Materials
Subgirts and Formed Shapes
Closure Materials
Insulation
Paint Materials
Metal panels

B. Drawings

1. Fabrication Drawings for Metal Panels shall indicate material, thickness, width and length, and any special miter or bevel cuts.

2. Installation Drawings for the following items shall indicate completely dimensioned structural frame and erection layouts, openings in walls, special framing details, construction details at corners, ridges, eaves, building intersections, curbs and flashing, location and type of mastic and metal filler strips,location and erection of subgirts, sandwich walls, and fire-ratedwalls.

Metal wall panels
Flashing and accessories

C. Reports: Test Reports shall be submitted for the following items:

1. Coatings and Base Metals of metal and siding type of test as specified.

2. Chemical Composition, Mechanical Usability and Soundness Tests, in accordance with AWS A5.1, for Welding Electrodes.

3. Leakage Tests

D. Certificates of Compliance shall be submitted for the following items showing conformance with referenced standards contained in this section.

Fasteners
Enamel Repair Paint

E. Samples: Contractor shall submit three pieces each of the following samples:

Metal wall panel material complete with insulation, 8 by 11 inches, with specified finishes

Color Panels, approximately 4 by 4 inches, for color range each type.

Fasteners, each type

Metal Closure Strips, 10 inches long of each type.

1.7 QUALITY ASSURANCE

A. Products herein specified establish the standard of quality for the factory insulated panel, based on the Vertical Foamwall - V wall system by Smith Steelite, 1005 Beaver Grade Road, Moon Township, Pennsylvania 15108-2944.

B. Manufacturers of wall systems shall have had a minimum of 10 years experience in manufacture of panels of type similar to that specified herein.

1.4 QUALIFICATIONS FOR WELDING WORK

A. Welding procedures shall be in accordance with AWS D1.1.

B. Operators shall be permitted to make only those types of weldments for which each is specifically qualified.

1.5 DELIVERY, HANDLING, AND STORAGE

A. All components of the wall shall be identified after fabrication by marks, clearly indicating their location on the building, packaging, if necessary, shall be the minimum necessary to protect the parts from damage during shipping and hoisting.

B. Metal wall panels shall be carefully handled at all times to prevent damage to the surfaces, edges, and ends. Contractor shall be responsible for arrangement with the manufacturer for adequate packaging and protection during shipment and offsite storage. Upon arrival at the job site, the sheets shall be checked for damage, dampness, and wet storage stain.

C. Moisture shall be removed from dampened or wetted sheets. Sheets not immediately used in the work shall be stored and protected in a covered, dry location that provides good air circulation free from effects of moisture and other corrosive environments. Sheets found with damage or stain shall not be used in the work.

1.6 FIELD MEASUREMENTS: Field measurements shall be taken prior to preparation of drawings and fabrication.

PART 2 - PRODUCTS

2.1 MATERIALS

A. System: Insulated Metal Panel System shall be factory assembled, 2 inch thickness, metal faced sandwich panels, with poured in place rigid expanded polyisocyanurate insulating core, in 24" and 30 inch widths as indicated, and lengths up to 30'-0" as shown on drawings. Provide a 1/8 inch nominal vertical side joint.

1. The panel facings shall be 24 gage steel conforming to ASTM A 653 structural quality Grade 33, with ASTM A 924, Class G-90 galvanizing. Panels shall be roll formed to the specified profile. The material shall be plumb and true, and within the tolerances listed in ASTM A 525.

2. Panel faces shall be smooth and with a striated profile.

B. Trim Members and Coping

1. Sheet metal trim members of same material and finish as the exterior panel skins.

C. Flashings, closers, fillers, metal expansion joints, ridge rolls, and other sheet metal accessories shall be factory-formed material of the same type and quality finish as specified for wall panels, and shall be not less than 0.0239 inch thick.

2.6 SUBGIRTS AND FORMED SHAPES

A. Panel subgirts, T-bars, Z-bars, and angle closers shall be die-formed shapes fabricated from steel conforming to ASTM A 36, hot-dip galvanized in accordance with ASTM A525, G90.

B. Die-formed subgirts shall have a minimum uncoated thickness of 0.0478 inch (No. 18 U.S. standard gage) and bar shapes shall be at least 1/4 by 1 inch. T-bars shall have a minimum uncoated thickness of 0.0299 inch (No. 22 U.S. standard gage) and Z-bars shall have a minimum uncoated thickness of 0.0747 inch (No. 14 U.S. standard gage).

C. Concealed clips shall be fabricated from hot-dip-galvanized steel conforming to ASTM A 366, coating designation ASTM A 525, G90.

D. Galvanized Steel Angles

1. Galvanized steel angles shall be hot-rolled carbon steel conforming to ASTM A 36, and hot-dip galvanized in accordance with ASTM A123.

E. Electrodes for Manual, Shielded Metal Arc Welding

1. Electrodes for manual, shielded metal arc welding shall meet the requirements of AWS D1.1, and shall be covered, mild-steel electrodes.

2.7 FASTENERS

A. Exposed fasteners for securing sheets to structural steel framing or to subgirts shall be No. 14 self-tapping, Type B, recessed hexagon-head, or Type 305 corrosion-resistant steel screws with cadmium-plate finish; length as required for the application. Fastener assembly shall include a corrosion-resistant steel washer and a neoprene washer, or an integral corrosion-resistant steel and neoprene washer. Exposed head of fastener shall match color of wall panels sheets by means of plastic caps or factory-coated heads.

B. Exposed fasteners for securing overlap-type side laps of corrugated profile steel materials, and for securing accessory steel flashing, shall be No. 14 by 3/4-inch Type B recessed hexagon-head, Type 305 corrosion-resistant, chromium-nickel-steel screws with corrosion-resistant steel and neoprene washers. Screw head caps shall match color of sheets.

2.8 CLOSURE MATERIALS

A. Mastic Closure Strips

1. Mastic closure strips shall be closed-cell, expanded cellular rubber conforming to ASTM D 1056, Type S, Class SCE-41 CMP. Closure strips shall be cut or premolded to the exact configuration of the specified wall panels material.

2. Closure strips shall be uniform in appearance, free of weak sections, bubbles, cracks, and defects.

B. Adhesives for Closure Strips

1. Adhesive for use with closure strips shall be the type recommended and furnished by the closure strip manufacturer.

C. Metal Closure Strips

1. Metal closure strips shall be factory fabricated accessories matching the type, thickness, and profile of the specified wall panels. Steel closure strips shall be the same thickness and finish as the exterior wall panels.

D. Joint Sealants

1. Sealants shall be an approved gunnable type for use in hand- or air-pressure calking guns at temperatures above 40 degrees F. They shall be used around doors, windows, masonry, and other construction material. Solids content shall be a minimum of 85 percent of the total volume. Sealant shall dry with a tough, durable surface skin which permits it to remain soft and pliable underneath, providing a weather tight joint. No migratory staining shall be permitted on painted or unpainted metal, glass, or other materials adjacent to panels.

2. Joints shall be primed with a compatible one-component or two-component primer as recommended by the sealant manufacturer.

E. Shop Applied: Sealant for shop-applied calking shall be an approved gun grade, nonsag one-component polysulfide or silicone conforming to ASTM C 920, Type II, and with a curing time to ensure the sealant's plasticity at the time of field erection.

F. Field Applied: Sealant for field-applied calking shall be an approved gun grade, nonsag one-component polysulfide or two-component polyurethane with an initial maximum Shore A durometer hardness of 25, and shall conform to ASTM C 920, Type II. Color shall match panel colors.

2.9 INSULATION: Insulation shall be poured in place, rigid expanded polyisocyanurate insulation core conforming to ASTM C 553, Form A, Class 1, Class A Fire Hazard Classification.

2.10 FABRICATION OF METAL PANELS: Manufacturer's standard product fabrication and details shall be provided. System components shall be factory fabricated ready for field installation.

2.11 REPAIR OF FINISH-PROTECTED MATERIALS: Repair paint for wall panels shall be compatible paint of the same formula and color as the specified finish furnished by the wall panel manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Panels shall be erected in accordance with the approved erection drawings, the printed instructions and safety precautions of the manufacturer.

B. Sheets shall not be subjected to overloading, abuse, or undue impact. Bent, chipped, or defective sheets shall not be applied.

C. Sheets shall be erected true and plumb and in exact alignment with the horizontal and vertical edges of the building, securely anchored, and with the indicated rake, eave, and curb overhang.

D. Work shall be installed to allow for thermal movement of the roofing and siding, movement of the building structure, and to provide permanent freedom from noise due to wind pressure.

E. Weld burns and abrasions due to assembly shall be touched up with the proper finish repair material.

F. Uncovered edge of the top sheet at sidelaps shall turn down for roofing and turn in for siding and doors.

3.4 ALIGNMENT OF STRUCTURAL FRAME

A. Erected structural-steel frame shall be inspected for plumb and true surfaces. Misalignment of framing and erection not in accordance with AISC S335 shall be corrected before commencing installation of wall panels.

3.5 WELDING: Procedures for manual, shielded metal-arc welding, the appearance and quality of welds made, and the methods used correcting welding work shall be in accordance with AWS D1.1.

3.6 FASTENING SYSTEM: Fastening system shall consist of concealed clips and fasteners installed in accordance with the manufacturer's printed instructions.

3.8 JOINT SEALANTS

A. Joints shall be made weathertight. End joints of metal siding, flashing at corners, eaves, rakes, curbs, and openings in walls shall be sealed with the specified joint sealant.

B. Sealing beads shall be continuous, not less than 1/2 inch in diameter, and applied to ensure a weathertight joint.

3.9 FLASHING AND CLOSURE INSTALLATION

A. Concealed Metal Flashing shall be installed at heads and sills of openings as indicated, at curbs and holders for closure and filler strips, and formed to the proper profile and thickness.

B. Exposed metal flashing shall be installed at building corners, jambs and sills, rakes and eaves, junctions between metal siding and roofing, valleys and changes of slope or direction in metal roofing, and building expansion joints and gutters. Flashing shall be of thickness and profile shown.

C. Exposed metal flashing shall be the same material, color, and finish as the specified metal wall panels.

D. Flashing shall be fastened at not more than 12 inches on center for walls, except where flashings are held in place by the same screws that secure covering sheets.

E. Flashing shall be furnished in at least 8-foot lengths. Exposed flashing shall have 1-inch locked and blind-soldered end joints, and expansion joints at intervals of not more than 16 feet.

F. Expansion joints shall be formed to the profile indicated with end joints flat-seamed, locked, and soldered, and with free-sliding, sleeve type slip joints at 16-foot intervals, designed to allow expansion and contraction and remain weathertight.

G. Exposed flashing and flashing subject to rain penetration shall be bedded in the specified joint sealant.

H. Flashing in contact with dissimilar metal shall be insulated by means of the specified asphalt mastic material to prevent electrolytic deterioration. Drips shall be formed to the profile indicated, with the edge folded back 1/2 inch to form a reinforced drip edge.

3.10 ACCEPTANCE PROVISIONS

A. Erection Tolerances: Metal siding shall be erected straight and true with plumb vertical lines correctly lapped and secured in accordance with the manufacturer's written instructions.

B. Leakage Tests: Finished application of metal wall panels shall be subject to inspection and test for leakage by the Construction Manager. Contractor shall provide all personnel and materials required for the testing, and shall clean tested surfaces immediately upon completion of testing.

C. Repairs to Finish

1. Scratches, abrasions, and minor surface defects of finish may be repaired with the specified repair materials. Finished repaired surfaces shall be uniform and free from variations of color and surface texture.

2. Repaired metal surfaces that are not acceptable to the Construction Manager shall be immediately removed and replaced with new material.

D. Paint-Finish Metal Siding

1. Paint-finish metal wall panels will be tested for color stability by the Construction Manager during the manufacturer's specified guarantee period. Tests will be performed by means of groups of 2-inch metal disks, fastened in exposed areas on all elevations of the building.

2. Panels that indicate color changes, fading, or surface degradation, determined by visual examination of the test areas after removal of the disks, shall be removed and replaced with new panels at no expense to the client.

3. New panels will be subject to the specified tests for an additional year from the date of their installation.

3.11 PROTECTION AND CLEANING: Remove from the installed work all mastic smears or other unsightly marks from panel surfaces, and repair damage or disfigurement of the work. Protect surfaces from damage until final acceptance.

END OF SECTION

SECTION 07510

BUILT-UP ASPHALT ROOFING

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 728	(1991) Specification for Perlite Thermal Insulation Board
ASTM D 2178	(1989) Asphalt Glass (Felt) Used in Roofing and Waterproofing
ASTM D 312	(1989) Asphalt Used in Roofing
ASTM D 3909	(1991) Specification for Asphalt Roll Roofing (Glass Mat) Surfaced with Mineral Granules
ASTM D 4586	(1993) Standard Specification for Asphalt Roof Cement, Asbestos Free

1.2 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Manufacturer's Catalog Data shall be submitted for the following items:

Asphalt Primer
Base Sheet
Roofing Felts
Cap Sheets
Bituminous Plastic Cement
Fasteners
Cants
Roof Walkways
Adhesives
Asphalt Base Emulsion

B. Manufacturer's Specifications: Provide manufacturer's detailed specification and installation instructions.

PART 2 - PRODUCTS

A. Bitumen: Asphalt, ASTM D312, Type III.

B. Roofing Felt: ASTM D-2178, Type VI, asphalt coated, 36" width, glass fiber felt, minimum weight 8.5 lbs per 100 sq. ft.

C. Base Sheet: SS-R-620B, Type II, asphalt coated glass fiber felt, GAFglas 75# Base Sheet.

E. Base Flashings: As recommended by manufacturer for each condition.

F. Bituminous plastic cement shall conform to ASTM D 4586, Type I for asphalt-saturated felts.

G. Cant and Edge Strips: Perlite composition, 4"x4" minimum.

H. Nails Into Wood: Large head barbed galvanized roofing nails through tin discs or an approved galvanized ring-shank composite roofing nail having minimum 1 square inch head.

I. Screws: For use into metal, of corrosion-resistant treated self-drilling self-tapping type, with either integral large head or driven through discs.

J. Insulation Fasteners: Mechanical self-drilling self-tapping screw type corrosion-resistant fasteners with separate plate, FM Class I Insulated Steel Deck Construction Windstrom Resistance Classifications I-60 and I-90 approved, UL approved for use in roof deck construction 360, and bearing an ICBO Research Report approval, Insul-Grip.

K. Roof Insulation:

1. First layer: Isocyanurate roof insulation, FS HH-I-1972, 2.4" thick unless otherwise indicated.

2. Second layer: Perlite roof insulation, conforming to ASTM C728, minimum 3/4" thickness.

L. Roof Expansion Joint Covers: Of standard manufacture, fabricated to provide 4 way movement as indicated, of 2 preformed stainless steel strips not less than 0.015" thick (8 gauge), mechanically and adhesively bonded to both sides of reinforced flashing. Provide factory fabricated, mitered corners, crossings, tees and other necessary accessories. Furnish in longest available lengths.

M. Cap Sheet: Mineral Surfaced Cap Sheet, conforming to ASTM D3909, weighing not less than 76 pounds per square.

N. Wood Nailers: Coordinate with work of Section 06100 and arrange for wood nailers at cant strips, at perimeter of openings through insulation, and where indicated or required. All wood shall be treated with water base preservative as specified in Section 06100.

PART 3 - EXECUTION

3.1 ROOFING SYSTEM: Contractor shall provide a roofing system consisting of insulation and asphalt bitumen and cap sheet surfacing on a metal deck. All components the roofing shall comprise a system using products either manufactured by the manufacturer of bitumen and felts, or specifically recommended by the manufacturer for use with proposed system.

3.2 SUMMARY OF MINIMUM MATERIAL WEIGHTS (PER 100 SQ FT)

Roofing and Insulation over Steel Decks

Polyisocyanurate insulation, 1 layer	100 sq. ft.	
mechanically fastened with plates and screws		100 sq. ft.
Bitumen Mopping to receive second		
layer of roof insulation	30 lbs.	
Perlite insulation, 3/4" thick, 1 layer	100 sq. ft.	
Glass Plies, 4 layers @ 11 lbs. each	44 lbs.	
Bitumen Moppings interply		

(5 @ 25 lbs.)	100 lbs.
Cap sheet, 1 layer	76 lbs.

3.3 PREPARATION:

A. Contractor shall verify that work of other trades that penetrates the roof deck or requires men and equipment to traverse the roof deck is complete.

B. Contractor shall examine deck surfaces for inadequate anchorage, foreign material, moisture, and unevenness which would prevent the execution and quality of application.

C. Contractor shall proceed with the roofing application only after defects have been corrected. Starting work designates acceptance of the surfaces by the Contractor.

3.4 GENERAL INSTALLATION REQUIREMENTS

A. Built-Up Roofing Application: Roofing shall be installed in accordance with the approved roofing manufacturer's specification and the NRCA Roofing and Waterproofing Manual applicable specification.

20-SERIES for Insulation Attachment
40-SERIES for Insulated Roof Decks

B. Insulation on Steel Decking: Mechanically fasten each board with plates and screws in the quantity required by Factory Mutual, boards in parallel courses with long dimension of boards perpendicular to the direction of roofing felts and cross joints staggered by half the board length. Mop second layer of insulation solid and even and apply roofing as specified.

3.5 APPLICATION OF ROOFING:

A. Roofing Membrane: Solid mop the top of the insulation and embed the base sheet, lapping joints 4-inches at edges and 6-inches at ends. Solid mop base sheet with asphalt and embed four plies of felt, shingle method, lapping 27-1/2 inches on sides, mopping between plies. End joints in felt layers shall be at least 12" apart, and end joints in successive layers shall be staggered. Each ply shall be lightly broomed into place.

A. Bitumen: Heat and apply all bitumen at equiviscous temperature (EVT) specified by roofing manufacturer. Do not heat asphalt bitumen above flash point. Heat all bitumen in kettles equipped with accurately calibrated and functioning thermometers and thermostats. If bulk bitumen is used, ensure that bitumen delivered at the roof deck is at correct temperature at all times.

B. Outlets: Set outlets below roof deck surface to ensure free flow of water and to prevent forming a water dam at rims. Lead collars shall be provided with all drains (see Plumbing Section). Install lead collar in uniform bed of plastic cement applied over base sheet. Complete installation of overlying plies and install ring and accessories.

C. Cant and Edge Strips: Provide minimum 4" high cant strips at angles between roof deck and vertical surfaces unless otherwise indicated. Provide edge strips as required at edges of roof deck. Fit strips flush at ends and to vertical surfaces, and bevel back from scuppers. Securely fasten strips in place with hot bitumen or mechanical fasteners.

D. The application of the complete roofing system, including insulation and top surfacing, shall be finished in one operation each day. Top surfacing shall be brought up to within 3 to

5 feet of the line of termination of each days work, and all exposed felts, including base sheets, shall be protected with a glaze coat of hot bitumen applied at a rate of not less than 25 pounds per 100 square feet.

E. The application of the built-up roofing shall follow the laying of the insulation by an amount limited by the minimum working space required for the operation.

F. In all procedures in which hot bitumen is used in bonding of materials to each other, or in laminating plies of felt into composite membrane, the operation shall be such that the application of the material which is laid into the bitumen shall follow immediately behind the application of the hot bitumen. There shall be no working ahead with the bitumen.

G. Felts and surfacing aggregates shall be embedded in, not laid on, the bitumen. Application of bitumen between membrane plies shall produce voidless coverage and complete penetration of the bitumen, both into the felt above and into the felt below. As sheet materials are being rolled into the hot bitumen, they shall be immediately and thoroughly broomed down to eliminate any air which might have been trapped and to provide tight, smooth laminations without wrinkles, buckles, kinks, or fish mouths.

H. Complete application of the roofing system shall be without pockets and blisters.

I. The practice of laying the felts dry and turning back the laps for mopping between plies will not be permitted.

J. All roofing plies shall be extended to the top of the cant strips. Felts shall be trimmed to a neat fit around vent pipes, roof drains and other projections through the roof.

K. Flashing: Built-up bituminous flashing shall be provided in the angles formed where roof decks abut walls, curbs, ventilators, pipes, and other vertical surfaces, and where necessary to make the work watertight. Flashing shall be installed after all plies of roofing have been applied but before the top surfacing is applied. Base flashing and parapet wall flashing shall be built-up of glass fiber felts. Cap flashing shall be metal as specified under Section 07600.

L. Built-up bituminous base flashing shall consist of 3 plies of felt. Each ply shall be embedded in a uniform trowelling of bituminous plastic cement not less than 1/16-inch thick. All felts shall be smoothed and pressed firmly into place so that a uniformly attached and completely laminated membrane results. Felts shall extend not less than 6, 9, and 12 inches respectively over the roofing membranes beyond the toe of the cant and not less than 4 inches or more than 10 inches above the top of the cant on vertical surfaces. Ends of felts shall be lapped not less than 12 inches and shall be sealed watertight with bituminous plastic cement. End laps shall be staggered. Top edges of base flashing system shall be nailed to nailers with large head roofing nails through metal discs spaced not more than 10 inches o.c. on a line 1-1/2 inches below the top of the felts. The finished base flashing shall be heavily coated with bituminous plastic cement 1/8-inch thick, extending from one inch above the top of the flashing felts on the vertical surface to one inch beyond the edge of the flashing felts on the roof surface.

M. Strip Flashing: Set flanges of sheet metal work, including lead pans of roof drain sumps, into a uniform 1/16-inch minimum thick bed of bituminous plastic cement and strip-in with two layers of felt cemented to the top of the flanges and to each other with 1/16-inch beds of bituminous plastic cement. The felts shall extend 3 and 6 inches, respectively, beyond the edges of the flanges and shall cover the flanges.

N. Pitch Pockets: Fill bottom half of pan with plastic cement, then fill to top with asphalt, Type I, slightly crowned to shed water.

O. Mineral Surfaced Cap Sheet: Cut rolls into approximate 12 foot lengths, unroll, and allow to flatten. Over the completed roof membrane, apply solid mopping of bitumen, and embed cap sheet solidly, lapping 2" at sides and 6" at ends of sheets. Use care to assure that asphalt is at proper temperature when sheets are installed and that sheets are solidly attached with all edges and ends securely sealed.

3.6 ROOF EXPANSION JOINT COVERS:

A. Install in accordance with manufacturer's recommendations and as follows. Install transition sections first. Provide field fabricated edges, tapers, end conditions and other special conditions as detailed or as required for complete, watertight, installation. Use uncured neoprene splice strips and adhesive to join lengths of joints. Remove polyethylene protection sheet immediately before applying adhesive.

B. Joint covers shall be installed on treated wood cants or curbs covered with weathering membrane. Joint covers shall not be installed flat on a roof membrane or at deck level without cants or curbs.

C. Metal flanges shall be set in plastic asphalt cement conforming to ASTM D4586, Type 2.

3.7 BITUMEN STOPS: Provide at roof edges, openings, and vertical projections prior to application of the roofing felts. Bitumen stops shall be formed with two 12-inch wide strips of ply felt. Strips shall be laminated with, and set into a bed of bituminous plastic cement with one half of the width overhanging the edge of the roof or opening. Where nailers are present, the strips, additionally shall be nailed with roofing nails spaced 12 inches o.c. After roof membrane is in place, the free portion of the strips shall be folded back over the roof membrane and embedded in a continuous bed of bituminous plastic cement.

3.8 CLEANING: Clean and repair surfaces to remain exposed that are stained or defaced by work of this Section. Where cleaning or repairs are not acceptable, remove the defective work and provide new work of the same kind as directed, at no extra cost to the Institute.

END OF SECTION

SECTION 07600

FLASHING AND SHEETMETAL

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 526	(1990) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Commercial Quality
ASTM B 32	(1989) Specification for Solder Metal
ASTM C 920	(1987) Standard Specification for Elastomeric Joint Sealants
ASTM D 4586	(1993) Standard Specification for Asphalt Roof Cement, Asbestos Free

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1	(1992) Structural Welding Code - Steel

SHEET METAL AND AIR CONDITIONING CONTRACTORS NATIONAL ASSOCIATION, INC. (SMACNA)

SMACNA-02A	(1980; 5th Ed) Architectural Sheet Metal Specifications

1.2 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Drawings:

1. Fabrication Drawings for the following items shall include material, description, and thickness.

Flashing
Sheet Metal
Accessories

2. Installation Drawings shall indicate location, dimensions, configuration, construction details, type of seams and fastening method for the following items:

Flashing
Sheet Metal
Accessories

B. Certificates of Compliance for the following items shall be submitted showing conformance with referenced standards contained in this section.

Galvanized Steel Sheetmetal
Fasteners

Solder Materials
Cements
Sealing Compounds

1.3 GENERAL REQUIREMENTS: Section 05055, "Welding Steel Construction," applies to work specified in this section.

PART 2 - PRODUCTS

2.1 SHEETMETAL MATERIALS

A. Galvanized Steel sheet shall conform to ASTM A 526, regular coating, designation Z90.

B. Corrosion-Resistant Steel shall be chromium-nickel steel conforming to ASTM A 167, Type 301, 302, 204, or 316, No. 2D finish, annealed temper as required for the end use.

C. Minimum Dimensions and Thicknesses: Materials shall be in accordance with SMACNA-02 and shall be not less than the following minimum thicknesses and weights.

Item	Corrosion Resistant Steel, Gage	Galvanized Steel, Gage
Building expansion joints, cap	28	26
Flashings		
Base	28	22
Cap, roof penetration, cap flashing equipment and structural supports, pitch pans	28	26
Cleats, 2 inches by 3 inches	26	24
Edge strips, 1-1/4 inches wide	24	20
Reglets	30	30
Cap flashing receivers	28	26
Gravel stop fascias:	22	20

2.2 CEMENTS AND SEALING COMPOUNDS

A. Bituminous Plastic Cement shall be an asphaltic-base material conforming to ASTM D 4586, compatible with the roofing asphalts and asphalt primer.

B. Sealing Compound shall be gun grade, one-component, nonsag, elastomeric, conforming to ASTM C 920. Base material shall be polysulfide, resistant to 50-percent joint movement.

2.3 SOLDER MATERIALS: Solder and flux shall meet the requirements of ASTM B 32. Solder shall be SN50.

2.4 FASTENERS: Fasteners shall be the same metal or a metal compatible with the material joined.

PART 3 - EXECUTION

3.1 GENERAL

A. Sheetmetal work shall conform to drawing details and to the applicable plate number and design and installation recommendations of SMACNA-02A. Finished sheetmetal installation shall be free from water leakage.

B. Surfaces to receive sheetmetal work shall be clean, smooth, dry, and free from defects and projections which might affect the work. Surfaces shall be plumb and true to a tolerance of not more than 1/2 inch in 40 feet, with no dips, waves, or uneven surfaces exceeding 1/8 inch in 10 feet in any direction. Lines, arises, and angles shall be sharp and uniform. Exposed edges of sheetmetal shall be folded back to form a 1/2-inch wide hem on the concealed side.

C. Fastening Methods

1. Fasteners shall be concealed. Only one edge shall be nailed to permit freedom of expansion perpendicular to the line of nailing. Nails shall be spaced at not more than 3 inches on center. Nails shall penetrate backing by not less than 1 inch.

2. Cleats shall be used for securing edges of sheetmetal members over 12-inches wide and at other designated locations. Cleats shall be fastened with two nails and the end folded over the nails. Other end of the cleat shall be locked into the seam or the folded edge of member being fastened. Cleats shall be spaced at not more than 12 inches on center.

3. Screws shall be fitted with [neoprene] [lead] washers to protect surface of metal sheet and provide a watertight connection.

D. Seams

A. Seams and lock joint construction shall conform to SMACNA-02A, Plate 100. Seams shall be straight and uniform in height, width, and finish as follows:

1. Flat-lock seams shall be not less than 3/4-inch wide.

2. Lap seams, when soldered, shall finish not less than 1-inch wide.

3. Lap seams, not soldered, shall overlap not less than 3 inches.

B. Loose-lock expansion seams shall be not less than 3-inches wide and shall provide for not less than a 1-inch movement within the joint. Joint shall be completely filled with the specified sealant applied at not less than 1/8-inch bed thickness.

C. Flat seams shall be made in the direction of flow. Seams not soldered shall be completely filled with plastic cement.

D. Surfaces to be joined by soldering shall be cleaned, pretinned, heated, fluxed, and sweat-soldered through the full contact area in accordance with the best standards of practice in modern sheet metal shops. Flux residue and foreign matter shall be removed after soldering. Soldered surfaces shall be rinsed with water and wiped clean.

E. Procedures for manual shielded metal-arc welding, the appearance and quality of welds made, and the methods used in correcting welding work shall conform to AWS D1.1.

F. Provisions for Expansion and Contraction: Expansion-joint configuration shall conform to the drawing details and to SMACNA-02. Floor slab expansion joints shall conform to SMACNA-02A. Joints shall be lapped 3/4 inch and soldered prior to installation in the concrete floor slab.

G. Dissimilar Metals: Dissimilar metals shall be isolated from each other by painting with bituminous paint.

3.2 FLASHING

A. Base Flashing: Metal base flashing shall be installed where the roof abuts vertical surfaces, in valleys, at ridges, and where the roof slope changes. Configuration shall conform to SMACNA-02A, Plate [____]. Flashing shall extend not less than 8 inches up vertical surfaces.

B. Cap and Counter Flashing: Metal cap or counter flashing shall be installed where horizontal roof surfaces abut vertical wall surfaces, at copings, at joints between existing and new construction, at penetrations of roof surfaces, and at equipment supports. Configuration shall conform to SMACNA-02A, Plate [____]. Flashing shall be formed in 10-foot lengths, except where shorter pieces are required; end joints shall be lapped not less than 3 inches. Joints shall not be soldered.

C. Edge Strips: Edge trim strips shall have a formed drip edge.

D. Flashing at Roof Penetrations and Equipment Supports: Metal flashing conforming to [SMACNA-02] [SMACNA-02A], Plate [____], shall be installed where piping, conduit, or equipment supports penetrate roof surfaces.

E. Single-pipe vents shall be flashed with lead flashing or a two-piece formed-metal housing of the specified sheetmetal, installed as indicated in SMACNA-02A, Plate [____].

F. Pitch Pans: A metal pitch pan conforming to [SMACNA-02] [SMACNA-02A], Plate [____], shall be installed where structural members, anchors, and equipment supports penetrate roof construction. Pan shall be installed over the final roofing ply. Flanges shall be set in bituminous plastic cement and shall receive two plies of stripped-in composition flashing.

3.3 GRAVEL-STOP FASCIAS: Gravel-stop fascias shall be installed at exposed edges of built-up roofs. Configuration shall conform to [SMACNA-02] [SMACNA-02A], Plate [____]. Lower edge of each gravel-stop fascia section shall be secured in place by hooking over a continuous edge strip or cleat. Flanges of each section shall extend out on the top of roofing felts not less than 3-1/2 inches. A 1/4-inch open joint shall be provided between each gravel-stop fascia section, with a 12-inch wide plate centered on the joint. System shall be installed in accordance with SMACNA-02A, Plate [____].

3.4 CLEANING: Exposed sheetmetal work shall be cleaned of all surface contaminants and imperfections at completion of installation.

END OF SECTION

SECTION 07920

SEALANTS AND CALKINGS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 1085	(1987) Butyl Rubber-Based Solvent-Release Sealants
ASTM C 509	(1991) Standard Specification for Elastomeric Cellular Preformed Gasket and Sealing Material
ASTM C 834	(1976; R 1986) Latex Sealing Compounds
ASTM C 920	(1987) Standard Specification for Elastomeric Joint Sealants
ASTM D 1056	(1991) Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber
ASTM D 1565	(1981; R 1986) Flexible Cellular Materials - Vinyl Chloride Polymers and Copolymers (Open-Cell Foam)

1.2 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Manufacturer's Catalog Data shall be submitted for the following items:

Flexible Cellular Backing
Bond-Preventitive Material
Primer
Oil and Resin-Based Sealants
Elastomeric Sealants
Latex Sealants
Butyl Rubber Based Sealants
Silicon Rubber Based Sealants
Solvents and Cleaning Agents

B. Instructions: Manufacturer's Installation Instructions shall be submitted for the following items covering procedures, suggested mixing equipment, storage requirements, and procedures for surface preparation.

Thermoplastic Sealing Compound
Two-Component Elastomeric Sealant

C. Certificates of Compliance shall be submitted for the following items showing conformance with referenced standards contained in this section.

Flexible Cellular Backing
Bond-Preventitive Material
Primer
Solvents and Cleaning Agents

D. Samples: The Contractor shall submit the following samples:

Three cured color bead samples of each color and type of Sealing Compound to be used in the work, approximately 1/4-inch wide by 1-inch long.

Three Labels for each sample container of sealants including the following information; supplier, name of material, formula or specification number, lot number, color, date of manufacture, mixing instructions, life expectancy of the application, curing time, and shelf life.

Three Backup Material samples of each material, grade, rod size, and tube size to be used in the work, full size by 12-inches long.

E. Samples:

1. Provide three cured color bead samples of each color and type of sealing compound to be used in the work, approximately 1/4-inch wide by 1-inch long.

2. Three labels for each sample container of sealants shall include the following information; supplier, name of material, formula or specification number, lot number, color, date of manufacture, mixing instructions, life expectancy of the application, curing time, and shelf life.

3. Three backup material samples of each material, grade, rod size, and tube size to be used in the work, full size by 12-inches long.

1.3 QUALITY ASSURANCE

A. Compatibility with Substrate: Sealants shall be verified for compatibility for use with joint substrates.

B. Joint Tolerance: Joint tolerances shall be in accordance with manufacturer's instructions.

C. Mock-Up: Sealants in mock-up [prepared by other trades] shall be installed by project personnel, using materials and techniques approved for use on the project.

1.4 DELIVERY, HANDLING, AND STORAGE: Materials shall be delivered in sealed containers that identify the product, manufacturer, color, directions for use, shelf life, and curing time at [____] degrees F. Materials shall be kept dry and shall be protected from freezing.

1.5 SPECIAL WARRANTY: Sealant joint shall be guaranteed against failure of sealant and against water penetration through each sealed joint for [five] [_____] years.

PART 2 - PRODUCTS

2.1 BACKUP MATERIAL

A. Flexible Cellular Backing

1. Sponge Rubber and Expanded Rubber material shall be [round] [____], ASTM D 1056, Type [1], [__], Class [A] [____], Grade [5] [____], rubber.

2. Vinyl Chloride Polymer material shall be [round] [____], ASTM D 1565, Grade [V014] [____], foam.

B. Synthetic Rubber: material shall be preformed [rods] [or] [tubes], ASTM C 509, Option [I] [____], Type [I] [____].

C. Polyethylene material shall be [open cell] [or] [closed cell] [polyethylene] [polyurethane] as recommended by the sealant manufacturer.

2.2 BOND-PREVENTIVE MATERIAL FOR SEALING COMPOUNDS: Bond-preventive material shall be [pressure sensitive tape,] as recommended by the sealant manufacturer to suit application.

2.3 PRIMER-TO-SEALANT COMPOUNDS: Primer shall be [non-staining type] [as recommended by sealant manufacturer] [____] to suit application.

2.4 SEALANTS

A. Elastomeric sealant shall be [single] [multi] component, color [as selected] [____], conforming to ASTM C 920, Type [____], Grade [____], Class [____], use [____]. [Base material shall be [urethane [____].]

B. Latex sealant shall be single component, color [as selected] [____], conforming to ASTM C 834.

C. Butyl Rubber Based sealant shall be single component, solvent release, color [as selected] [____], conforming to ASTM C 1085.

D. Silicon Rubber Base: Rubber base silicon sealant shall be single component, solvent release, color [as selected] [____], conforming to ASTM C 920, Non-sag, Type [____], Grade [____], Class [25] [____].

2.5 SOLVENTS AND CLEANING AGENTS: Solvents, cleaning agents, and accessory materials shall be provided as recommended by the manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION: Unsound substrates shall be repaired. Joint dimensions and surfaces receiving unround substrates them shall be verified that they comply with the manufacturer's recommendations.

3.2 PREPARATION: Prepare [and prime] joints in accordance with manufacturer's instructions. Adjacent exposed surfaces shall be protected.

3.3 INSTALLATION

A. Backup material shall be installed with a [blunt] [rounded] [concave] tool.

B. Backup material shall be [33] [_____] percent oversize for closed cell and at least [50] [_____] percent oversize for open cell material, unless otherwise indicated.

C. Multi-component sealants shall be mixed according to manufacturer's instruction and applied to ensure proper width and depth. Three-sided adhesion shall be avoided. Sealants shall be applied within recommended temperature and humidity conditions.

D. Sealants shall be installed free of air pockets, foreign embedded matter, ridges and sags.

3.4 INSPECTION AND ACCEPTANCE PROVISIONS: All work shall be inspected for proper installation. Calking and sealing shall be rejected for the following deficiencies:

A. Calking compound having a finished surface not conforming to specifications.

B. Sealing compound with color not matching the sample or surface not complying with specifications.

C. Sealing compound failing to adhere to side surfaces of joints.

3.5 CLEANING AND REPAIRING: Surfaces adjoining joint excess and smears resulting from installation shall be cleaned. Defective work shall be removed and replaced with calking and sealing materials as indicated.

3.6 PROTECTION: Installed sealants shall be protected until cured.

END OF SECTION

SECTION 08100

METAL DOORS AND FRAMES

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1	(1992) Structural Welding Code - Steel

DOOR AND HARDWARE INSTITUTE (DHI)

DHI A115.1	(1990) Preparation for Mortise Locks for 1-3/8 Inch and 1-3/4 Inch Doors
DHI A115.2	(1988) Door and Frame Preparation for Bored or Cylindrical Locks for 1-3/8 Inch and 1-3/4 Inch Doors
DHI A115.4	(1988) Standard Steel Door and Frame Preparation for Lever Extension Flush Bolts

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 80	(1990) Fire Doors and Windows

STEEL DOOR INSTITUTE (SDOI)

SDOI SDI 100	(1991) Standard Steel Doors and Frames
SDOI SDI 105	(1991) Erection Instructions for Steel Frames

1.2 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Manufacturer's Catalog Data shall be submitted for the following items:

Doors
Frames
Finish Hardware
Accessories

B. Drawings:

1. Fabrication Drawings for the following items shall show location and size of all holes to be punched for hardware attachment, size, shape, gage and finish.

Steel Doors
Frames

2. Installation Drawings for the following items shall be in accordance with the paragraph entitled, "Installation," of this section.

Steel Doors
Frames

C. Certificates of Compliance for the following items shall be submitted showing conformance with referenced standards contained in this section.

Doors
Frames
Finish Hardware
Accessories

1.3 DELIVERY, HANDLING, AND STORAGE: Doors, frames, and accessories shall be protected from damage during handling, transportation, and at the job site. Materials shall be stored at the site, under cover, and on wood blocking or suitable floors.

1.4 GENERAL REQUIREMENTS: Section 05055, "Welding Steel Construction," applies to work specified in this section.

PART 2 - PRODUCTS

2.1 GENERAL

A. Doors, frames, and accessories shall conform to SDOI SDI 100 and the requirements specified herein. Welding shall be in accordance with the recommended practice of the Structural Welding Code, Sections 1 through 6, AWS D1.1 and as specified by the producer of the metal being welded. Welds behind finished surfaces shall cause no distortion or discoloration on the exposed side.

B. Doors: Doors shall be heavy duty, 1-3/4-inch, 18-gage, flush or seamless hollow steel construction, electrolytic zinc-coated with honeycomb core reinforcement.

1. Door louvers shall be inserted type. Exterior louvers shall be provided with a 14- by 18-mesh bronze insect screen secured to the louvers on the interior side of the door.

2. Fire-rated doors shall be the types that have been investigated and fire tested as a fire door assembly, complete with the type of fire door hardware to be used in the work. Fire-rated doors shall be labeled with the applicable fire rating of the door construction provided.

C. Frames

1. Exterior frames shall be 16-gage full welded-unit-type.

2. Interior frames shall be 16-gage full welded-unit, field assembled] type.

3. Fire-rated frames shall be the types that have been investigated and fire tested as an assembly, complete with the type of hardware to be used in the work. Fire-rated frames shall be labeled with the applicable fire rating of the frame construction provided.

2.2 FINISH HARDWARE PREPARATIONS AND LOCATIONS

A. Preparation for hardware shall be in accordance with DHI A115.1, DHI A115.2, and DHI A115.4, as applicable.

B. Frames, except fire-rated labeled frames, shall be punched to receive molded-rubber door silencers. Single door frames shall be punched for three silencers in the lock side jamb. Double door frames shall be punched for one silencer in each leaf of the frame head. Lock strikes shall be set out to provide clearance for the silencer.

C. Hardware locations shall comply with SDOI SDI 100, Table V, except when template dimensions and multiple-item installations require an alternative location.

D. Reinforcement for finished hardware shall meet or exceed the requirements of SDOI SDI 100, Table IV.

2.3 FINISHING: Doors and frames shall be primed and finished in accordance with SDOI SDI 100.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Door Clearance: Clearances shall be those specified in SDOI SDI 100. Clearances for fire-rated doors shall be as specified in NFPA 80.

B. Frame Installation and Tolerances: Frames shall be installed in accordance with SDOI SDI 105. Fire-rated frames shall be installed in accordance with NFPA 80. Frames shall be installed within the following tolerances:

Deviation in location from that indicated on the drawings: Plus or minus 1/4 inch

Deviation from plumb or horizontal:

In 8 feet	Not more than 1/16 inch
In 12 feet	Not more than 1/8 inch

C. Finish-Hardware Installation: Hardware shall be installed and adjusted in accordance with the hardware manufacturer's printed directions. After the installation is completed, hardware shall be adjusted and lubricated to ensure proper performance.

D. Final Adjustment: Before final acceptance, finish hardware shall be checked and readjusted as required to ensure proper operation of the finish hardware.

END OF SECTION

SECTION 08120

ALUMINUM ENTRANCES AND STOREFRONT FRAMING

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

ALUMINUM ASSOCIATION (AA)

AA SAS-30	(1986) Specifications for Aluminum Structures Construction Manual Series Section 1

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC S328	(1986) Specification for Structural Steel Buildings Load and Resistance Factor Design

AMERICAN IRON AND STEEL INSTITUTE (AISI)

AISI SG-673	(1986; Errata 1990) Cold-Formed Steel Design Manual

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A117.1	(1986) Buildings and Facilities - Providing Accessibility and Usability for Physically Handicapped People

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B18.22	(1981) Plain Washers

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 123	(1989a; E1) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153	(1982; R 1987) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 27	(1991) Standard Specification for Steel Castings, Carbon, for General Application
ASTM A 283	(1993) Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
ASTM A 307	(1992) Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength
ASTM A 563	(1993) Standard Specification for Carbon and Alloy Steel Nuts

ASTM B 136	(1984) Standard Method for Measurement of Stain Resistance of Anodic Coatings on Aluminum
ASTM B 137	(1989) Standard Test Method for Measurement of Mass of Coating on Anodically Coated Aluminum
ASTM B 209	(1993) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B 221	(1993) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes and Tubes
ASTM C 509	(1991) Standard Specification for Elastomeric Cellular Preformed Gasket and Sealing Material
ASTM D 1730	(1967; R 1993) Standard Practices for Preparation of Aluminum and Aluminum-Alloy Surfaces for Painting

AMERICAN WELDING SOCIETY (AWS)

AWS A2.4	(1986) Standard Symbols for Welding, Brazing and Nondestructive Examination
AWS A5.1	(1991) Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding
AWS D1.1	(1992) Structural Welding Code - Steel

FEDERAL SPECIFICATIONS (FS)

FS FF-B-588	(Rev D) Bolt, Toggle; and Expansion Sleeve, Screw
FS FF-W-84	(Rev A; Am 3) Washers, Lock (Spring)
FS TT-C-490	(Rev C; Am 2) Cleaning Methods for Ferrous Surfaces and Pretreatments for Organic Coatings
FS TT-C-494	(Rev B; Notice 1) Coating Compound, Bituminous, Solvent Type, Acid Resistant

UNDERWRITERS LABORATORIES (UL)

UL-01	(1991; Supplement 1991) Building Materials Directory

1.2 PERFORMANCE REQUIREMENTS

A. Allowable Design Stresses:

1. Aluminum-alloy framing member allowable design stresses shall be in accordance with AA SAS-30 for the specified aluminum alloy.

2. Hot-rolled structural steel member allowable design stresses and design rules shall be in accordance with AISC S328 for the specified structural steel.

3. Cold-formed light-gage steel structural member allowable design stresses and design rules shall be in accordance with AISI SG-673, for the specified structural-steel sheet or strip.

B. Design Wind Load: Design wind load shall be [15] [30] [35] pounds per square foot.

C. Structural Requirements

1. Doors and frames shall be designed to withstand the specified design wind load acting normal to the plane of the entrance wall either inward or outward.

2. Deflection of any metal framing member in a direction normal to the plane of the entrance wall, when the glazed entrance is subjected to the specified wind pressure, shall not exceed 1/175 of the clear span of the member or 3/4 inch, whichever value is the lesser.

3. Deflection of any metal member in a direction parallel to the plane of the entrance wall, when the metal member is carrying its full design load, shall not exceed 75 percent of the design clearance dimension between that member and the glass, sash, panel, or other part immediately below it.

D. Provisions for Thermal Movement: Doors and frames shall be designed to provide for expansion and contraction of the component parts caused by an ambient temperature range of 0 to 100 degrees F without causing buckling, opening of joints, overstressing of fasteners, or other harmful effects.

1.3 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data

1. Manufacturer's Catalog Data shall be submitted for the following items:

Aluminum Doors
Paint Materials
Glazing Materials
Installation Materials
Frames
Weatherstripping

2. Design Analysis and Calculations for the following items shall indicate the allowable design loads as specified in the paragraph entitled, "Performance Requirements," of this section.

Aluminum Doors
Frames
Aluminum Alloys

B. Drawings

1. Fabrication Drawings for the following items shall be in accordance with the paragraph entitled, "Fabrication," of this section.

Doors and Frames

2. Installation Drawings shall include the following information:

a. Door and frame locations in the building, layout and elevations, dimensions, shapes and sizes of members, thicknesses of metals, types and locations of shop and field connections, details of anchorage to other construction, method of glazing, and other pertinent construction and erection details.

b. Welds shall be in accordance with AWS A2.4 welding symbols.

Doors
Frames

C. Instructions: Preventive Maintenance and Inspection for the aluminum manufacturer's recommended Cleaning Materials and Application Methods shall be submitted, including detrimental effects to the aluminum finish when improperly applied.

D. Certificates of Compliance shall be submitted for the following items showing conformance with referenced standards contained in this section.

Metals for Fabrication
Paint Materials
Glazing Materials
Installation Materials

E. Samples: Contractor shall submit the following samples:

1. Two samples of painted aluminum Finish in specified color, for exposed-to-view surfaces, approximately 12-inches square, to illustrate color, gloss and appearance.

2. Preformed Glazing Gasket, full size by 12 inches long. Anchorage Devices and Fasteners, one full size of each type to be used in the work.

F. Operation and Maintenance Manuals shall be submitted for the following items:

Doors
Frames

1.4 QUALIFICATIONS FOR WELDING WORK

A. Welding processes shall be in accordance with AWS D1.1.Construction Manager reserves the right to require that test specimens be made in the presence of an authorized representative and that such test specimens be tested by an approved laboratory.

B. Welders shall have been qualified by tests in accordance with AWS D1.1. In addition to the above requirements, tests shall be performed on test pieces in positions and with clearances equivalent to those actually encountered in construction. When a test weld fails to meet requirements, an immediate retest of two test welds shall be made, and each test weld shall pass. Failure of the retest shall require that the welder be retested after further practice or training and that a complete set of test welds be made.]

1.5 APPROVING AUTHORITY: References to the need for approval in AWS D1.1 shall mean approval by the Construction Manager, and all references to the Building Commissioner shall mean the Construction Manager.

1.6 DELIVERY, HANDLING, AND STORAGE

A. Doors, frames, and accessories shall be protected from damage during handling, transportation, and at the job site. Materials shall be stored at the site under cover on wood blocking or on suitable floors.

B. Packaged materials shall be stored in their original, unopened packages.

1.7 FIELD MEASUREMENTS: Field measurements shall be taken prior to the preparation of drawings and fabrication.

PART 2 - PRODUCTS

2.1 METALS FOR FABRICATION

A. Aluminum-Alloy Extrusions shall conform to ASTM B 221. Alloy and temper shall be that recommended by the aluminum producer for the specified anodic coating with integral color and shall have mechanical properties equal to or exceeding those of 6063-T5. Sheets and plates shall conform to ASTM B 209, Alloy 5005, and Temper H16.

B. Metals for Fasteners: Metals for fasteners shall be a type recommended by the door manufacturer and shall be aluminum or stainless steel.

2.2 PAINT MATERIAL:

A. Shop paint for concealed surfaces of aluminum shall conform to FS TT-C-494, Type II, bituminous solvent type.

B. Shop paint for exposed surfaces of aluminum shall be manufacturer's standard silicon polyester finish paint and 2 component epoxy primer. Color shall be blue as selected by Construction Manager.

2.3 GLAZING MATERIALS Preformed glazing gaskets shall be elastomeric compression type, extruded to shape with factory-made tight fitting corners to suit the type of flush glazing and glass size. Material shall conform to ASTM C 509.

2.4 FABRICATION

A. Workmanship

1. Metal parts shall be accurately formed. Joints, except those designed to accommodate movement, shall be accurately fitted and rigidly assembled.

2. Welding shall be in accordance with AWS D1.1 and shall be done with filler metals and by methods recommended by the producer of the metal being welded. Welds behind finished surfaces shall cause no distortion or discoloration on the exposed side. Welded joints shall be cleaned of all welding flux and dressed on all exposed and contact surfaces.

3. Insofar as practical, fitting and assembly of the work shall be done in the manufacturer's plant. Work that cannot be permanently factory assembled shall be marked before shipment for proper assembly at the site.

B. Preparation for Finish Hardware: Preparations for mortised and concealed hardware shall be done at the factory and shall include cutouts, recesses, mortises, reinforcing, drilling, and tapping to receive the specified hardware sets. Preparations for hardware shall be made to the template of the manufacturer of each hardware item. Where concealed closers and other mechanisms are required, the necessary space, cutouts, reinforcement, and provisions for secure fastening shall be made. Where butt or pivot hinges are required, doors and frames shall be reinforced with backing plates to ensure adequate strength of the fastening.

C. Protection of Aluminum from Dissimilar Materials

1. Surfaces that will come in contact with dissimilar metals, masonry, concrete, or wood shall be shop primed.

2. Surfaces shall be prepared in conformance with ASTM D 1730, Type B, Method [2] [3].

3. Surfaces shall be given one shop coat of paint which shall be applied to dry, clean surfaces to provide a continuous minimum dry-film thickness of 1.5 mils (0.0015 inch).

D. Doors

1. Doors shall be swing type, full glazed, stile-and-rail construction with medium stile, of the size indicated.

2. Stiles and rails shall be fabricated of aluminum-alloy tubular extrusions having a wall thickness not less than 0.125 inch. Corners shall be joined by both concealed welding and mechanical fastening. Corner connections shall be accurately milled to a hairline watertight joint.

3. Single swing doors shall have not more than 3/32-inch clearance at jambs and heads, 3/16-inch clearance at meeting edges of pairs of doors, and 1/2-inch clearance at the bottom. Dimensions are nominal and subject to the manufacturer's tolerances. Lock edges of doors shall provide the proper operating clearance.

4. Glazing moldings shall be fabricated of aluminum-alloy extrusions with wall thicknesses not less than 0.050 inch. Moldings shall be the snap-in flush glazing type with preformed glazing gasket, sized to receive the type and thickness of the glass. Moldings on the exterior face of doors shall be the nonremovable type without exposed screws. Moldings shall be carefully fitted and joined at corners.

E. Storefront Framing and Door Frames

1. Frames shall be of the section dimensions and arrangements indicated.

2. Frames shall be fabricated of aluminum-alloy extrusions with a wall thickness of not less than 0.125 inch. Frame joints shall be sealed to prevent leakage. Door stops applied to the frames shall be secured with concealed fasteners. Anchors shall be provided for securing the frames to building construction. Sizes, shapes, and methods of anchoring shall be as detailed on the approved drawings.

3. Structural steel members required for the reinforcement of framing sections shall be provided with the frames and shall be hot-rolled shapes, hot-formed tubing, or cold-formed light-gage steel. Reinforcement shall be concealed inside the frame members.

4. Glazed openings in frames shall be designed for flush glazing. Glazing moldings and preformed glazing gaskets shall be as specified for doors.

F. Finish: Silicon polyester paint over 2 component epoxy primer, each coat baked on at paint manufacturer's recommended time and temperature; blue color and gloss, as selected by Construction Manager.

G. Hardware Locations: Hardware locations shall be as follows:

HARDWARE ITEM	LOCATION
Door handles	Centerline of grip 42 inches above the floor
Door pulls	Top fastening 45 inches above the floor
Pushbars, single	Centerline 45 inches above the floor
Deadlocks	Centerline of strike 60 inches above the floor
Panic exit	Centerline of strike 40-5/16 inches devices above the floor
Top flush bolt	Centerline of front plate 72 inches above the floor
Bottom flush bolt	Centerline of front plate 12 inches above the floor
Top butt hinges	11-3/4 inches from the rabbet section of the head of the frame to the centerline of the hinge
Bottom butt hinges	13 inches from the finished floor to the centerline of the hinge
Intermediate butt hinges	Equally spaced between the top and bottom butt hinges
Pivot hinges (top, bottom, and intermediate)	In accordance with the pivot manufacturer's printed instructions

H. Weatherstripping

1. Exterior doors shall be provided with weatherstripping at heads, jambs, and meeting stiles.

2. Weatherstripping shall be silicone treated wool pile inserted in a corrosion-resistant steel or extruded aluminum-alloy housing. Weatherstripping at meeting stiles of pairs of doors shall be adjustable. Weatherstripping shall be mortised into the door edges, or frame, or both, as required to suit the conditions.Weatherstripping shall be designed for easy removal and replacement.

2.6 INSTALLATION MATERIALS

A. Toggle Bolts shall be tumble-wing type, class and style best suited for the work, conforming to FS FF-B-588, Type II.

B. Standard Threaded Fasteners

1. Standard threaded fasteners shall be as follows: Standard steel bolts: Regular hexagon head, low-carbon steel, coarse-thread series, conforming to ASTM A 307.

2. Nuts: Plain hexagon, regular style, carbon steel, conforming to ASTM A 563.

3. Plain washers: Round, general assembly purpose grade, carbon steel, conforming to ASME B18.22.

4. Lockwashers: Helical-spring, carbon steel, of the style best suited for the work, conforming to FS FF-W-84, Class A.

C. Electrodes for Welding Steel by the manual shielded metal-arc welding process shall meet the requirements of AWS D1.1 and shall be covered mild-steel electrodes conforming to AWS A5.1, E60 series.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Doors, Frames and Accessories shall be installed in accordance with the approved shop drawings and descriptive data.

B. Field Welding Steel, Touchup Painting:

1. Procedures of manual shielded metal-arc welding, the appearance and quality of welds made, and the methods used in correcting welding work shall conform to AWS D1.1.

2. After completion of welding, field welds and scarred surfaces on steel work and on adjacent ferrous-metal surfaces shall be touchup painted. Before start of touchup painting, weld scars, bruises, abrasions, and rust spots shall be wire brushed and solvent cleaned. Paint used for touchup painting shall be the same as that used for shop painting steel.

C. Installation Tolerances: Doors and frames shall be installed in a manner not to exceed the following limits of tolerance:

Deviation in location from that indicated on the drawings: Plus or minus 1/4 inch

Deviation from the plumb or horizontal:

In 12 feet: Not more than 1/8 inch
In 24 or more feet: Not more than 1/4 inch

Offset from true alignment at joints between members in line end-to-end:
Not more than 1/16 inch

D. Placing Frames: Supporting members, including materials embedded in other construction, shall be completely in place before placing frames. Framing members shall be installed plumb, level, and in alignment within the limits of the installation tolerances specified. Temporary supports and bracing shall be provided as required to maintain the position, stability, and alignment of the framing members while they are being permanently connected.

E. Door Installation: Doors shall fit accurately in frames within the specified door clearances.

F. Finish Hardware Installation: Contractor shall drill and tap as required for the application of surface-mounted finish hardware. True position shall be located by template to ensure accurate placement. Hardware items shall be installed in accordance with the manufacturer's printed instructions.

1. Thresholds shall be bedded in mastic and secured with corrosion-resistant steel flathead machine screws and lead expansion shields.

2. After installation is completed, hardware shall be adjusted and lubricated to ensure proper performance.

3.2 CLEANING

A. Upon completion of the installation, work shall be cleaned to remove all mastic smears and other foreign materials.

B. Before final acceptance, exposed-to-view aluminum surfaces shall be thoroughly washed with clean water and soap and rinsed with clean water. Acid solutions, steel wool, or other harsh abrasives shall not be used. Stains that remain after washing shall be removed or the finish restored in accordance with the aluminum producer's recommendations.

3.3 FINAL ADJUSTMENT: Before final acceptance, finish hardware shall be checked and readjusted as required to ensure proper operation.

3.4 ACCEPTANCE PROVISIONS: Doors and frames will be rejected for, but not limited to, any of the following deficiencies:

A. Exposed-to-view aluminum surfaces having color and appearance that are outside the color and appearance range of the approved samples for aluminum finish

B. Doors and frames not conforming to the requirements for installation tolerances and door clearances specified.

C. Hardware that is not complete and operating properly

D. Doors and frames having stained, discolored, abraded, or otherwise damaged exposed-to-view aluminum surfaces that cannot be restored by cleaning or repairing

3.5 REPAIR OF DEFECTIVE WORK: Defective work shall be removed and replaced with new at no additional cost to the Institute.

END OF SECTION

SECTION 08210

WOOD DOORS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

NATIONAL WOOD WINDOW AND DOOR ASSOCIATION (NWWDA)

NWWDA I.S. 1	(1987) Wood Flush Doors

1.2 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Manufacturer's Catalog Data shall be submitted for the following items:

Solid Core Doors
Fire Rated Doors
Facing
Cutout Openings
Door Louvers

B. Drawings

1. Fabrication Drawings shall show locations and dimensions for the following items:

Solid Core Doors
Fire-Rated Doors

2. Installation Drawings shall be submitted for the following items:

Solid Core Doors
Fire-Rated Doors
Facing
Cutout Openings
Door Louvers
Finish Hardware

C. Certificates: Certificates of Compliance shall be submitted for the following items showing conformance with referenced standards contained in this section.

Doors
Facing

PART 2 - PRODUCTS

2.1 GENERAL: Doors shall comply with the requirements of NWWDA I.S. 1, and as specified.

A. Solid Core Doors: Solid core wood flush doors shall be 5-ply, glue block core, or 7-ply MAT-formed particle board core.

B. Fire-Rated Labeled Doors: Fire-rated doors and frames shall be the types that have been investigated and fire tested as a fire door assembly, complete with the type of fire-door hardware to be used in the work. Fire-rated doors and frames shall be labeled. The labels shall indicate the applicable fire rating of the door construction provided.

2.2 FACING: Facings indicated as "paint finish" shall be sound grade, conforming to NWWDA I.S. 1. Facings indicated as stain-transparent finish shall be premium grade conforming to NWWDA I.S. 1. Face veneer and veneer cut shall be Cherry, Plain Slice.

2.3 CUTOUT OPENINGS: Cutout openings for lights and louvers shall be made in accordance with NWWDA I.S. 1.

2.4 DOOR LOUVERS: Louvers and frames shall be inverted 60-degree V-blade, enamel-finished steel, approximately 1 inch wide, stationary, sightproof. Each blade shall be spaced at not more than two per inch and formed from No. 20 U.S. Standard gage steel in baked enamel finish, color as selected. Louver retainer stops shall be steel or hardwood, matching the color and finish of the door.

2.5 BEVELING AND FITTING: Beveling and standard prefitting of wood doors shall be in accordance with NWWDA I.S. 1.

2.6 EDGE SEALING: Top and bottom edges of doors and surfaces of all cutouts shall be factory-sealed against moisture penetration. Edges and cutouts of exterior out-swinging wood doors shall be factory sealed to preclude moisture penetration. Top and bottom rails and sills of cutouts shall receive factory-installed aluminum flashing.

2.7 DOOR FINISHING: Doors to receive a job-site-applied finish shall be clean and sanded smooth to remove handling and storage marks, raised grain, minor surface marks, and abrasions and shall be left ready for finishing as specified in Section 09900, "Painting."

PART 3 - EXECUTION

3.1 GENERAL: Doors shall be accurately installed in framed openings and shall maintain the specified clearances and tolerances.

A. Finish hardware sets shall be installed in accordance with the approved hardware schedule and the approved drawings. Hardware shall be temporarily removed as required for job-site finishing.

B. After finish painting has been completed, hardware and accessories shall be reinstalled and final adjustments made for proper door operation.

3.2 ACCEPTANCE PROVISIONS: Doors will be checked by the Construction Manager for warp, twist, delamination, and manufacturing and installation defects. Doors exhibiting defects and doors outside the tolerances listed in NWWDA I.S. 1 shall be removed and replaced with new doors.

END OF SECTION

SECTION 08305

ACCESS PANELS

PART 1 - GENERAL

1.1 SUBMITTALS:

A. Drawings: Provide complete shop drawings showing all conditions of installation.

B. Data: Provide manufacturer's brochures and complete list of access panels required for project showing location, size, surface on which installed and type of panel for wall application.

PART 2 - PRODUCTS

2.1 GENERAL: Provide access panels in finish construction, where indicated on the architectural drawings, and wherever required for access to concealed mechanical and electrical equipment. Panels shown on architectural drawings shall be furnished under this section. Those required for access to equipment, but not shown on architectural drawings, shall be furnished as part of the work requiring the access. All access panels shall conform to the following requirements.

2.2 MANUFACTURERS: Panels specified below are those of Karp and Larsen's, unless otherwise noted. Equivalent products of Milcor, or Babcock/Davis will be acceptable, subject to approval. All panels shall be of one manufacturer, unless otherwise approved.

2.3 TYPES

A. Plaster Construction:

1. Walls and ceilings (fire rated): 24" x 24" U.L. 1-1/2 hr. B label cam lock type manufactured by Karp Associates, Inc. KRP-150 FR, or Larsen's L-FRAP, prime coated steel finish, screw-driver operated.

2. Walls and ceilings (non-rated): 24" x 24" cam lock type manufactured by Karp Associates, Inc., DSC-214PL, or Larsen's L-PSW, screw-driver operated.

3. Ceramic tile (mortar set), sizes as indicated on drawings, manufactured by Karp Associates, Inc., DSC-214M, or Larsen's L-MPSS stainless steel, screw-driver operated.

B. Gypsum Wallboard Construction:

1. For non-rated walls and ceilings, except as otherwise specified: Factory prime coated steel door and frame assembly, standard flush screwdriver operated cam latch and fitted with stainless steel flush hinges. Unless otherwise indicated, Karp Associates, Inc. KDW, or Larsen's L-DWA.

2. For acoustic tile surfaced gypsum wallboard: Karp KSTC/CAD, or Larsen's L-CPA, screwdriver lock.

3. For ceramic tile surfaced Portland cement backing board and gypsum wallboard: Karp DSC-214M SS, or Larsen's L-MPSS, stainless steel, screwdriver lock.

4. For fire rated walls and ceilings: Karp KRP-150FR, or Larsen's L-FRAP, bearing UL 1-1/2B label, equipped with automatic closing device, knurled knob operator and cylinder lock.

2.4 FINISHES: Access panels in painted walls shall be furnished with factory-applied prime coat, unless otherwise indicated. Access panels in tile walls and vinyl wall covered walls shall be stainless steel, or shall have polished chrome finish, unless otherwise indicated.

PART 3 - EXECUTION

3.1 INSTALLATION: Install access panels in accordance with manufacturer's recommendations. Provide channel framing for panels, and securely attach panels to frames. Align panels so that finish surface of panels is in same plane as finish material. Panels shall be plumb and level.

END OF SECTION

SECTION 08331

OVERHEAD COILING DOORS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 153	(1982; R 1987) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 27	(1991) Standard Specification for Steel Castings, Carbon, for General Application
ASTM A 307	(1992) Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength
ASTM A 36	(1991) Standard Specification for Structural Steel
ASTM A 446	(1991) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Structural (Physical) Quality
ASTM A 48	(1983; R 1993) Standard Specification for Gray Iron Castings
ASTM A 525	(1991b) Standard Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
ASTM A 526	(1990) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Commercial Quality
ASTM A 53	(1993) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM D 2000	(1990) Standard Classification System for Rubber Products in Automotive Applications
ASTM E 152	(1981a) Fire Tests of Door Assemblies

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B29.1M	(1986) Precision Power Transmission Roller Chains, Attachments and Sprockets

ASME B29.11M	(1984) Combination Chains, Attachments and Sprocket Teeth

FEDERAL SPECIFICATIONS (FS)

FS FF-B-171	(Rev A; Am 1) Bearings, Ball, Annular (General Purpose)
FS TT-C-490	(Rev C; Am 2) Cleaning Methods for Ferrous Surfaces and Pretreatments for Organic Coatings
FS TT-W-571	(Rev J) Wood Preservation: Treating Practices

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	(1988; Rev 1 - Mar 1989) Enclosures for Industrial Control and Systems
NEMA MG 1	(1987; Rev 1 - Mar and July 1988, Jan 1989; Rev 2 - May and Nov 1989, May, Sept, and Nov 1990, Jan and Mar 1991) Motors and Generators
NEMA ST 1	(1988) Specialty Transformers (Except General Purpose Type)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 80	(1990) Fire Doors and Windows

UNDERWRITERS LABORATORIES, INC. (UL)

UL 674	(1989; 2nd Ed) Electric Motors and Generators for Use in Hazardous (Classified) Locations
UL-02	(1992) Building Materials Directory

1.2 PERFORMANCE REQUIREMENTS

A. Wind Loading: Doors shall be designed and reinforced to withstand a wind loading pressure of at least [_____] pounds per square foot with a maximum deflection of 1/120 of the opening width.

B. Fire Doors, Frames, and Hardware

1. Fire doors, frames, and hardware shall be types that have been fire tested, rated, and labeled in accordance with ASTM E 152.They shall bear metal UL labels as evidence of the rating. Labels shall indicate the rating in hours of duration of exposure to fire, with a letter following the hourly rating to designate the location for which the assembly is designed and the temperature rise on the unexposed face of the door at the end of 30 minutes of fire exposure.

2. Door frames shall bear the UL label:"Listed Fire Door Frame." Special frames constructed of materials other than steel and intended for use with doors rated at less than 3 hours shall bear a UL label indicating the hourly rating.

3. Metal UL labels shall be attached to each item of hardware in accordance with requirements specified in the UL-02.

1.3 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data

1. Equipment and Performance Data for the following items shall be submitted in accordance with the paragraph entitled, "Performance Requirements," of this section.

Overhead Coiling Doors
Hardware
Counterbalancing Mechanism
Door Operators
Fire-Rated Doors

2. Manufacturer's Catalog Data for the following items shall be submitted listing all accessories including supports, locks and latches, and weatherstripping.

Doors
Hardware
Counterbalancing Mechanism
Manual Door Operators
Electric Door Operators
Fire-Rated Doors

B. Drawings

1. Fabrication Drawings shall show complete assembly with hardware and framing details for the following items:

Doors
Counterbalancing Mechanism
Door Operators

2. Installation Drawings for Overhead Coiling Door Assemblies shall show rough frame opening dimensions, hardware and anchor locations, and counterbalancing mechanism and door operator details.

C. Operation and Maintenance Manuals: Contractor shall submit 6 copies of the Operation and Maintenance Manuals 30 days prior to testing the Overhead Door Assemblies. Data shall be updated and resubmitted for final approval no later than 30 days prior to contract completion. Operation and maintenance manuals shall be consistent with manufacturer's standard brochures, schematics, printed instructions, general operating procedures, and safety precautions. Test data shall be legible and of good quality.

1.4 FIELD MEASUREMENTS: Field measurements shall be taken prior to preparation of drawings and fabrication.

1.5 WARRANTY: Contractor shall furnish a written guarantee that the helical spring and counterbalance mechanism are free from defects in material and workmanship and that they will remain so for not less than [_____] years after completion and acceptance of the project. Contractor shall warrant that upon notification by the Institute, he will immediately make good any defects in material, workmanship, and door operation within the same time period covered by the guarantee, at no cost to the Institute.

PART 2 - PRODUCTS

2.1 DOORS

A. Curtain Construction: Curtains shall be fabricated from steel sheets conforming to ASTM A 446/A 446M, Grade A, or to ASTM A 526/A 526M, with the additional requirement of a minimum yield point of 33,000 psi. Sheets shall be galvanized in accordance with ASTM A 525, G90.

1. Doors shall be fabricated from interlocking cold-rolled slats, with section profiles as specified, designed to withstand the specified wind loading. Slats shall be continuous without splices for the width of the door.

2. For doors not exceeding 14 feet in width, slats shall be flat-profile design, with a depth not less than 0.625 inch, a center-to-center width not more than 2.75 inches, and not less than a 0.0478-inch uncoated thickness.

3. For doors not exceeding 18 feet in width, slats shall be flat-profile design, with a depth not less than 0.75 inch, a center-to-center width not more than 2.75 inches, and not less than a 0.0478-inch uncoated thickness.

B. Curtain Bottom Bars shall be pairs of angles not less than 2.0 by 2.0 inches by 0.188 inch. Angles shall be steel conforming to ASTM A 36/A 36M.Angles and fasteners shall be galvanized in accordance with ASTM A 525, G90. Welds and abrasions shall be coated with paint conforming to MS DOD-P-21035.

C. Wind Locks shall be cast steel conforming to ASTM A 27, Grade B. Locks shall be galvanized in accordance with ASTM A 525, G90, and secured to the curtain slats.A wind lock shall be provided on every other curtain slat.

D. Weatherstripping

1. Weatherstripping for door heads shall be 1/8-inch thick sheet natural rubber or neoprene rubber air baffles secured to the insides of hoods with galvanized-steel fasteners through continuous galvanized-steel pressure bars at least 5/8-inch wide and 1/8-inch thick.

2. Weatherstripping for door-jamb guides shall be 1/8-inch thick strip natural rubber or neoprene rubber secured to the exterior sides of jamb guides with galvanized-steel fasteners through continuous galvanized-steel pressure bars at least 5/8-inch wide and 1/8-inch thick.

3. Bottom astragals shall be 1/8-inch thick sheet natural rubber or neoprene rubber secured to the bottom bars.

4. Weatherstripping and astragals shall be natural rubber or neoprene rubber conforming to ASTM D 2000.

2.2 HARDWARE

A. Curtain Jamb Guides shall be fabricated from a combination of steel angles of sufficient size to retain the curtain against the specified wind loadings.Guides shall be fabricated from rolled structural-quality carbon-steel angles conforming to ASTM A 36. Guide assembly shall be galvanized in accordance with ASTM A 525, G90. Bolt holes shall be slotted for track adjustment. Welds and abrasions shall be coated with paint conforming to MS DOD-P-21035.

B. Equipment Supports: Door-operating equipment supports shall be fabricated from steel shapes and plates conforming to ASTM A 36, galvanized in accordance with ASTM A 525, G90. Shapes and plates shall be sized in accordance with the manufacturer's standard practices for the size, weight, and type of door installation.

C. Threaded Fasteners shall consist of unfinished low-carbon steel bolts and nuts conforming to ASTM A 307, Grade A, galvanized per ASTM A 153, Table 1.

D. Locks and Latches

1. Manually operated push-up doors shall have galvanized-steel lifting handles on each side of the door and shall be complete with a cylinder lock and locking device.

2. Locking assembly shall consist of a keyed cylinder lock, a spring-loaded dead bolt, a chrome operating handle, a cam plate, and lock bars with adjustable guides to engage through slots in the track.

3. Doors shall be arranged to accept cylinders furnished under Section "Finish Hardware"

2.3 COUNTERBALANCING MECHANISM: Doors shall be counterbalanced by an adjustable, steel, helical torsion spring mounted around a steel shaft in a spring barrel and connected to the door curtain with the required barrel rings.

A. Brackets: Mounting brackets shall be the manufacturer's standard with one located at each end of the counterbalance barrel.Brackets shall be gray cast iron conforming to ASTM A 48.

B. Hoods shall be fabricated from steel sheets conforming to ASTM A 446, Grade A, or to ASTM A 526/A 526M, with the additional requirement of a minimum yield strength of 33,000 psi. Sheets shall be galvanized in accordance with ASTM A 525, G90. Material shall have an uncoated thickness of not less than 0.0299 inch. Hoods shall be reinforced to prevent hood deflection.

C. Counterbalance Barrels: Counterbalance-barrel components shall be as follows:

1. Spring barrels shall be hot-formed structural-quality carbon-steel, welded or seamless pipe conforming to ASTM A 53, Type E or S, Grade A, with the steel yield point and design stresses conforming to ASTM A 36. Pipe shall be of sufficient diameter and wall thickness to limit deflection to a maximum of 1/360 of the span.Barrels shall be hot-dip galvanized, inside and outside, in conformance with ASTM A 525, G90.

2. Counterbalance springs shall be oil-tempered helical steel springs designed with a safety factor of not less than 4. Springs shall be sized to counterbalance the weight of the curtain at any point of its travel, and shall be capable of being adjusted to counterbalance not less than 125 percent of the normal curtain load. Spring adjustment shall be arranged in such a way that the curtain need not be raised or lowered to secure the adjustment.

3. Counterbalance shafts shall be case-hardened steel of the proper size to hold the fixed ends of the spring and carry the torsional load of the spring.

4. Barrel plugs shall be fabricated from cast steel machined to fit the ends of the barrel. Plugs shall secure the ends of the spring to the barrel and the shaft. Plugs shall be galvanized in conformance with ASTM A 525, G90.

5. Barrel rings shall be fabricated from malleable iron of the proper involute shape to coil the curtain in a uniformly increasing diameter.

6. Shaft bearings shall be factory-sealed ball bearings conforming to FS FF-B-171 and of the proper size for load and shaft diameters.

2.4 MANUAL DOOR OPERATORS

A. Manual Push-Up Door Operators: Door operators shall consist of lifting handles, locks, and latches. Counterbalance mechanisms shall be adjusted so that the required lift or pull for operation does not exceed 25 pounds. Operating mechanisms shall be designed so that the curtain can be stopped at any point in its upward or downward travel and will remain in that position until pushed to the fully open or closed position.

B. Manual Chain-Hoist Door Operators: Door operators shall consist of an endless steel hand chain, chain-pocket wheel and guard, and a geared reduction unit of at least a 3 to 1 ratio. Required pull for operation shall not exceed 35 pounds.

C. Chain hoists shall have a self-locking mechanism allowing the curtain to be stopped at any point in its upward or downward travel and to remain in that position until moved to the fully open or closed position.

1. Hand chains shall be cadmium-plated alloy steel conforming to ASME B29.11M. Yield point of the chain shall be at least three times the required hand-chain pull.

2. Chain-sprocket wheels shall be cast iron conforming to ASTM A 48.

D. Manual Crank-Hoist Door Operators: Door operators shall consist of wall-mounted cranks and crank gear boxes, steel crank drive shaft, and a geared reduction unit of at least a 3 to 1 ratio. Required lift or pull for operation shall not exceed 35 pounds.

1. Crank hoists shall have a self-locking mechanism allowing the curtain to be stopped at any point in its upward or downward travel and remain in that position until moved to the fully open or closed position.

2. Driving gears shall be steel castings with machine-cut teeth and with keys and keyways for mounting on shafts.

3. Bearings shall be factory-sealed ball bearings conforming to FS FF-B-171 and of the proper size for load and shaft diameters.

4. Drive shafts shall be cold-rolled, polished steel.

5. Gear boxes shall be oiltight, fabricated from wrought iron, with a design suitable for mounting on wall or curtain track guides.

2.5 ELECTRIC DOOR OPERATORS:

A. Electrical wiring shall conform to the applicable requirements of Section 16150, "Manufactured Wiring Systems."

B. Door operator controls shall conform to the applicable requirements of Section 16475, "Overcurrent Protective Devices."

C. Electric door-operator assemblies shall be the sizes and capacities recommended and provided by the door manufacturer for specified doors. Assemblies shall be complete with electric motors and factory-prewired motor controls, gear reduction units, solenoid-operated brakes, clutches, remote-control stations, manual or automatic control devices, and control of stations and accessories as required for proper operation of the doors.

D. Operators shall be so designed that motors may be removed without disturbing the limit-switch adjustment and without affecting the emergency auxiliary operators.

E. A manual operator of crank-gear or chain-gear mechanisms with a release clutch shall be provided to permit manual operation of doors in case of power failure.Emergency manual operator shall be so arranged that it may be put into and out of operation from floor level, and its use shall not affect the adjustment of the limit switches.An electrical or mechanical device shall be provided which will automatically disconnect the motor from the operating mechanism when the emergency manual operating mechanism is engaged.

F. Door-Operator Types: Door operators shall be [wall-mounted units] [counterbalancing bracket-mounted units] consisting of an electric motor, a worm-gear drive from the motor to the reduction gear box, a chain or worm-gear drive from the reduction gear box to the gear wheel mounted on the counterbalance shaft, and a quick-clutch disconnect release for manual operation.Motor, clutch, and drive assembly shall be the horsepower rating and design determined by the door manufacturer for the size of the door and as specified.

G. Motors shall be the high-starting-torque, reversible, constant-duty electrical type with overload protection.Motors shall be of sufficient torque and horsepower to move the door in either direction from any position and produce a door-travel speed of not less than 8 nor more than 12 inches per second without exceeding the horsepower rating.

1. Motors shall conform to NEMA MG 1 and to the requirements specified.

2. Fractional horsepower motors up to 1/2 horsepower shall be single-phase, 115-volt, 60-hertz, or 115/230-volt, 60-hertz.A dual voltage rating may be provided at the option of the Contractor.

3. Motors 1/2 horsepower and larger shall be three-phase, 230/460-volt, 60-hertz.

4. Motor frame sizes shall conform to NEMA MG 1.

5. Motor enclosures shall be open drip-proof and shall be certified for continuous operation at full nameplate power output in an ambient temperature of 104 degrees F.

5. Motor enclosures shall be totally enclosed nonventilated or fan-cooled enclosures certified for continuous operation at full nameplate power output in an ambient temperature of 104 degrees F. Enclosures shall be fitted with plugged drains.

6. Motor Bearings:

a. Bearings shall be bronze-sleeve or heavy-duty ball or roller antifriction type with full provisions for the type of thrust imposed by the specific duty load.

b. Bearings in motors less than 1/2 horsepower shall be prelubricated and factory sealed.

c. Motors coupled to worm-gear reduction units shall be equipped with either ball or roller bearings.

d. Bearings in motors 1/2 horsepower or larger shall be equipped with lubrication service fittings.Lubrication fittings shall be fitted with color-coded plastic or metal dust caps.

e. In any motor, bearings that are lubricated at the factory for extended duty periods shall not need to be lubricated for a given number of operating hours. An appropriate tag or label on the motor shall display this information.

7. Motor Starters, Controls, and Enclosures

a. Each door motor shall have a factory-wired, unfused, disconnect switch; a reversing, across-the-line magnetic starter with thermal overload protection; 120-volt operating coils with a control transformer limit switch; and a safety interlock assembled in a NEMA ICS 6 type enclosure as specified herein.

b. Adjustable switches, electrically interlocked with the motor controls and set to stop the door automatically at the fully open and fully closed position, shall be provided.

H. Control Enclosures: Control enclosures shall conform to NEMA ICS 6 for [general purpose NEMA Type 1.] [oiltight and dusttight NEMA Type 13.] [explosionproof, NEMA Type 7, group as indicated.] [explosionproof NEMA Type 9, group as indicated.]

I. Transformer: Starters with 230/460 to 115 volt control transformers with one secondary fuse shall be provided when it is required to reduce the voltage on control circuits to 120 volts or less.Transformers shall conform to NEMA ST 1.

J. Safety-Edge Device: Each door shall be provided with a pneumatic safety device extending the full width of the door and located within a U-section neoprene or rubber astragal mounted on the bottom rail of the bottom door section.Device shall immediately stop and reverse the door upon contact with an obstruction in the door opening during downward travel and shall cause the door to return to full-open position. Safety device shall not be a substitute for a limit switch. Safety device shall be connected to the control circuit through a retracting safety cord and reel.

K. Remote-Control Stations

1. Interior remote-control stations shall be full-guarded, momentary-contact three-button, heavy-duty, surface-mounted NEMA ICS 6 type enclosures as specified. Buttons shall be marked "OPEN," "CLOSE," and "STOP."The "CLOSE" button shall be the type requiring a constant pressure to maintain the closing motion of the door.When the door is in motion and the "STOP" button is pressed, the door shall stop instantly and remain in the stopped position; from the stopped position, the door may then be operated in either direction.

2. Exterior control stations shall be full-guarded, momentary-contact three-button standard-duty, surface-mounted, weatherproof type, NEMA ICS 6, Type 4 enclosures, key-operated, with the same operating functions as specified herein for interior remote-control stations.

L. Speed-Reduction Units shall consist of hardened-steel worm and bronze worm gear assemblies running in oil or grease and encased in a sealed casing, coupled to the motor through a flexible coupling. Drive shafts shall rotate on ball- or roller-bearing assemblies that are integral with the unit.

1. Minimum ratings of speed reduction units shall be in accordance with AGMA provisions for class of service.

2. Worm gears shall be ground to provide accurate thread form; all other types of gearing shall have machined teeth.All gears shall be surface hardened.

3. Bearings shall be the antifriction type equipped with oil seals.

M. Chain Drives: Roller chains shall be power-transmission series steel roller type conforming to ASME B29.1M, with a minimum safety factor of 10 times the design load. Roller-chain side bars, rollers, pins, and bushings shall be heat-treated or otherwise hardened. Chain sprockets shall be high-carbon steel with machine-cut hardened teeth, finished bore and keyseat, and hollow-head setscrews.

N. Brakes shall be internally expanding 360-degree shoe brakes or shoe and drum brakes, solenoid-operated and electrically interlocked to the control circuit to set automatically when power is interrupted.

O. Clutches shall be the 4-inch diameter, multiple face, externally adjustable friction type or adjustable centrifugal type.

2.6 FIRE-RATED DOORS

A. Fire doors shall be the dimension, fire rating, and operating type indicated and shall consist of interlocking hot-dip galvanized steel slats, a bottom bar, wall guides, counterbalancing, and an automatic mechanism. Doors with electric operators shall be designed so that the electric assembly does not interfere with fire-release devices.

B. Door manufacturer's standard interconnecting fusible links shall be provided for doors on both sides of a wall.

C. Fire Ratings: Doors shall meet the applicable requirements of ASTM E 152 for the following rating:

[Doors shall be Class A, 3-hour rated.]

[Doors shall be Class B, 1-1/2-hour rated.]

[Doors shall be Class C, 3/4-hour rated.]

[Doors shall be Class D, 1-1/2-hour rated.]

2.7 SURFACE FINISHING

A. Zinc-coated steel materials shall be chemically cleaned, rinsed, given a zinc-phosphate conversion coating, rinsed with cold water, and then sealed with a chromic-acid rinse in accordance with FS TT-C-490, Method III, Type I. Minimum weight of the pretreatment coating shall be not less than 150 milligrams per square foot.

B. Pretreated zinc-coated steel sheets shall be given the manufacturer's standard prime coat of paint applied to both faces of the door after forming.]

C. Pretreated zinc-coated steel sheets shall be given the manufacturer's standard prime coat and an enamel finish coat applied to the exterior face after forming.]

PART 3 - EXECUTION

3.1 GENERAL

A. Doors, tracks, and operating equipment shall be installed complete with specified preparatory framing, jamb and head mold stops, anchors, inserts, hangers, and equipment supports in accordance with approved drawings, manufacturer's printed instructions, and as specified.

B. Door guide-track assembly shall be fastened to steel or wood framing with 1/2-inch galvanized machine bolts or lag screws, not more than 24 inches on center, and erected plumb and true to a vertical alignment with not more than 1/8 inch deviation in 20 feet.

C. Fire doors shall be installed in accordance with NFPA 80 and the manufacturer's standard procedure for the fire rating and type of door operation indicated.]

3.3 STEEL FRAMING: Steel framing at jambs and heads of door openings shall be plumb, true, and securely anchored in place. Vertical members shall be plumb, with a deviation of not more than 1/16 inch in 20 feet. Inside faces of steel jambs shall extend to the ceiling or to the minimum headroom height of the door.

3.4 ACCEPTANCE PROVISIONS

A. After installation, doors, track, and operating equipment will be examined and tested by the Institute for general operation, for operation against the specified wind pressure, and for resistance to weather.

B. Doors that fail the required tests shall be adjusted and retested.Doors that have been adjusted and which fail subsequent tests shall be removed and replaced with new doors.New doors shall be tested and adjusted at no additional cost to the Institute.

C. Maintenance and Adjustment: Not more than 90 days after completion and acceptance of the project, the Contractor shall examine, lubricate, test, and re-adjust doors as required for proper operation.

END OF SECTION

SECTION 08805

GLASS AND GLAZING

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN ARCHITECTURAL MANUFACTURERS ASSOCIATION (AAMA)

AAMA 801-809	(1986) Voluntary Specifications for Sealants

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z97.1	(1989) American National Standards for Safety Glazing Material Used in Buildings - Safety Performance Specifications and Methods of Test

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 1036	(1991) Standard Specification for Flat Glass
ASTM C 669	(1975; R 1989) Standard Specification for Glazing Compounds for Back Bedding and Face Glazing of Metal Sash
ASTM C 920	(1987) Standard Specification for Elastomeric Joint Sealants

FLAT GLASS MARKETING ASSOCIATION (FGMA)

FGMA-01	(1990) Glazing Manual

UNDERWRITERS LABORATORIES (UL)

UL-02	(1992) Building Materials Directory

1.2 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Certificates of Compliance shall be submitted for the following items showing conformance with the referenced standards and tests contained in this section.

Glass Materials
Glazing Materials
Tempered Glass

B. Samples; Contractor shall submit the following samples:

1. Not less than 2 different samples 10 by 12 inches of each glass of the specified type, class, thickness, and finish shall be provide for inspection and approval by the Construction Manager prior to delivery of material to site.

2. Color samples of each color and type of glazing and sealing compound to be used in the work, beads approximately 1/4-inch wide by 1 inch long, to illustrate the glazing or sealing compound manufacturer's standard color range after setting or curing.

Clear Glass
Tinted Glass
Safety Rated Tempered Glass
Double Glazing Units
Glazing Compound
Elastomeric Sealing Compound

1.3 DELIVERY, STORAGE AND HANDLING: Manufactured glass units shall be delivered and stored until installation in the manufacturer's container's and shall be clearly marked on the exterior as to type, and quantity of units. When special moisture protection is required, glass shall be stored in accordance with the manufacturer's recommendations.

PART 2 - PRODUCTS

2.1 GLASS MATERIALS

A. Clear Glass shall be float type conforming to ASTM C 1036, Type I, Class 1, Quality q3. Maximum allowable areas of glass subject to wind pressure shall conform to the glass manufacturer's recommendations.

B. Tinted Glass: Glass shall be float type conforming to ASTM C 1036, Type I, Class 3, Quality q3. Edges shall be factory or shop clean-cut. Tint shall be blue. Maximum allowable areas of glass subject to wind pressure shall conform to the glass manufacturer's recommendations.

C. Safety-Rated Tempered Glass shall conform to ANSI Z97.1 and shall bear the ANSI safety glass marking. Glass before tempering shall be the float type conforming to ASTM C 1036, Type I, Class 1, Quality q3. Glass shall be factory-cut to suit each opening. Edges shall be clean cut.

D. Double-Glazing Units:

1. Units shall be factory fabricated, shall be two panels of flat glass separated by a hermetically sealed, dehydrated air space. Maximum allowable areas of glass subject to wind pressure shall conform to the glass manufacturer's recommendations.

2. Double-glazing units shall consist of one light of clear float glass, 1/4" thick and one light of tinted glass (color blue), 1/4" thick with 1/2" air space and metal edge shield.

2.2 GLAZING MATERIALS

A. Elastic Glazing Compound shall conform to ASTM C 669. Color of the sealing compound shall match the color of the metal sash as closely as possible. Unless otherwise specified, elastic glazing compound shall conform to ASTM C 920, Type S, Class 25, and shall be used for glazing-in metal. A glazing compound having a composition and color particularly adapted for aluminum and requiring no painting shall be used for glazing-in aluminum.

B. Glazing Tape shall be nonskinning, nonoily, reinforced class, butyl- or polyisobutylene-base resilient preformed compound conforming to AAMA 801-809.

C. Elastomeric Sealing Compound shall be the two-component, nonsag type, resistant to 50 percent total joint movement, conforming to ASTM C 920, Type S, Class 25. Compound shall match the color of the metal sash as closely as possible. Primer for the compound shall be as recommended by the elastomeric sealing compound manufacturer.

D. Solvents and Cleaning Agents: Solvents, cleaning agents, and other cleaning materials shall be as recommended by the glazing-material manufacturer.

E. Resilient Setting Blocks and Spacers Blocks shall be solid chloroprene elastomeric extrusions having a Shore A durometer hardness between 70 and 90. Thickness shall be approximately the same as the glass-edge clearance dimension; the length shall be 4 inches, minimum.

F. Spacers shall be solid chloroprene elastomeric extrusions having a Shore A durometer hardness between 40 and 50. Spacers shall be 2- to 3-inches long with thickness and height to suit the application.

PART 3 - EXECUTION

3.1 GENERAL

A. Glass shall be installed in accordance with the manufacturer's printed instructions.

B. Field cutting, or nipping or grinding the edges of glass will not be permitted.

C. Operable sash shall move freely and properly in the frame of the unit prior to the start of glazing. Movable items shall be securely fixed or in a closed and locked position until the glazing material has set.

D. Sizes of glass shown on drawings are approximate.Sizes and proper edge clearances shall be determined by measuring the actual unit to receive glass. Except where specified otherwise, each piece of glass shall bear the manufacturer's label to identify its type as well as thickness and quality. Labels shall not be removed until final approval is obtained.

3.2 TEMPERATURE AND ATMOSPHERIC CONDITIONS: Glazing materials shall not be installed when the ambient temperature is below 40 or above 100 degrees F. Exterior glazing shall not be performed in damp or rainy weather.

3.3 GLAZED OPENINGS PREPARATION: Surface of rabbets shall be clean and dry prior to the start of glazing. Surfaces in contact with glazing materials shall be clean and free of loose particles, surface dust, and other foreign matter. When elastomeric sealing compound is used, the surfaces shall be cleaned with a solvent that leaves no residue. Surfaces shall be wiped dry before the solvent has air dried.

3.4 CLEARANCES AND POSITIONING GLASS: Face and edge clearances and positioning glass with setting blocks and spacers shall be as recommended in the FGMA-01.

3.5 APPLICATION OF GLAZING COMPOUNDS: Glazing compounds shall be installed in accordance with the manufacturer's printed instructions and as follows:

A. Elastic glazing compound shall be knife-applied as it comes from the container, without adulteration.

B. Glazing tape shall be compressed slightly to obtain a positive bond and neatly mitered or butted at corners. Backing paper shall be removed prior to installation of the glass.

C. Elastomeric sealing-compound components shall be mixed. Compound shall be gun-applied to fill the cavity without air pockets.

how big is your glass

3.6 SINGLE GLASS IN METAL SASH WITH FACE GLAZING

Single-glass lights up to 50 united inches in size, with the greatest dimension not exceeding 30 inches, shall be set in metal sash with elastic glazing-compound back bed, heel bead, and front putty.

Single-glass lights between 50 and 100 united inches in size, with the greatest dimension between 30 and 50 inches, shall be set in metal sash with a glazing-tape back bed, an elastic-glazing compound heel bead, and front putty.

Glass lights shall be secured with glazing clips placed at sill, head, and jambs 18 inches on center, minimum. Each ventilator shall be provided with a minimum of four glazing clips.

Front of each glass light edge in the sash rabbet shall be face-puttied with elastic glazing compound to form a triangular fillet, stopping 1/16 inch short of the sight line. Corners shall be mitered finish and excess compound shall be removed. Surplus back-bed material shall be stripped at an angle without undercutting.

3.7 SINGLE GLASS IN METAL SASH WITH CHANNEL GLAZING

Single-glass lights up to 100 united inches in size shall be set in metal sash with thermoplastic sealing-compound back bed, heel bead, and bedding of stop.

Single-glass lights shall be set in metal sash with glazing-tape back bed, elastomeric sealing-compound heel bead, glazing-tape bedding of stop, and elastomeric sealing-compound topping bead on both sides of the glass light. Glazing tape shall be kept down at least 1/8-inch below the sight line.

Clear-glass lights between 100 and 150 united inches in size shall be set with glazing-tape back bed, thermoplastic sealing-compound heel bead, glazing-tape bedding of stop, and thermoplastic sealing-compound topping bead on both sides of the glass light. Glazing tape shall be kept down at least 1/8-inch below the sight line.

Single-glass lights over 100 united inches size shall be set with glazing tape-back bed, elastomeric sealing-compound heel bead, glazing-tape bedding of stop, and elastomeric sealing-compound topping bead on both sides of the glass light. Glazing tape shall be kept down at least 1/8-inch below the sight line.

Tinted-glass lights over 100 united inches in size shall be set with glazing-tape back bed, elastomeric sealing-compound heel bead, glazing-tape bedding of stop, and elastomeric sealing-compound topping bead on both sides of the glass light. Glazing tape shall be kept down at least 1/8-inch below the sight line.

A void shall be provided at the head and jambs for clear-glass, and for all tinted-glass lights.

Excess sealing compound on the sash shall be removed with a glazing knife at a slight angle over the sight line.

3.8 DOUBLE UNITS IN METAL SASH WITH CHANNEL GLAZING

Double-glazing units shall be set in metal sash with channel glazing in accordance with the recommendations of the FGMA-01.

A void shall be provided at the head and jambs. Excess elastomeric glazing compound on the sash shall be removed with a glazing knife at a slight angle over the sight line.

3.10 SINGLE GLASS IN ALUMINUM DOORS WITH FLUSH GLAZING

Single-glass lights shall be secured in aluminum doors with the door and frame manufacturer's preformed glazing gaskets and installed in accordance with the manufacturer's printed instructions. Lights shall be positioned with resilient setting blocks as specified.

3.11 GLASS PROTECTION

Glazed openings shall be identified during the construction period by tapes or flags that are not in contact with the glass.

Temporary labels shall be removed immediately after the glass and glazing work has been approved.

3.12 CLEANING

Upon completion of work, glass surfaces shall be cleaned and shall be free of glazing- or sealing-compound, smears, and other defacement.

END OF SECTION

SECTION 09260

GYPSUM BOARD SYSTEMS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 111	(1990) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel, Products

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 569/A 569M	(1991; Rev A) Standard Specification for Steel, Carbon (0.15 Maximum, Percent), Hot-Rolled Sheet and Strip Commercial Quality
ASTM A 641	(1992) Standard Specification for Zinc Coated (Galvanized) Carbon Steel Wire
ASTM C 36	(1985; R 1988) Gypsum Wallboard
ASTM C 442	(1984a; R 1988) Gypsum Backing Board and Coreboard
ASTM C 473	(1987a) Physical Testing of Gypsum Board Products and Gypsum Lath
ASTM C 475	(1989) Joint Compound and Joint Tape for Finishing Gypsum Board
ASTM C 630	(1991) Water-Resistant Gypsum Backing Board
ASTM C 645	(1988) Non-Load (Axial) Bearing Steel Studs, Runners (Track) and Rigid Furring Channels for Screw Applications of Gypsum Board
ASTM D 2103	(1986) Standard Specification for Polyethylene Film and Sheeting
ASTM E 119	(1988) Standard Test Methods for Fire Tests of Building Construction and Materials
ASTM E 84	(1991a) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E 90	(1990) Standard Test Method for Laboratory Measurement of Airborne-Sound Transmission Loss of Building Partitions

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B18.2.1	(1981; R 1992) Square and Hex Bolts and Screws, Including Hex Cap and Lag Screws (Inch Series)
ASME B18.2.2	(1987) Square and Hex Nuts (Inch Series)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101	(1991) Code for Safety to Life from Fire in Buildings and Structures

SHEET METAL AND AIR CONDITIONING CONTRACTORS NATIONAL ASSOCIATION, INC. (SMACNA)

SMACNA-02A	(1980; 5th Ed) Architectural Sheet Metal Specifications

1.2 SYSTEM DESCRIPTION

A. Partition Configurations

1. Single-Layer Partitions: Single-layer drywall partitions shall be fire-retardant, 5/8" thick, gypsum wallboard.

2. Double-Layer Partitions: Double-layer drywall partitions shall consist of two layers of 5/8" thick fire-retardant gypsum wallboard.

B. Performance Requirements

1. Fire Retardant Requirements: Type X gypsum wallboard shall provide at least 1 hour fire-retardant rating for 5/8-inch thick material or 3/4-hour fire-retardant rating for 1/2-inch material when applied in single-layer, nailed on each face of load-bearing, wood framing members, and when tested in accordance with ASTM E 119.

2. When tested in accordance with ASTM E 84, gypsum wallboard shall have a maximum flame-spread rating of 15, fuel contributed 15, and smoke developed 15.

C. Ceiling Assembly Fire Ratings: Gypsum drywall ceiling assembly shall have a fire rating of 1 hour. Drywall construction shall be in accordance with the UL design and test as listed by the drywall manufacturer.

D. Permeance Requirements: Back gypsum wallboard shall meet the permeance requirements specified in ASTM C 36.

E. Sound Transmission Classifications: Sound transmission classification (STC) shall be as published by the gypsum wallboard manufacturer. Classifications shall be established in accordance with ASTM E 90 and shall reflect acoustical performance values obtained in laboratory tests by a recognized independent acoustical laboratory. Gypsum drywall ceiling shall have an STC of 35 to 40.

1.3 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Manufacturer's Catalog Data shall be submitted for the following items including fire ratings, sound transmission classification, and permeance requirements where applicable.

Gypsum Wallboard

Ceiling and Wall Framing
Furring
Rated Wallboard Assemblies
Joint Tapes
Compounds
Steel Stud Framing
Metal Ceiling Materials
Fasteners
Adhesives

B. Drawings

1. Fabrication Drawings shall be submitted for the following items consisting of fabrication and assembly details to be performed in the factory.

Hangers and Inserts
Suspension, Furring, and Channels
Steel Stud Framing
Metal Accessories and Trim

C. Installation Drawings shall be submitted for Gypsum Wallboard Systems in accordance with the paragraph entitled, "Erection, Installation, and Application."

D. Certificates

1. Certificates of Compliance shall be submitted for Gypsum Wallboard Systems indicating that the proposed materials meet or exceed the project specifications and the listed reference specifications.

2. Certification for Fire-Rated Gypsum Wallboard shall indicate the flame spread, fuel contributed, and smoke developed, together with the UL test number and the testing agency by which certification is made.

E. Samples: The following samples shall be submitted:

Gypsum Wallboard: Three full-size samples of each type.
Steel-Stud Framing and Trim: Three samples each, 8-inches long.
Fasteners: Three 12-inch square samples of each type of gypsum wallboard

1.4 DELIVERY, HANDLING, AND STORAGE:

A. Materials shall be protected from weather, soil, and damage during delivery, while stored, and during construction. Materials shall be delivered in the manufacturer's original packages; containers or bundles shall bear the brand name and the name of the manufacturer.

B. Materials shall be stored in dry, weathertight, and properly ventilated areas. Gypsum wallboard shall be neatly stacked flat, with care taken to avoid sagging or damage to edges, ends, and surfaces. Wallboard delivered to the building shall be kept protected and banded with midpoint slat spaces of 2 by 1/2-inch material extended full width between each layer of gypsum wallboard.

1.5 PROJECT/SITE CONDITIONS

A. Environmental Requirements:

1. Temperature: A temperature of not less than 55 degrees F shall be provided in areas of work during the application of the materials and shall be maintained until the joint treatment compounds are dry.

2. Ventilation shall be provided to eliminate moisture within the building.

3. Moisture Control: Gypsum wallboard installation and joint treatment shall be accomplished in a uniform temperature with sufficient ventilation to ensure that throughout the application period the wallboard moisture does not exceed 8 percent. Wallboard that has a moisture content in excess of 8 percent shall not be installed.

B. Field Measurements shall be taken before installation of materials to verify the indicated dimensions and to ensure proper fit of the work.

PART 2 - PRODUCTS

2.1 WALLBOARD MATERIALS

A. General Requirements for Wallboard: Gypsum wallboard shall conform to ASTM C 36 of grade and form as specified for each type of board. Wallboard shall be 48-inches wide, shall have thickness as indicated, and a maximum practical length for end use.

B. Ceiling: Board for drywall ceilings shall be 5/8-inch thick, fire-retardant gypsum wallboard.

C. Fire-Retardant Gypsum Wallboard shall be Grade X, Form a, at least 5/8 inch thick.

D. Water-Resistant Backing Board: Backing board for use with ceramic tile or other nonabsorbent wall tiles shall be moisture-resistant and thickness as indicated and shall meet the requirements of water resistance of ASTM C 630 when tested in accordance with ASTM C 473.

E. Joint Materials

1. Joint Tapes shall be plain or perforated material conforming to ASTM C 475, Type II, Styles 1 and 2.

2. Compounds and Adhesives

a. Joint compound shall be an adhesive, without fillers, conforming to ASTM C 475, Type I, Style 3.

b. Laminating adhesive shall be joint compound of the type used for embedding tape or a material recommended by the manufacturer of the gypsum board. Ready-mixed joint compound (Style 3) shall not be used as laminating adhesive.

F. Metal Fasteners

1. Screws shall be steel, self-tapping drywall type, bugle head, self-drilling point; the length shall be as recommended by the drywall manufacturer for the type of system being installed.

2. Screws for anchorage of runner channels to studs and securing gypsum backing board to metal studs and furring channels shall be 1 inch long. Screws for temporary support of gypsum wallboard face ply shall be 1-5/8-inches long of the same type.

3. Bolts shall be steel and conform to ASME B18.2.1, Type II, regular hexagon bolts.

4. Nuts shall be steel, plain, hexagon, Type II, and shall conform to ASME B18.2.2.

5. Expansion shields shall conform to ASTM C 514, Group, Type, and Class as required.

G. Metal Framing Materials

1. Hangers and Inserts

a. Wire hangers for main runner channels shall be galvanized soft steel wire not less than 28-gage, conforming to ASTM A 641, steel number 1010, Class 2 zinc coating.

b. Hot-dip galvanized flat steel hangers 1 by 3/16 inch; galvanized concrete insert-type rod hangers may be substituted for wire hangers.

c. Tie wires for splicing furring channels or for securing furring channels to main running channels shall be galvanized soft steel wire not less than 16-gage with Class 2 zinc coating.

d. Clips used in lieu of tie wire shall be galvanized steel equivalent in holding power to that provided by the tie wires and of a type recommended by the gypsum board manufacturer.

2. Suspension, Furring, and Channels

a. Channels shall be formed from galvanized steel sheets conforming to SMACNA-02A, Type I, Class d, ordinary zinc coated (commercial).

b. Main runner channels shall be 1-1/2-inch, hot- or cold-rolled, galvanized steel. Hot-rolled channels shall weigh not less than 1.12 pounds per linear foot. Cold-rolled channels shall be not less than 16-gage uncoated steel with flanges at least 19/32-inch wide.

c. Furring channels shall be roll-formed, galvanized steel not less than 0.021 inch thick before galvanizing, with steel face width of 1-3/8 inches and a depth of 7/8 inch, and shall have reinforced, folded edges.

d. Furring channels for miscellaneous framing shall be 3/4-inch wide, cold-rolled galvanized steel not less than 16-gage before galvanizing, and shall weigh not less than 0.33 pounds per linear feet.

3. Steel-Stud Framing

a. Steel studs, floor and ceiling runners, angle runners, and furring channels shall be electrogalvanized, cold-rolled steel conforming to ASTM C 645 ordinary zinc coated (commercial).

b. Metal studs shall be formed, zinc-coated sections of channel or Z-shape, of 26-gage minimum thickness, and of widths indicated on the drawings. Stud flanges that come in contact with gypsum wallboard shall be a minimum of 1-1/4 inches wide, with a 1/4-inch stiffening lip with turned or folded edges. Holes shall be regularly punched in studs to facilitate installation of electrical wiring, conduit, or horizontal bracing.

c. Floor and ceiling runners shall be not less than 26-gage steel before galvanizing, with 1-1/4-inch flanges, sized to nest with steel stud.

d. Angle runners shall be 1-3/8 inches by 7/8 inch and not less than 22-gage.

H. Metal Accessories and Trim

1. Corner Beads and Trim

a. Corner beads shall be 30-gage minimum, hot-dip galvanized steel, with 1-1/4- by 1-1/4-inch flanges and a 1/8-inch beaded corner.

b. Corner beads shall be formed to an angle of 90 degrees and shall be zinc-coated steel or protected aluminum with legs approximately 3/4-inch wide and cemented under pressure with a rubber-base adhesive to tough-paper jointing-tape wings not less than 1-inch wide. Zinc-coated steel shall conform to SMACNA-02, SMACNA-02A, and AASHTO M 111, Type I, Class C.

c. Casing trim shall be 28-gage nominal thickness, hot-dip galvanized steel channel, depth as required for wallboard, with attached tape flange.

2. Control Joint Material

a. Control joint material shall be one piece, 29-gage, roll-formed zinc, formed 7/16-inch deep by 1/4-inch wide with a perforated flange 7/8-inch wide on each side of the joint opening, with a protective plastic strip.

b. Control joints shall be formed of casing bead trim and installed back to back over separate framing or furring members. A space of 3/16 inch shall be maintained between opposite casing beads.

I. Calking: Control joint calking shall be as recommended by the drywall manufacturer and shall be the same type used for partition and ceiling assemblies when the fire rating and STC were established.

J. Dust Membrane: Dust membrane shall be clear, 4-mil polyethylene film, conforming to ASTM D 2103, Type 13000.

2.2 SOURCE QUALITY CONTROL: Gypsum wallboard shall be tested at the manufacturing plant in accordance with ASTM C 473 for flexural strength, thickness and weight of paper and predecorated board surfacing, and thickness of edge of recessed or tapered-edge gypsum wallboard.

PART 3 - EXECUTION

3.1 PREPARATION: Defective wall and ceiling surfaces shall be corrected prior to application of drywall materials.

3.2 ERECTION, INSTALLATION, AND APPLICATION

A. Framing: Framing members to receive gypsum wallboard shall be straight, plumb, and true and spaced not to exceed the maximum spacings for the board thickness.

B. Board Length: Boards of maximum practical length shall be used to minimize the number of end joints. Edges of boards shall be butted together but shall not be forced.

C. Staggering Boards: Joints shall be staggered and shall not be aligned with the edge of an opening nor positioned so that the corners of four boards will meet at a common point.

D. Joints: All abutting ends or edge joints shall occur over solid bearing,(over the web surface of furring channels) and shall be fitted neatly and accurately, with all end joints staggered. Wallboard shall be supported as recommended by the manufacturer, with additional framing at all cutouts and openings.

E. Ceiling Abuts Dissimilar Wall: Perimeter of ceilings shall be finished with an edge bead trim where ceiling abuts dissimilar wall materials.

F. Wall Trim shall be applied to wall and accurately aligned with the finished ceiling. Ceiling board edges that adjoin walls shall be laid on the horizontal leg of the trim strip, and the space behind the junction shall be closed with a dust membrane. Membrane shall be applied in advance of the wallboard application.

G. Corners and Edges: Exposed corners and edges and the perimeter of door, window, and borrowed-light frames shall be finished with the specified metal trim.

H. Tolerance and Alignment: Finished wallboard application shall be plumb and true, with all joints aligned to within a 1/16-inch tolerance and with all surfaces shimmed and aligned to a plane and even surface having a maximum variation of 1/8 inch in 8 feet.

I. Midheight Horizontal Bracing shall be continuous in partitions for all heights above 8 feet 6 inches. Bracing shall be standard runner channel for stud size specified. Channel shall be secured rigidly in place at each stud.

J. Partition Bracing: Where gypsum wallboard partitions do not extend to the underside of construction above, they shall be braced at the top channel with a V-frame perpendicular to the line of the partition located 18 feet 8 inches maximum on center where partitioning is not intersected or otherwise braced. V-braces shall be composed of two 2-by 2-by 1/8-inch angles attached to metal clips. When brace is in final position, it shall be welded, or holes shall be drilled and the brace bolted in permanent position. Partitions shall not exceed 16 feet in height.

K. Ply: Wallboard shall be applied to ceilings in single-ply, with the long dimension of the wallboard at right angle to the furring members as specified herein and in accordance with the drywall manufacturer's instructions for the type and classification of wall assembly indicated.

L. Fastening: Board shall be fastened with power-driven, phillips-head screws at a maximum spacing of 12 inches on center in the field of the board and at 8 inches on center at edges and along abutting ends. Screws shall be placed not closer than 3/8 inch to ends or edges of boards.

M. Installation of Control Joints Control joints shall be provided where indicated and shall be screwed in place.

N. Ceiling control joints fastened securely in place shall be provided at spacing not to exceed 50 feet in each direction.

O. Vertical control joints in long runs of drywall partitions shall be provided at spacing not to exceed 30 feet on center; at partition intersections with structural floors and columns; and at walls of dissimilar materials.

P. Abutting Concrete Slabs: Where tops of drywall partitions abut concrete slab floors, a 1/2 inch gap for deflection shall be provided between the top of stud and bottom of floor slab. A double slip track consisting of an inside and outside deep leg track shall be provided with studs screwed to the inside track. Runner tracks shall be embedded in calking or in an adhesive recommended by the drywall manufacturer, then stub-nailed in place.

Q. Trim: Edges of exposed drywall shall be trimmed with the specified metal bead.

R. Framed Openings: Support members shall be provided at ceiling openings as required for access panels, recessed lighting fixtures, and heating and ventilating ducts. Support members shall be not less than 1-1/2-inch main runner channels located where required and shall be provided in sufficient number to support furring and wallboard attachment.

S. Joint Finishing

1. Joints between wallboard panels and joints at metal trim shall be reinforced with joint tape and embedding-type joint compound and concealed with at least two applications of finishing compound in accordance with the printed instructions of the manufacturer of the gypsum wallboard. Screw depressions shall be filled with at least three coats of joint compound. Flanges at corner beads, edge trim, and control joints shall be concealed with at least two applications of joint compound, feathered and sanded smooth.

2. Joint and screw-depression treatment shall be accomplished after wallboard is in place. A minimum of 24 hours' drying time shall be allowed between the application of each coat. Where necessary, the last coating shall be sanded lightly with 2/0 sandpaper to leave a smooth finish flush with the paper face of the wallboard. Control joints shall be concealed with three coats of joint cement. After the second coating has dried, a third coating shall be applied very thin to a smooth surface and feathered out 12 to 16 inches on both sides of the joint. If necessary, the joints, when dry, shall be sanded lightly with 2/0 sandpaper to leave a smooth, flush surface. Care shall be taken not to scuff the paper surface of the wallboard when sandpapering the cement. Water content of the finish bedding cement coat shall be in strict accordance with the manufacturer's specifications.

T. Moisture Proofing: Edges of gypsum wallboard adjoining tile bases and cut edges in areas of high humidity shall be sealed before erection with a waterproofing agent, plastic tape, joint compound, or material approved by the manufacturer of the wallboard.

U. Installation of Gypsum Drywall Ceilings

1. Metal-Framed Drywall Ceilings: Metal-framed drywall ceilings shall be installed and finished as specified and in accordance with the drywall manufacturer's written instructions for drywall ceilings installed over suspended or furred metal grilles and as required for the indicated fire rating and STC.

2. Metal Suspension Grilles: Main runner channels suspended or furred from the bottom chord of steel joists shall have the wire hanger looped around the runner channel and

twisted a minimum of three times around itself. Hangers shall be plumb and spaced at not more than 4 feet on center.

3. Main runner channels shall be spliced with 12-inch nested laps and tied securely near each end of the splice with two loops of 8-gage hanger wire. Splices shall be staggered.

4. Furring channels or resilient channels shall be installed at right angles to main runner channels or structural supporting members, and shall be fastened with clips or tie wires at a maximum spacing of 48 inches on center. Resilient channels shall be screw fastened to wood members. Furring channels or resilient channels shall be spaced at 24 inches on center. Channels shall be extended to within 2 inches of perimeter walls and abutting elements. Channels shall not be anchored or buried in the wall.

5. Furring shall be spliced with 8-inch nested laps and tied securely near each of the splice with two loops of 16-gage tie wire. Splices shall be staggered.

6. Suspension grilles shall be reinforced with 3/4-inch, cold-rolled channels or with furring channels at light troffers or any openings that interrupt the main runner or furring channels. Reinforcing channels shall be wire tied to and parallel to the main runner channels.

V. Steel Stud Framing

1. Floor and ceiling runner tracks shall be accurately aligned and securely attached to floors, structural ceilings, finished ceilings, or roof deck. Track shall be attached to metal ceiling grilles with a double strand of 18-gage tie wire spaced at no more than 16 inches on center, and to to steel framing or steel joists with machine bolts at 24 inches on center,

2. Runners shall extend beyond open-end partitions for at least 12 inches. Upon installation of end studs, runner extensions shall be bent and nested with the stud and attached with at least two sheet metal screws. Runners shall be furnished in longest practical lengths with butt joints.

3. Steel studs shall be size indicated, spaced at 24 inches on center. A maximum height span of 12 feet shall be used for 2-1/2-inch studs. Maximum height span for 3-5/8-inch studs shall be 16 feet.

4. Studs for pipe chases, ventilating shaft framing, and steel column or beam fireproofing shall be the size indicated, spaced 16 inches on center.

5. Studs shall be positioned plumb in ceiling and floor runners and attached with at least one self-tapping screw on each side of the stud ends. Studs shall be installed in continuous lengths with no splicing.

6. Stud shall be placed no more than 1/2 inch from door frames, framed openings, abutting partitions, and partition corners. Studs shall be securely anchored direct or with spacers to door and borrowed-light frames by screw attachment.

7. Top-runner channels of intersecting partitions shall have the web extended across the intersected channel. Extended web shall be fastened with two screws. Flanges of the intersecting channel shall be cut, bent, and fastened to the flanges of the continuously intersected channel with two screws in each flange.

8. Partition reinforcement shall be provided over door and borrowed-light frame openings and, where required, for support of plumbing fixtures, accessories, and electrical and

mechanical equipment. Reinforcement shall consist of cut-to-length sections of runner track or cold-rolled channels extending at least 2 feet on each side of the opening and braced and fastened to studs in accordance with the manufacturer's directions.

9. Head and jamb framing at door openings shall consist of a tube made up of one runner channel and one stud. Tubes at door jambs shall extend the full height of the partition and shall be fastened together with screws at a minimum of 24 inches center-to-center each flange.

10. Tube over the door head shall be fastened together with a minimum of three screws each flange. Runner channel section of the header tube shall be cut 12-inches longer than the span between the two jamb studs. A web bend shall be made with 6 inches extended in a vertical direction on each jamb tube and fastened with a minimum of two screws. Flanges shall be extended horizontally and fastened to the flanges of the vertical stud. Cut-to-length studs shall then be positioned at not more than 16-inch spacing over the door opening and secured to the tube with a web flange bend with a minimum of two screws. Runner channel sections of tubes shall be secured to the door frame head and jamb with two 1/4-inch machine bolts, nuts, and washers.

W. Fixture Attachment: Metal mounting strips shall be provided for cabinets and shelving as indicated. Mounting strip shall be braced and secured between studs; attachment bolts that extend through bracing, studs, and drywall shall be provided.

X. Steel Framed Drywall Partitions

1. Single-Layer Partition Over Steel Framing: Gypsum wallboard shall be applied and finished as specified and in accordance with the drywall manufacturer's written instructions for a UL-approved, 1-hour fire-rated, single-layer, screw-stud drywall partition, with an STC of at least 41. All perimeter joints shall be calked.

Y. Metal Furring

1. Furring to receive gypsum wallboard shall be the specified galvanized-steel furring channels of the type and spacing as indicated. Clips and fasteners shall be provided as required for type of installation and in accordance with the wallboard manufacturer's written instructions. Furring members shall be installed plumb and true, shimmed to a plane surface, and spaced as indicated. Plane surface shall vary less than 1/8 inch in 8 feet.

2. Metal wall furring channels shall be installed vertically with horizontal spacing of not over 16 inches on center and shall be securely anchored to walls with suitable fasteners spaced 24 inches on center. Fasteners shall penetrate alternate wing flanges (staggered) of the furring channel. Metal wall furring channels shall also be placed horizontally at floors and ceilings; at heads of door frames; over and under wall louvers, access panels, and other opening in the walls, and shall be securely anchored as specified above.

Z. Surface Finishing

1. Surface defects and damage shall be corrected to leave wallboard smooth, uniform in appearance, and ready to receive finish as specified in other sections of these specifications.

2. All control joints shall be properly and completely filled with the specified sealant.

3. Joints shall be sanded when dry after each application of joint compound. Final finish shall be uniformly smooth and flush with the paper face of the wallboard.

4. Surfaces of the work, and adjacent surfaces soiled as a result of this work shall be cleaned.

END OF SECTION

SECTION 09265

PORTLAND CEMENT BACKING BOARD

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

ASTM C 473	(1987a) Physical Testing of Gypsum Board Products and Gypsum Lath
ASTM C 947	(1989) Standard Test Method for Flexural Properties of Thin-Section Glass-Fiber-Reinforced Concrete
ASTM C 948	(1986) Test Method for Dry and Wet Bulk Density, Water Absorption and Apparent Porosity of Thin Sections of Glass-Fiber-Reinforced Concrete
ASTM D 2394	(1993) Standard Methods for Simulated Service Testing of Wood and Wood-Base Finish Flooring
ASTM E 84	(1991a) Standard Test Method for Surface Burning Characteristics of Building Materials

1.2 SUBMITTALS:

A. Product Data: Submit covering each type of installations, including finish accessories, sealing, and manufacturer's written installation instructions with copies of code approvals for each type of system.

1.3 JOB CONDITIONS: Make a detailed inspection of areas and surfaces to be enclosed or covered by Portland cement backing board and arrange for correction of defective workmanship or materials. Ascertain that other work enclosed by backing board has been inspected and approved before starting installation; otherwise, uncover as directed at no additional contract cost.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Reinforced portland cement board: Standard manufacturer, equivalent to "Wonderboard" by Custom Building Products, "Durock" by USG, or "Latapanel Mfr-100" by Laticrete. Where used with ceramic tile, product shall be approved for quality as backer board by the Ceramic Tile Institute. The material shall conform to the following:

Physical property, units	Test Method	Acceptable value
Flexural strength, psi	ASTM C947	750
Water absorption, percent maximum by weight	ASTM C948	10
Compressive strength, psi (1" diameter disk)	ASTM D2394	1,400
Nail pull resistance, pounds	ASTM C473	125
Weight, pounds per square foot @ 1/2" thickness	ASTM C473	3
Surface burning characteristic	ASTM E84	5.0

B. Fasteners:

1. Screws for reinforced portland cement backer board framing up to 20 gauge: 1-1/4" bugle head with high-low threads and type "S" point. Screws shall be stainless steel for use on building exterior and shall have non-corrosive finish for interior use.

2. Screws for metal framing heavier than 20 gauge: 1-1/4" bugle head with S-12 point, with self embedding head specially designed for use with board. Fasteners shall be stainless steel for exterior, non-corrosive finish for interior.

C. Caulking Compound: Permanently non-hardening acoustical sealant supplied or recommended by wallboard manufacturer.

D. Moisture barrier: 6-mil polyethylene sheeting, or 15 pound asphalt saturated building felt.

PART 3 - EXECUTION

3.1 PREPARATION: Where portland cement backer board is used in wet areas, such as showers, apply one layer of moisture barrier over framing before wallboard is installed. Lap upper sheets over lower sheets not less than 3 inches. Attach sheets to framing sufficiently to hold in place until wallboard is installed.

3.2 INSTALLATION OF REINFORCED PORTLAND CEMENT BOARD: Use boards of maximum practicable sizes, and where necessary, cut to fit as directed by manufacturer. Apply boards horizontally, leaving a 1/8" to 3/16" gap between panels, and attach with specified screws. Fasteners shall be spaced not closer than 3/8" from edges of boards, or, if approved, screws with 3/4" washers may be placed in the joint formed by adjacent boards. Fill all horizontal and vertical joints solidly with mortar before taping. Apply fiberglass tape, embedded in a skim coat of mortar as recommended by manufacturer for use in wet areas.

3.3 CAULKING: Caulk between edges of board and other materials, including floors, exterior and interior walls, and at structure above, using sealants specified in Section 07920, forming a complete perimeter seal. Caulk around penetrations in same manner.

END OF SECTION

SECTION 09310

CERAMIC TILE

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A108.1	(1985) Installation of Grout in Ceramic Tile
ANSI A118.4	(1992) Latex-Portland Cement Mortar.
ANSI A137.1	(1988) Ceramic Tile

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 144	(1991) Standard Specification for Aggregate for Masonry Mortar
ASTM C 150	(1994) Standard Specification for Portland Cement
ASTM C 171	(1991) Standard Specification for Sheet Materials for Curing Concrete
ASTM C 241	(1990) Standard Specification for Abrasion Resistance of Stone Subjected to Foot Traffic
ASTM C 424	(1992) Standard Test Method for Crazing Resistance of Fired Glazed Whitewares by Autoclave Treatment
ASTM C 482	(1986) Standard Test Method for Bond Strength of Ceramic Tile to Portland Cement
ASTM C 485	(1988) Standard Test Method for Measuring Warpage of Ceramic Tile
ASTM C 499	(1989) Standard Test Method for Facial Dimensions and Thickness of Flat, Rectangular Ceramic Wall and Floor Tile
ASTM C 648	(1989) Standard Test Method for Breaking Strength of Ceramic Tile
ASTM D 2103	(1986) Standard Specification for Polyethylene Film and Sheeting

TILE COUNCIL OF AMERICA (TCA)

(1993) Handbook for Ceramic Tile Installation

1.2 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Manufacturer's Catalog Data shall be submitted for the following items:

Wall Tile
Ceramic Tile Trim
Ceramic Floor Tile
Mortar and Materials
Grout Materials

B. Certificates of Compliance shall be submitted for the following items showing conformance with the referenced standards contained in this section.

Wall Tile
Ceramic Tile Trim
Ceramic Floor Tile
Mortar and Materials
Grout Materials

C. Samples:

1. Manufacturer's Standard Color Charts shall be submitted for Ceramic Tile showing the manufacturer's recommended color and finish selections.

2. Three full-size samples of each type, color and pattern of Ceramic Tile.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Grout Materials: Grout for glazed wall and ceramic mosaic tile shall be a commercial portland cement grout mixture conforming to ANSI A108.1, with the addition of special latex grout additive.

B. Mortar: Latex Portland cement mortar conforming to ANSI A118.4.

2.2 COMPONENTS

A. Wall Tile:

1. Standard grade, matte-glazed units conforming to ANSI A137.1 shall be not less than 5/16-inch thick; cushion edge; with spacer lug construction. Wall tile shall have nominal face dimensions as follows:

4 1/4 by 4 1/4 inch
6 by 4 1/4 inch
6 by 6 inch

2. Wall tile characteristics (using procedures of ANSI A137.1):

a. Structural Defects: Standard Grade tile shall be inspected from a distance of 610 millimeter (2 feet) from the table to identify edge cracks. Small cracks parallel to the face must be less than 12.7 millimeter (1/2 inch).

b. Facial Defects: Testing framework shall consist of 80 pieces of 108 by 108 millimeter (4 1/4 by 4 1/4 inch) tile in ten vertical columns (40 pieces of 152 by 152 millimeter (6 by 6 inch). Inspector shall stand 915 millimeter (36 inch) away from the framework and follow the procedure as outlined in ANSI A137.1.

c. The range of major thickness in a sample lot shall not exceed 0.79 millimeter (0.031 inch) using ASTM C 499. Crazing Resistance shall be according to ASTM C 424 where 1034 kPa (150 psi) shall be used for one cycle. Average Bonding Strength shall be 345 kPa (50 psi) or greater, using ASTM C 482. Average Breaking Strength shall be 400 Newton (90 pounds force) or greater as per ASTM C 648.

B. Ceramic Floor Tile

1. Standard grade, unglazed, impervious porcelain-type ceramic mosaic tile shall conform to ANSI A137.1. Water absorption shall not exceed 0.5 percent. Tile shall be nominal 1/4-inch thick; cushion edge; factory mounted on sheets. *thickness*

2. Floor tile shall have nominal face dimensions as follows:

4 by 4 inch
6 by 6 inch
8 by 8 inch

3. Floor Tile Characteristics are outlined in ANSI A137.1 and are the same as wall tile except the range of major thickness in a sample lot shall not exceed 0.040 inch using ASTM C 499. Average breaking strength shall be 250 pounds force or greater as per ASTM C 648.

2.3 ACCESSORIES

A. Ceramic Tile Trim shall be of the same material as ceramic wall tile and shall conform to ANSI A137.1.

1. According to ASTM C 499, thickness shall be measured on flat portions 12.7 millimeter (1/2 inch) from the edges. Range of major thickness is not to exceed 0.79 millimeter (0.031 inch) for wall tile grim and 1.02 millimeter (0.040 inch) for floor tile trim. The average reported thickness shall be within 0.51 millimeter (0.02 inch) of the average reported wall or floor tile average thickness.

2. Warpage using ASTM C 485, shall be measured 9.5 millimeter (3/8 inch) from the edge. Crazing Resistance shall be per ASTM C 424 using 1034 kPa (150 psi) for one cycle. Bonding strength shall be equal to or greater than 345 kPa (50 psi) using ASTM C 482.

3. Trim shapes shall be provided at external and internal corners; at head, jamb, and sills of openings; and as follows:

Base trim shall consist of sanitary cove units.

Trim at top of surface mounted tile wainscots shall be surface bull nose shapes.

External corner trim shall be cap shapes.

Internal corner trim shall be cap shapes of square corner, combination angle, and stretcher type.

2.4 MIXES

A. Latex-Portland Cement Mortar: shall conform to ANSI A118.4, except factory inclusion of aggregate is not required.

PART 3 - EXECUTION

3.1 PREPARATION

A. Before commencing work, field pattern and border line locations shall be established and the work shall be centered symmetrically so that no tile need be cut to less than half size. Joints in wall tile shall be aligned vertically and horizontally; staggered joints will not be accepted.

B. Protection: Tile and areas to receive tile shall be maintained at a minimum temperature of 60 degrees F for not less than 2 days before starting work and not less than 3 days after completion.

C. Covering Tile Floors: Tile floors shall be covered, after grouting and cleaning, with kraft paper or polyethylene-curing covers conforming to ASTM C 171. Adjoining sheets shall be side-lapped not less than 6 inches. End laps shall be not less than 12 inches. Cement or tape joints to form a continuous membrane. Floor covers shall be maintained in good condition.

3.2 INSTALLATION: Installation and workmanship shall be in accordance with TCA Handbook, Method F113 for floors, and W243 for walls. Use latex Portland cement morter. Printed instructions of manufacturers of commercial mortars and grouts shall be followed.

3.3 FIELD QUALITY CONTROL

A. Tests: Finished tile installation shall display no uneven surfaces or high or low spots in excess of 1/8 inch in 8 feet when measured with an 8-foot straightedge in any direction. Tile floors pitched to a floor drain shall be measured at any point along an 8-foot radius from the floor drain.

3.4 SCHEDULES

A. Repairing: Damaged and unacceptable portions of completed work shall be removed and replaced with new work to match adjacent surfaces at no additional cost to the Government.

B. Cleaning: Upon completion of setting and grouting, tile shall be sponged and washed thoroughly and polished with clean, dry cloths. Surfaces of the work, and adjacent surfaces soiled as a result of this work, shall be cleaned. Equipment, surplus materials, and rubbish from the work shall be removed from the site.

END OF SECTION

SECTION 09514

ACOUSTIC CEILINGS, EXPOSED GRID

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B18.6.3	(1972; R 1991) Machine Screws and Machine Screw Nuts
ASME B18.6.4	(1981) Thread Forming and Thread Cutting, Tapping Screws and Metallic Drive Screws

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 366	(1991) Standard Specification for Steel, Sheet, Carbon, Cold-Rolled, Commercial Quality
ASTM A 591	(1989) Steel Sheet, Electrolytic Zinc-Coated, for Light Coating Mass Applications
ASTM B 633	(1985) Electrodeposited Coatings of Zinc on Iron and Steel
ASTM C 423	(1990a) Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method
ASTM C 635	(1991) Standard Specification for the Manufacture, Performance and Testing of Metal Suspension Systems for Acoustical Tile and Lay-In Panel Ceilings
ASTM C 636	(1992) Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels
ASTM D 1593	(1989) Nonrigid Vinyl Chloride Plastic Sheeting
ASTM E 1264	(1990) Standard Classification for Acoustical Ceiling Products
ASTM E 413	(1987) Rating Sound Insulation
ASTM E 90	(1990) Standard Test Method for Laboratory Measurement of Airborne-Sound Transmission Loss of Building Partitions

UNDERWRITERS LABORATORIES (UL)

UL-02	(1992) Building Materials Directory

1.2 PERFORMANCE REQUIREMENTS

A. Noise Reduction Coefficient Grade: Noise reduction coefficient (NRC) grade of acoustic ceilings shall be tested or certified by an approved testing laboratory in accordance with ASTM C 423, and shall be as follows:

MOUNTING TYPE	NRC GRADE
[No. 7	[0.70 to 0.80
	[0.65 to 0.75
	[0.60 to 0.70
	[0.55 to 0.65
	[0.50 to 0.60
	[0.45 to 0.55

B. Ceiling Sound-Transmission Classification: Sound Transmission Classification (STC) of the indicated acoustic ceilings shall be an 11-frequency test method conforming to ASTM E 90, and shall be as follows:

CONDITION AT PARTITIONS	CEILING STC
[Continuous	[25 to 29
	[30 to 34
	[35 to 39
	[40 to 44
	[45 to 49
[Interrupted	[25 to 29
	[30 to 34
	[35 to 39
	[40 to 44
	[45 to 49
[[____	[____

1.3 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Manufacturer's Catalog Data shall be submitted for the following items showing UL classification of fire-rated ceilings giving materials, construction details, types of floor and roof constructions to be protected, and UL design number and fire protection time rating for each required floor or roof construction and acoustic ceiling assembly.

Acoustic Materials
Suspension System Materials
Suspension Materials

B. Drawings:

1. Fabrication Drawings shall be submitted for Exposed Grid Acoustic Ceilings consisting of fabrication and assembly details to be performed in the factory.

2. Installation Drawings shall be submitted for Exposed Grid Acoustic Ceilings showing intermediate framing of hanger supports that fall between framing members; fastening of suspension system to top plate of nonbearing partitions; hanger fastenings at roof framing members and at main runners; acoustic unit support at ceiling fixtures; the splicing method for main and cross runners; positioning of splines; details of access acoustic tiles or panels; and the suspension system structural classification in accordance with ASTM C 635.

C. Instructions

1. Manufacturer's Instructions shall be submitted showing printed instructions covering installation of Acoustic Materials and Suspension Systems.

2. Preventive Maintenance and Inspection shall be submitted showing the acoustic material manufacturer's recommended cleaning and application methods.

3. Posted Instructions shall be submitted for Acoustic Ceiling Systems consisting of labels, signs, and templates of operating instructions that are required to be mounted or installed on or near the product for normal, safe operation.

D. Certificates of Compliance shall be submitted for the following showing conformance with the referenced standards contained in this section.

Acoustic Materials
Suspension System Materials
Suspension Materials

E. Samples: The following samples shall be submitted:

1. Acoustic Units: Three full-size samples of each type and pattern to illustrate the manufacturer's standard color and appearance range.

2. Suspension System Members: Three full-size samples of each type.

3. Anchorage Devices and Fasteners: Three full-size samples of each type.

4. After approval, samples may be used in the construction provided each sample is clearly identified and its location recorded.

1.4 DELIVERY, HANDLING, AND STORAGE: Materials shall be delivered and stored in their original, unopened packages bearing labels clearly identifying manufacturer's name, brand name, material, type or class, UL listing when applicable, and other pertinent data. Acoustic materials shall be stored in a weathertight and dry place, having a temperature not less than 65 degrees F and relative humidity not more than 70 percent, and for at least 24 hours prior to installation.

1.5 FIELD MEASUREMENTS: Field measurements shall be taken prior to preparation of drawings and fabrication, to ensure proper fitting of the work.

1.6 MAINTENANCE INSTRUCTIONS: The Contractor shall follow the acoustic material manufacturer's recommended cleaning and application methods, including precautions in the use of cleaning materials that may be detrimental to acoustic surfaces and the finish of exposed metal components.

PART 2 - PRODUCTS

2.1 FIRE-RATED CEILING SYSTEMS: Materials and methods used for fire-rated ceiling systems shall meet the minimum requirements of ASTM E 1264, ASTM C 635, ASTM C 636, and ASTM E 119.

2.2 ACOUSTIC MATERIALS

A. Acoustic Panels shall be types as listed below, sizes as indicated on the drawings, by not less than 5/8] inch thick, with square trimmed and butt edges. Patterns shall be as indicated.

1. Cellulose Fiber Units shall be prefabricated, cellulose composition type, not more than 25 flame spread index class and not less than 0.75 light-reflectance coefficient grade, conforming to ASTM E 1264. The finish of exposed-to-view surfaces of the units shall be a factory-applied, washable, white paint.

2. Mineral Fiber Acoustic Units shall be prefabricated, mineral-composition type, not more than 25 flame spread index class and 0.75 or more light reflectance coefficient grade, conforming to ASTM E 1264. Finish of exposed-to-view surfaces of the units shall be a factory-applied, washable, white paint.

3. Plastic Membrane-Faced Units shall be mineral-composition type, not more than 25 flame spread index class and not less than 0.75 light coefficient grade, conforming to ASTM E 1264. Plastic membrane shall be factory-applied, white, polyester-film material, not less than 0.0015 inch thick, conforming to ASTM D 2103 white, embossed-polyvinylchloride film material conforming to ASTM D 1593. Thickness tolerance shall be plus 0.0007 inch or minus 0.0003 inch.

2.3 SUSPENSION SYSTEM MATERIALS

A. Exposed, Direct Hung, Main Runners

1. Main runners shall be cold-formed bulb-tee sections, single- or double-web type, fabricated from specified steel sheets. Web height shall be not less than 1-1/2 inches, and the bottom flange width not less than 15/16 inch. Webs shall be drilled or grooved to receive cross runner end tabs and main runner splices.

2. The structural classification shall be intermediate duty in accordance with ASTM C 635. Steel sheets for single-web type shall be not less than 0.0209-inch thick. Steel sheets for double-web type shall be not less than 0.0179-inch thick.

3. Finish of the exposed-to-view surfaces shall be baked-on white enamel. Finish shall pass the high humidity test specified in ASTM C 635.

B. Wall Moldings shall be cold-formed angle sections, fabricated from specified steel sheets not less than 0.0209-inch thick.

1. Height of moldings shall be as required to accommodate the type of runners used. Where exposed main runners are used, the exposed leg width of moldings shall be the same as the flange width of the runners. Where bullnose masonry units are used for wall and partition construction, inside-and outside-corner caps shall be provided. Corner caps shall be one-piece, shop-fabricated units having a radius conforming to the bullnose and exposed face width the same as the exposed width of the adjoining wall molding. Corner caps shall extend at least 12 inches on each side of the corner, and shall be butt-joined to the adjacent wall molding with concealed fastenings.

2. Finish of exposed-to-view surfaces of moldings and corner caps shall be the same as the runners.

2.4 SUSPENSION MATERIALS

A. Hanger Wire shall be 12-gage galvanized, soft annealed, mild steel wire in accordance with ASTM C 636.

B. Machine Screws shall conform to ASME B18.6.3 zinc-coated carbon steel.

PART 3 - EXECUTION

3.1 ACOUSTIC MATERIAL: Acoustic material shall be installed in accordance with the manufacturer's recommendations and as indicated.

3.2 CONDITIONS AT BUILDING

A. Work above the ceiling line shall be completed, and approved, prior to the start of acoustic work.

B. Spaces to receive acoustic materials shall be maintained at 60 to 85 degrees F, and not more than 70 percent relative humidity for at least 48 hours prior to and during the installation of acoustic work, and until final acceptance.

C. Installation shall be per ASTM C 636, and as indicated.

3.3 ITEMS EMBEDDED IN OTHER CONSTRUCTION: Placement locations and installation instructions shall be provided for items embedded in other construction.

3.4 ARRANGEMENT OF ACOUSTIC CEILINGS:

A. Acoustic units shall be so arranged that units less than one-half width do not occur unless otherwise indicated or required to suit conditions. Ceilings shall be so arranged that either the tile joint or the tile centerline centers on ceiling fixtures.

B. Acoustic units shall be so arranged that joints are parallel with room axis in both directions, and straight and in alignment. Runners shall be so arranged that the main runners are parallel with the room axis indicated, and straight and in alignment.

3.5 PLACING SUSPENSION SYSTEM MEMBERS

A. Hanger wires shall be vertical and suspended from structural supporting members.

1. Wires shall be secured to the bottom chord of joists or structural members by wire-tying or by metal clips especially designed for the purpose.

2. Direct-hung suspension system members shall be supported by hangers spaced not more than 6 inches from each end, and not more than 48 inches on center between end hangers. Members shall be kept 1/2 inch away from walls or partitions. Hangers shall be attached to the members to prevent vertical movement or rotation of the member. Members shall be installed level within 1/8 inch in 12 feet. Leveling shall be performed with the hanger wires taut to prevent subsequent downward movement of the members when the ceiling loads are imposed. Kinks or bends shall not be made in the hanger wires as a means of leveling the members.

3. Abutting and intersecting runners shall be joined by approved methods. A joint connection shall provide the following alignment:

a. Exposed surfaces of two abutting main runners shall lie within a vertical distance of 1/64 inch of the same horizontal plane, and within a horizontal distance of 1/64 inch of the same vertical plane.

b. Exposed surfaces of two intersecting cross runners shall lie within a vertical distance of 1/64 inch of the same plane with the cross runner always above the main runner. There shall be no visually apparent angular displacement of the longitudinal axis of one runner with respect to the other runner.

c. The horizontal gap between the exposed surfaces of abutting or intersecting members shall not exceed 0.020 inch.

d. Wall moldings shall be installed so that the extended leg of angle moldings, or the bottom flange of channel moldings, lies in the same horizontal plane as that of the runners resting on the molding. Wall molding at inside corners shall be cut and bent to conform to the corner and at outside corners shall be neatly butted. Corner caps shall be provided where the corners are constructed of bullnose masonry units. Moldings shall be fastened to wall at not more than 3 inches from each end, and not more than 16 inches on center between the end fastener holes.

3.6 FRAMING OPENINGS FOR CEILING FIXTURES: Support members shall be provided at openings for ceiling fixtures and as indicated. Support members shall be of the size required to support the load without permitting deflection of the ceiling in excess of the performance requirements for the suspension system structural classification specified. Intermediate supports and separate hangers shall be provided if required.

3.7 ACOUSTIC LAY-IN-PANELS FOR EXPOSED-GRID CEILINGS:

A. Exposed, direct-hung main runners shall be arranged as indicated and spaced not more than 48 inches on center.

B. Where recessed lighting fixtures are indicated, exposed main runners shall be located parallel with the long dimension and on both sides of each fixture.

C. Exposed cross runners shall be spaced nominally 24 inches on center. When 24- by 24-inch lay-in panels are used, intermediate, exposed cross runners, 24 inches on center, shall be provided, installed parallel to the main runner, and intersecting the 48-inch long exposed cross runners at midpoint.

D. Moldings shall be installed at walls and other vertical surfaces, except where movable metal partitions having caps designed to receive suspension system members are indicated.

E. Lay-in panels shall be installed with edges resting on the flanges of the suspension system members and held in place with approved hold-down clips. Four holddown clips shall be provided for each acoustic lay-in panel. Clips shall be located approximately at the center of the sides and ends of each panel.

3.8 MARKING LOCATION OF MECHANICAL SYSTEM CONTROLS: Access units in acoustic ceilings that are located directly below mechanical system controls shall be marked with an identification plate. Plate shall be 0.032-inch thick aluminum, 3/4 inch in diameter, stamped with the letters "AP" finished the same as the acoustic material, and attached by an approved method near one corner on the face of each access unit.

END OF SECTION

SECTION 09650

RESILIENT FLOORING

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B 221	(1993) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes and Tubes
ASTM F 1066	(1987) Standard Specification for Vinyl Composition Floor Tile

FEDERAL SPECIFICATIONS (FS)

FS SS-T-312	(Rev B; Notice 1) Tile, Floor; Asphalt, Rubber, Vinyl, Vinyl-Asbestos
FS SS-W-40	(Rev A; Int Am 1, Notice 1) Wall Base:Rubber, and Vinyl Plastic

1.2 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Manufacturer's Catalog Data shall be submitted for the following items:

Vinyl Composite Tile
Base
Vinyl Reducer Strips
Vinyl Feature Strips
Substrate Primer/Sealer
Adhesives
Edge Strips

B. Instructions

1. Manufacturer's Instructions shall be submitted showing printed instructions covering installation of Resilient Flooring Systems.

2. Preventive Maintenance and Inspection shall be submitted showing the resilient flooring material manufacturer's recommended cleaning and application methods.

C. Samples

1. Manufacturer's Standard Color Charts shall be submitted for Resilient Flooring showing the manufacturer's recommended color and finish selections.

2. Following selection of colors, 2 full size samples of each selected color of floor tile and two 12" long samples of base shall be submitted.

1.3 DELIVERY, HANDLING, AND STORAGE:

A. Materials shall be delivered to the project site in their original packages or containers bearing labels clearly identifying the manufacturer, brand name, and quality or grade.

B. Materials shall be stored in their original unbroken packages or containers in the area in which they will be installed.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General Requirements: Resilient flooring, base, and edging strips shall be the manufacturer's standard color range.

B. Vinyl Composition Tile: Tile shall conform to ASTM F 1066, Composition I, 12 by 12 inches square, colors and patterns as selected. Thickness shall be 1/8 inch.

C. Base: Base shall be vinyl composition and the selected style conforming to FS SS-W-40. Base, exclusive of corners, shall be furnished in 12-foot lengths or rolls not less than 50 feet long. Each wing of corners shall be not less than 2 inches long.

D. Vinyl Reducer Strips shall conform to FS SS-T-312. Strips shall be 1-inch wide, in the lengths required to minimize joints, and 1/8-inch thick.

E. Vinyl Feature Strips shall conform to FS SS-T-312 and shall be 1/8-inch thick.

F. Substrate Primer/Sealer shall comply with the resilient flooring manufacturer's recommendations for the type and location of substrate and the end use of the area to be covered. Primer/sealer shall be nonstaining to the resilient flooring.

G. Adhesive: Emulsion adhesive shall be used with emulsion primer. Adhesive shall be nonstaining to the resilient flooring.

H. Edge Strips shall be extruded-aluminum alloy conforming to ASTM B 221, Temper F, 1/8-inch thick and 3/4-inch wide, butt type, and beveled on the exposed edge. Strips shall be installed in accordance with the manufacturer's recommendation.

I. Wax: Slip-resistant water-emulsion carnauba wax, and UL labeled.

PART 3 - EXECUTION

3.1 CONDITIONS AT BUILDING

A. Surfaces to receive stair-tread materials shall be maintained at an ambient temperature of at least 70 degrees F for at least 48 hours prior to, during, and for 48 hours after completion of the stair-tread installation.

B. Specified materials shall be installed only when normal temperature and humidity conditions approximate the interior conditions of the building that will exist when occupied.

C. Installation of the resilient flooring shall be deferred until other work that might cause damage to flooring has been completed.

3.2 PREPARATION OF SUBSTRATE SURFACES

A. Surfaces to receive specified materials shall be clean, smooth, cured, and free from materials detrimental to achieving the required bond.

B. Concrete substrate surfaces shall be coated completely with a primer/sealer in accordance with the resilient-material manufacturer's recommendations.

3.3 APPLICATION OF FLOORING AND BASE: Conform to the flooring manufacturer's recommended moisture testing and installation procedures and requirements herein. Provide flooring in cabinets and casework without bottoms and in closets in same room.

A. Preparation: Clean substrates of all deleterious substances and foreign matter. Fill all cracks or depressions with latex leveling compound of the type recommended by flooring manufacturer for the specific job conditions. Prior to laying flooring, test concrete for adequate dryness using the testing procedure conforming to flooring manufacturer's directions. Prime concrete floor slabs on grade; prime other slabs if so recommended by flooring manufacturer.

B. Vinyl Composition Tile Installation: Mix sufficient quantity of tiles to complete each area before laying to avoid color variations. Install flooring with tight joints, pattern direction as approved. Lay flooring square with axis of rooms, starting on center lines with tile joint or tile center so that border tiles are not less than 4" wide, accurately aligned. Install reducer strips at exposed edges of flooring and where shown. Cut flooring mechanically to produce square true edges. Closely trim to pipes, jambs, outlets, and like conditions.

C. Base Installation: Securely cement to backing in long lengths, minimum 18" long filler pieces, top and toe continuously contacting wall and floor, all joints tight. Provide factory-made internal and external corners, and end stops where cove base ends at jambs and offsets.

3.4 APPLICATION OF VINYL STRIPS:

A. Vinyl reducer strips shall be applied in conjunction with the specified flooring materials where required. Reducer strips shall be tightly butted to the resilient flooring with the fewest possible seams, in accordance with the manufacturer's instructions.

B. Vinyl feature strips shall be applied in conjunction with the flooring materials and patterns. Feature strips shall be tightly butted to the resilient flooring with the fewest possible seams, as approved by the manufacturer.

3.5 APPLICATION OF EDGE STRIPS: Edge strips shall be installed at exposed edges of resilient flooring and where thresholds are not required. Top surface shall be flush with resilient flooring. Strips shall be secured to the subfloor as recommended by the manufacturer.

3.6 CLEANING, WAXING, AND COMPLETION: Keep flooring and base surfaces clean as installation progresses. Clean flooring and base when sufficiently seated and remove foreign substances. Immediately prior to acceptance of building, apply at least 2 coats of wax on resilient tile flooring in accordance with wax manufacturer's instructions, each coat machine buffed. Clean adjacent surfaces of adhesive or other defacement. Replace all damaged or defective work to the original specified and acceptable condition.

3.8 ACCEPTANCE PROVISIONS

A. Rejection: Floor surfaces will be rejected when colors or patterns do not match the color or pattern of approved samples.

B. Repairing: Damaged and unacceptable portions of the completed work shall be removed and replaced with new work to match adjacent surfaces at no additional cost to the Government.

C. Cleaning: Surfaces of the work, and adjacent surfaces soiled as a result of the work, shall be cleaned. Equipment, surplus materials, and rubbish from the work shall be removed from the site.

3.9 EXTRA MATERIAL: Upon completion of the vinyl composition tile flooring installation, spare tiles of each type, color, and pattern from the same lot as those installed shall be furnished at the rate of five tiles for each 1,000 tiles or fraction thereof installed, and 250 lineal feet of base.

END OF SECTION

SECTION 09680

CARPET

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

CARPET AND RUG INSTITUTE (CRI)

CRI 104	(1991) Installation of Commercial Textile Floorcovering Materials

FEDERAL SPECIFICATIONS (FS)

FS SS-W-40	(Rev A; Int Am 1, Notice 1) Wall Base: Rubber, and Vinyl Plastic

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 253	(1990) Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source
NFPA 258	(1989) Standard Research Test Method foror Determining Smoke Generation of Solid Materials

1.2 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Manufacturer's Catalog Data shall be submitted for the following items:

Carpet
Carpet Moldings
Base

B. Drawings: Installation Drawings shall be submitted for the following items diagramming the location of seams, edge moldings, and carpet direction for approval prior to installation.

Carpet
Carpet Moldings
Base

C. Instructions: Manufacturer's Instructions shall be submitted showing printed instructions covering installation of Carpet.

D. Certificates of Compliance shall be submitted for following showing conformance with the referenced standards contained in this section.

Carpet
Carpet Moldings
Base

E. Samples: The following samples shall be submitted:

Samples of Seam Tape, Edge Molding, adhesive, and any other accessories to be used.

Three samples, each 4 inches square, of each type of Carpet to be used.

A sample of each Accessory.

PART 2 - PRODUCTS

2.1 CARPET TYPE AND CONSTRUCTION:

A. The following specifies the construction for [modular] [broadloom] carpet.

1. Type shall be [tufted] [woven] [fusion bonded] [_____]
2. Finished pile height shall be [_____]
3. Gage
4. Stitches per inch \^millimeter^\ shall be [_____]
5. Face weight shall be [_____]
6. Backing: Primary shall be [_____] Secondary shall be [_____]
7. Dye method shall be [_____]
8. Total weight shall be [_____]
9. Weight density factor shall be [_____]

B. Flammability

1. Radiant panel test shall be Class I, 0.45 watt/cm2 or greater in accordance with NFPA 253.

2. Smoke density shall be 450 or less in accordance with NFPA 258.

C. Color and pattern shall be chosen from the manufacturer's catalog data.

2.2 CARPET MOLDINGS: Carpet moldings, either vinyl or aluminum, shall be installed where floor covering material changes or carpet edge does not abut a vertical surface.

2.3 BASE: Base shall be vinyl conforming to FS SS-W-40. Minimum overall thickness of base shall be not less than 0.125 inch, color as selected from manufacturer's full line. Straight style, 4 inches high. Base shall be furnished in rolls not less than 96 feet long. Corners shall be premolded with wings not less than 2 inches long.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Carpeting shall be installed in accordance with CRI 104 and the carpet manufacturer's instructions.

B. Type of installation required for this project is Direct Glue Down. Contiguous carpeting shall be a product of the same dye lot. Corrections in measurements made by the Contractor shall be at no additional cost to the Government.

C. Transportation of carpet within the jobsite shall be the responsibility of the Contractor.

3.2 PREPARATORY WORK: Contractor shall verify that surfaces to receive carpet are thoroughly clean, dry, dust-free, and in a satisfactory condition to be carpeted. Contractor shall notify the Government in writing of any conditions that will prevent the production of unsatisfactory work. Start of carpet installation shall be an indication of acceptance of the surfaces as being satisfactory for installing carpeting and he shall automatically assume the responsibility for any unacceptable finish work caused by floor conditions.

3.3 ACCEPTANCE PROVISIONS: Contractor shall be fully responsible for the installation upon completing of each area. Installation will be inspected and approved by the Contracting Officer prior to acceptance. Damaged and unacceptable portions of completed work shall be removed and replaced with new carpeting.

3.4 CLEANING Surfaces of new carpeting and adjacent surfaces soiled as a result of this work shall be cleaned thoroughly. Equipment, surplus materials, and rubbish from work shall be removed from the site.

END OF SECTION

SECTION 09900

PAINTING

PART 1 - GENERAL

1.1 COMPLIANCE WITH REGULATIONS: All materials shall comply with the current rules and regulations of the local air quality management district, with the rules regarding volatile organic compounds, and with FDA rules and regulations for dangerous materials in paint.

1.2 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. List of Paint Materials: Prior to submittal of samples, submit a complete list of proposed paint materials, identifying each material by manufacturer's name, product name and number, including primers, thinners, and coloring agents, together with manufacturers' catalog data fully describing each material as to contents, recommended usage, and preparation and application methods. Identify surfaces to receive various paint materials. Do not deviate from approved list.

B. Color Samples: Prior to preparing samples, obtain color and gloss selections and instructions. Using materials from approved list, prepare and submit 8-1/2" by 11" samples of each complete opaque paint finish.

C. Natural or Stain Finish Samples: Prepare samples on 12" squares of the same species and appearance of wood as used in the work.

D. Certificates:

1. Submit certificate showing that all products meet the requirements of paragraph "Compliance with Regulations" above.

2. Certificates of Compliance shall be submitted for Paint Materials showing conformance with the referenced standards contained in this section.

1.3 JOB CONDITIONS.

A. Protection: Protect all painting while in progress and cover and protect adjoining surfaces and property of others from damage. Exercise care to prevent paint from contacting surfaces not to be painted. During painting of exterior work, cover windows, doors, concrete, and other surfaces not to be painted.

B. Examination of Surfaces: Examine surfaces to be painted or finished under this Section and verify satisfactory condition. Unsatisfactory conditions shall be corrected before application of the first coat of paint.

C. Weather Conditions: Apply paint to clean, dry, prepared surfaces. Do not apply exterior paint during rainy, damp, foggy, or excessively hot and/or windy weather. Arrange for temporary heat and ventilation for interior painting.

D. Precaution: Place oily rags and waste in self-closing metal containers, removed from site at the end of each day. Do not let rags and waste accumulate.

1.4 EXTRA STOCK

A. Provide a one gallon container of each paint color and surface texture to Owner at Acceptance.

B. Label each container with color, texture, and original application locations, in addition to the manufacturer's label.

PART 2 - PRODUCTS

2.1 MATERIALS: Use the paint products of only one paint manufacturer unless otherwise specified or approved. In any case, primers, intermediate, and finish coats in each painting system must all be the products of the same manufacturer, including thinners and coloring agents, except for materials furnished with shop prime coat by other trades. To the maximum extent feasible, factory mix paint materials to correct color, gloss, and consistency for application. Furnish paints from one of the following manufacturers:

Benjamin Moore
Pittsburgh
Sherwin-Williams

A. Specific paint and minimum number of coats shall be as indicated on Tables I through V at the end of this section.

B. Special finishes specified hereinafter shall be products of one of the named manufacturers in each case.

PART 3 - EXECUTION

3.1 WORKMANSHIP: Apply painting materials in accordance with manufacturer's instructions by brush or roller; spray painting is not allowed without specific approval in each case. Apply each coat at the proper consistency, free of brush or roller marks, sags, runs, or other evidence of poor workmanship. Do not lap paint on glass, hardware, and other surfaces not to be painted; apply masking as required. Sand between enamel coats.

3.2 PREPARATION: Properly prepare surfaces to receive finishes.

A. Concrete: Fill cracks, holes, and other blemishes with portland cement patching plaster or a stiff paste mixed of finish paint and fine sand, finished to match adjoining surfaces. Remove glaze by sanding, wire brushing, or light brush-off sandblasting. Neutralize all alkali conditions according to the paint manufacturer's directions. Dry surfaces to receive breathing type latex paints at least two weeks, free of visible moisture. Dry the surfaces to receive oil, alkyd, or epoxy based paint until the moisture content does not exceed 8% when tested with an electronic moisture-measuring instrument.

1. Precast Concrete Sections: Poured concrete must be allowed to cure for 60-90 days. Remove laitance, form release oils, bond breakers, and other surface films which may inhibit paint adherence by washing, or other approved method. All cracks, voids, honeycombs, dimples, etc., shall be sacked and sanded smooth prior to cleaning operations.

B. Exterior Plaster: Fill hairline cracks with portland cement patching material; report larger cracks for correction. Test and ensure plaster is sufficiently dry to receive the paint finish.

C. Gypsum Wallboard: Touch-up minor defects with spackle and sand smooth and flush. Report other defects as specified. Verify that skim coat specified in Section 09250 is properly applied. If not, apply one coat of heavy bodied primer over entire surface by brush or roller.

D. Shop Coated Metal: Degrease and clean of foreign matter. Clean and spot paint field connections, welds, soldered joints, burned, or abraded portions with same material used in shop coats. After complete hardening, sand entire surfaces for coat to follow.

E. Uncoated Ferrous Metal: Degrease and clean of dirt, rust, mill scale, and all other foreign matter using a combination of rotary brushes, solvent, or sandblasting to achieve a clean surface consistent with SSPC-SP3. Remove pits and welding slag, and clean surfaces to bright metal before priming. Apply metal primer not more than three hours after preparation.

F. Galvanized Metal: Degrease and clean of foreign matter. Apply specified pretreatment and immediately apply primer paint.

G. Metal to receive High Performance Coatings: Provide SSPC-SP 6-63 (NACE No. 3), Commercial Blast Cleaning. All oil, grease, dirt, rust scale and foreign matter shall be removed, and all rust, mill scale, and old paint shall be removed except for slight shadows, streaks or discolorations.

H. Enameled Woodwork: Remove handling marks and effects of exposure to moisture with a thorough sanding over all surfaces of the exposed portions, using at least 150 grit or finer sandpaper and thoroughly clean all surfaces before applying sealer. After priming, putty nail holes, cracks, or other defects with putty matching color of finish paint. Cover knots and sappy areas with shellac or approved knot sealer. Sand each base coat smooth when dry.

I. Transparent Finished Woodwork: Remove handling marks and effects of exposure to moisture with a thorough sanding parallel to the grain of the wood, over all surfaces of the exposed portions, including interiors of cases and drawers, using at least 150 grit or finer sandpaper and thoroughly clean all surfaces before applying sealer. Repair all defects with filler tinted to match stain or wood color, as required, after first coat of sanding sealer and remove all smears.

J. Doors, Wood, and Steel: Seal top and bottom edges after cleaning with coat of primer in addition to scheduled coats.

K. Fixtures, Equipment, and Hardware Items: Coordinate with the work of other sections, and coordinate removal of fixtures, equipment, and hardware as required to perform painting. Items to be removed include, without limitation: signs and graphics; switch and receptacle plates; escutcheons and plates; all surface-mounted equipment; free-standing equipment blocking access; grilles and louvers at ducts opening into finished spaces; and other items as required and directed.

L. Surfaces Not Mentioned: Prepare surfaces according to recommendations of the paint manufacturer and as approved.

M. Moisture Content: Measure moisture at surfaces using an electronic moisture meter. Do not apply finishes unless moisture is below the following maximums:

1. Exterior Plaster and Concrete: 15 percent
2. Interior Plaster and Gypsum Wallboard: 12 percent
3. Interior Wood: 15 percent measured in accordance with ASTM D2016

3.3 COATS: The number of paint coats specified to be applied are minimum. Apply additional coats if required to obtain complete coverage and approved results. Ensure acceptable paint finishes of uniform color, free from cloudy or mottled areas and evident thinness on arrises. "Spot" or undercoat surfaces as necessary to produce such results. Tint each coat a slightly different shade of finish color to permit identification. Conform to the approved Samples. Obtain approval of each coat before applying next coat; otherwise, apply an additional coat over entire surface involved at no additional contract cost.

3.4 COLORS: The numbers given in the following schedule indicate the types of paints required for each surface, identified by their number in white. The actual paint to be applied on each surface shall be the same material in the color or colors as selected, and as approved on submitted samples. Allow for the use of several colors in each room or space, and for doors, frames, dadoes, trim and other items to be finished in different colors.

3.5 DEGREE OF GLOSS: Degrees of gloss shown on drawings and herein specified are approximate only. The exact degree of gloss required for each surface will be determined. Materials shall meet the following requirements for degree of gloss, when tested according to ASTM D523, using Gardner Laboratory 60 degree gloss meter after 14 days.

NOMENCLATURE	PERCENTAGE OF GLOSS
Flat	Less than 25
Suede or eggshell	25 - 55
Semi-gloss	55 - 70
Gloss or high gloss	More than 70

3.6 MISCELLANEOUS PAINTING:

A. Duct Interiors: Paint with flat black fire-retardant paint to the extent visible through grilles and registers in finished rooms and spaces.

B. Fire Extinguisher and Fire Hose Cabinets: Apply 2 coats of paint finish, inside and out, matching finish and color of adjoining areas, unless otherwise noted or directed.

C. Color Coding. In mechanical and electrical equipment rooms and spaces, paint all ducts, piping, conduit, equipment, and machinery, except such items having a complete factory finish, as specified for interior metal, colors as directed. Not more than 8 colors will be required.

D. Weatherstripping or Sound Seals. Paint exposed metal surfaces to match the door frame, whether or not unfinished, furnished with factory prime coat, or factory treated for paint adhesion.

E. Doors: Coat tops, bottoms, and edges with all coats as scheduled for faces. Coat cutouts for hinges, edges of lockset holes and strikes same as for first coat.

F. Access doors, panels, registers, and grilles: Generally, paint same color as surrounding walls and ceiling. Paint interiors of ducts showing through registers and grilles black.

G. Door Trim and Prime Coated Hinges: Paint trim to match door and paint hinges to match frame.

H. Rooftop HVAC and Airhandler Units: Field paint specified color. See Schedule.

I. Speaker Grilles: Paint to match surrounding surfaces.

J. Miscellaneous. For any items not specifically indicated or specified that require a paint finish, apply 3 coats of paint as directed.

3.7 CLEANING AND TOUCH-UP WORK. Make a detailed inspection of paint finishes after all painting is completed, remove spatterings of paint from the adjoining surfaces, and make good all damage that may be caused by cleaning operations. Carefully touch-up all abraded, stained, or otherwise disfigured painting, as approved, and leave entire painting in first-class condition.

TABLE I
HIGH PERFORMANC INDUSTRIAL COATINGS FOR METAL

SURFACE, COATS	AMERON	PORTER	CARBOLINE
Ferrous metal, shop primed, urethane finish One coat (5.0 mil DFT)	Amercoat 450HS gloss, or Amercoat 455 semigloss	Hythane 8731 semigloss, or Hythane 4610 gloss	D834 semigloss, or 132 gloss
Ferrous metal, unprimed, prepare per SSPC-6 First coat, 3 mils DFT Second coat, 3 mils DFT	Amercoat 385 Amercoat 450HS gloss, or Amercoat 455 semigloss	315R Zinc Lock Hythane 8731 semigloss, or Hythane 4610 gloss	D858 epoxy primer D834 semigloss, or 132 gloss

TABLE I
HIGH PERFORMANC INDUSTRIAL COATINGS FOR METAL

SURFACE, COATS	AMERON	PORTER	CARBOLINE
Ferrous metal, unprimed, w/o SSPC6 prep. First coat, 3 mils DFT Second coat, 3 mils DFT	Amerlock 400 Amercoat 450HS gloss, or Amercoat 455 semigloss	MCR 43, 4300 epoxy Hythane 8731 semigloss, or Hythane 4610 gloss	188 epoxy primer D834 semigloss, or 132 gloss
Ferrous or galvanized steel, aluminum, prepare per SSPC-6 One coat, 5 mils dft.	PSX 700 Siloxane		
Galvanized & aluminum First coat, 4 mils DFT Second coat, 3 mils DFT	Amerlock 400 Amercoat 450 gloss, or Amercoat 455 semigloss	MCR 43, 4361 epoxy Hythane 8731 semigloss, or Hythane 4610 gloss	190 HP epoxy D834 semigloss, or 132 gloss

TABLE Ii
EXTERIOR PAINTING SCHEDULE

SURFACE, COATS	BENJAMIN MOORE	PITTSBURGH	SHERWIN-WILLIAMS
Exterior concrete First coat Second coat	077 105	6-8 Sun-Proof 72 Flat	A5-V2 Super Paint Flat
Ferrous Metal First coat Second coat Third coat	Ironclad 162 Impervo 133 Impervo 133	6-208 Primer 54 Q.D. Enamel 54 Q.D. Enamel	B50N2 Primer B54 Enamel B54 Enamel
Galvanized Metal Pretreat First coat Second coat Third coat	Solvent wash Ironclad 162 Ironclad 133 Ironclad 133	Solvent wash 6-712 Primer 54 Q.D. Enamel 54 Q.D. Enamel	Solvent wash Galvite B54 Enamel B54 Enamel

TABLE III INTERIOR ENAMEL MATERIALS			
SURFACE, COATS	BENJAMIN MOORE	PITTSBURGH	SHERWIN-WILLIAMS
Enamel Finish, Gloss Alkyd	Impervo 133	6-252 Alkyd Gloss	ProMar 200 Alkyd Gloss
Enamel Finish, Semi-Gloss, Alkyd	Alkyd Dulamel 207	22 Line Semi-Gloss	ProMar 200 Alkyd Semi-Gloss
Enamel Finish, Eggshell	Regal 319	89 Line Eggshell	Classic 99 Eggshell

TABLE IV INTERIOR PAINTING SCHEDULE			
SURFACE, COATS			
Gypsum board, flat finish First coat Second coat	 215 Regal Flat 215 Regal Flat	 80 Wallhide 80 Wallhide	 Super Paint Flat Super Paint Flat
Concrete, flat finish First coat Second coat	 200 Alkyd Sealer 215 Regal Flat	 6-1 Alkyd Seal 80 Wallhide	 B42-W2 Primer Super Paint Flat
Gypsum board, enamel finish First coat Second coat Third coat	 201 Prime Seal Enamel finish Enamel finish	 6-2 Wall Sealer Enamel finish Enamel finish	 B28-W1 Primer Enamel finish Enamel finish
Ferrous metal First coat Second coat Third coat	 163 Ironclad Enamel Finish Enamel finish	 6-208 Rust Inhibitor Enamel finish Enamel finish	 B50-N2 KemKromik Enamel finish Enamel finish
Galvanized metal Pretreat First coat Second coat Third coat	 Solvent etch 162 Ironclad Enamel finish Enamel finish	 Solvent etch 6-712 Primer Enamel finish Enamel finish	 Solvent etch Galvite Enamel finish Enamel finish
Wood, transparent finish			
Wood, opaque finish, enamel			

END OF SECTION

SECTION 10160

METAL TOILET COMPARTMENTS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

ALUMINUM ASSOCIATION (AA)

AA DAF-45	(1980) Designation System for Aluminum Finishes

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 123	(1989a; E1) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 167	(1992) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A 336	(1989) Standard Specification for Steel Forgings, Alloy, for Pressure and High-Temperature Parts
ASTM A 385	(1980; R 1991) Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip)
ASTM A 525	(1991b) Standard Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
ASTM A 526	(1990) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Commercial Quality
ASTM B 221	(1993) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes and Tubes
ASTM B 36	(1991a) Brass Plate, Sheet, Strip, and Rolled Bar
ASTM B 456	(1991a) Standard Specification for Electrodeposited Coatings of Copper Plus Nickel Plus Chromium and Nickel Plus Chromium
ASTM B 86	(1988) Standard Specification for Zinc Base Alloy Die Castings
ASTM D 2092	(1986) Standard Practice for Preparation of Zinc-Coated Galvanized Steel Surfaces for Painting

FEDERAL SPECIFICATIONS (FS)

FS FF-B-588	(Rev D) Bolt, Toggle; and Expansion Sleeve, Screw

FS FF-S-325	(Int Amd 3) Shield, Expansion; Nail, Expansion; and Nail, Drive Screw (Devices, Anchoring, Masonry)
FS QQ-C-320	(Rev B; Am 4) Chromium Plating (Electrodeposited)

1.2 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Manufacturer's Catalog Data shall be submitted for the following items:

Galvanized Steel Sheet
Sound Deadening Cores
Partition Panels and Doors
Anchoring Devices and Fasteners
Hardware and Fittings
Brackets
Door Hardware
Overhead-Braced Partitions

B. Drawings

1. Fabrication Drawings shall be submitted for Metal Toilet Partitions and Urinal Screens consisting of fabrication and assembly details to be performed in the factory.

2. Installation Drawings shall be submitted for Metal Toilet Partitions and Urinal Screens in accordance with the paragraph entitled, "Installation," of this section. Drawings shall indicate the type of partition, location, mounting height, cutouts, and reinforcement required for toilet-room accessories.

C. Certificates: Certification that metal toilet partitions will be free of defects in materials, fabrication, finish, and installation and will remain so for a period of not less than 3 years after completion.

D. Samples:

1. Three samples of a Panel showing a finished edge on two adjacent sides and core construction, each not less than 12-inches square

2. Three of each item of Hardware, Fittings, and Fasteners

3. Approved hardware samples may be installed in the work if properly identified.

1.3 DELIVERY, HANDLING, AND STORAGE: Materials shall be protected from weather, soil, and damage during delivery, storage, and construction. Materials shall be delivered in the original, unopened packages or containers bearing the brand name and the name of the material.

1.4 FIELD MEASUREMENTS: Field measurements shall be taken prior to the preparation of drawing and fabrication to ensure proper fits.

PART 2 - PRODUCTS

2.1 GALVANIZED STEEL SHEET: Galvanized steel sheet shall be cold-rolled, stretcher-level, commercial quality material conforming to ASTM A 526 with zinc coating conforming to

ASTM A 525, G90. Surface preparation of material for painting shall conform to ASTM D 2092, Method A.

2.2 SOUND-DEADENING CORES: Sound deadening shall consist of treated kraft paper honeycomb cores with a cell size of not more than 1 inch. Resin-material content shall weigh not less than 11 percent of the finished core weight. Expanded cores shall be faced on both sides with kraft paper.

2.3 PARTITION PANELS AND DOORS: Partition panels and doors shall be not less than 1 inch thick with face sheets not less than 0.0396 inch thick.

2.4 PARTITION FABRICATION: Partition panels, doors, screens, and pilasters required for the project shall be fabricated from galvanized-steel face sheets with formed edges. Face sheets shall be pressure-laminated to the sound-deadening core with edges sealed with a continuous locking strip and corners mitered and welded. Welds shall be ground smooth. Concealed reinforcement shall be provided for installation of hardware, fittings, and accessories. Surface of face sheets shall be smooth and free from wave, warp, or buckle.

2.5 PREPARATION: Before application of an enamel coating system, galvanized-steel surfaces shall be solvent-cleaned to remove processing compounds, oils, and other contaminants harmful to coating-system adhesion. After cleaning, the surfaces shall be coated with a metal-pretreatment phosphate coating. After pretreatment, exposed galvanized-steel surfaces shall be finished with a baked-enamel coating system as specified.

2.6 ENAMEL COATING SYSTEM: Enamel coating system shall consist of a factory-applied baked acrylic enamel coating system. Coating system shall be a durable, washable, stain-resistant, mar-resistant finish.

2.7 ANCHORING DEVICES AND FASTENERS: Steel anchoring devices and fasteners shall be hot-dipped galvanized after fabrication in conformance with ASTM A 385 and ASTM A 123. Galvanized anchoring devices shall be concealed. Toggle bolts shall conform to FS FF-B-588. Exposed fasteners shall have one-way heads.

2.8 HARDWARE AND FITTINGS

A. Materials:

1. Cold-rolled sheet steel shall conform to ASTM A 336/A 336M, commercial quality.
2. Zinc-base alloy shall conform to ASTM B 86, Alloy AC41-A.
3. Brass shall conform to ASTM B 36/B 36M, Alloy C26800.
4. Aluminum shall conform to ASTM B 221.
5. Corrosion-resistant steel shall conform to ASTM A 167, Type 302 or 304.

B. Finishes

1. Chrome plating shall conform to ASTM B 456.
2. Aluminum shall have a clear anodic coating conforming to AA DAF-45.
3. Corrosion-resistant steel shall have a No. 4 finish.

4. Exposed fasteners shall match the hardware and fittings.

2.9 BRACKETS: Wall brackets shall be two-ear panel brackets, T-style, 1-inch stock. Panel-to-pilaster brackets shall be stirrup style.

2.10 DOOR HARDWARE

A. Hinges shall be self-lubricating with the indicated swing. Hinges shall have gravity return movement. Hinge shall be adjustable to hold in-swinging doors open at any angle up to 90 degrees and outswinging doors to 10 degrees.

B. Latch and pull shall be a combination rubber-faced door strike and keeper equipped with emergency access.

C. Coat hooks shall be combination units with hooks and rubber tipped pins.

2.11 OVERHEAD-BRACED PARTITIONS: Pilasters shall be not less than 1-1/4 inches thick with face sheets not less than 0.0396 inch thick. Anchoring device at the bottom of the pilaster shall consist of a channel-shaped floor stirrup fabricated from not less than 0.0635-inch thick material and a leveling bolt. Stirrup shall be secured to the pilaster with not less than a 3/16-inch bolt and nut after the pilaster is leveled. Stirrup shall be secured to the floor with not less than two lead expansion shields and sheetmetal screws. Overhead brace shall be fabricated from a continuous extruded aluminum tube not less than 1 inch wide by 1-1/2 inches high, 0.125-inch wall thickness. Finish shall be AA-C22A31 in accordance with AA DAF-45. Brace shall be set and secured into the top of each pilaster. Trim piece at the floor shall be 3 inches high and fabricated from not less than 0.030-inch thick corrosion-resistant steel.

2.12 SCREENS: Urinal screens shall be fabricated from the same types of panels and pilasters as the toilet partitions. Fittings and fasteners shall be corrosion-resistant steel. Screens shall be wall hung with mounting brackets.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Partitions shall be installed rigid, straight, plumb, and level, with the panels centered between the fixtures. Contractor shall provide a panel clearance of not more than 1/2 inch and shall secure the panels to walls and pilasters with not less than two wall brackets attached near the top and bottom of the panel. Wall brackets shall be located so that holes for wall bolts occur in masonry or tile joints. Panels shall be secured to pilasters with brackets matching the wall brackets.

B. Panels shall be secured to ceramic tile on gypsum wallboard or plastered walls with toggle bolts using not less than 1/4-20 screws of the length required for the wall thickness. Toggle bolts shall have a load-carrying strength of not less than 600 pounds per anchor.

3.2 OVERHEAD-BRACED PARTITIONS:

A. Pilasters shall be secured to the floor with the anchorage device specified. Leveling device shall be readily accessible for leveling, plumbing, and tightening the installation. Overhead brace shall be secured to the pilaster face with not less than two fasteners per face. Expansion shields shall have a minimum 2-inch penetration into the concrete slab.

B. Tops of doors shall be parallel with the overhead brace when doors are in a closed position.

3.3 FINAL ADJUSTMENTS: After completion of the installation, the Contractor shall make final adjustments to the pilaster-leveling devices, door hardware, and other working parts of the partition assembly.

3.4 CLEANING: Surfaces of the work and adjacent surfaces soiled as a result of the work shall be cleaned in an approved manner. Equipment, surplus materials, and rubbish from the work shall be removed from the site.

END OF SECTION

SECTION 10271

ELEVATED FLOOR SYSTEM

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A208.1	(1979; R 1986) Mat-Formed Wood Particleboard

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 526	(1990) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Commercial Quality
ASTM B 85	(1984) Standard Specification for Aluminum-Alloy Die Casting

FEDERAL SPECIFICATIONS (FS)

FS DDD-C-001799	(Base) Carpet, Squares, Pile Surface, Tile Type, With or Without Attached Cushion
FS TT-C-490	(Rev C; Am 2) Cleaning Methods for Ferrous Surfaces and Pretreatments for Organic Coatings
FS TT-S-300	(Rev A) Shellac, Cut

MILITARY SPECIFICATIONS (MS)

MS MIL-C-22750	(Rev E; Am 1) Coating, Epoxy, VOC Compliant
MS MIL-P-23377	(Rev F) Primer Coatings: Epoxy, Chemical and Solvent Resistant

NATIONAL INSTITUTE FOR STANDARDS AND TECHNOLOGY (NIST)

NIST PS 1	(1983) Construction and Industrial Plywood

1.2 SYSTEM DESIGN: Elevated floor system shall consist of structural panels mounted on a grid system with adjustable pedestals to provide an underfloor space for accommodating electrical wiring and mechanical service lines. Lateral bracing of grid areas and equipment supports shall be as necessary.

1.3 PERFORMANCE REQUIREMENTS: The Contractor warrants that, upon notification by the Institute, they will immediately replace defective work with new work at no additional cost to the Institute.

A. Elevated Floor Panels shall be capable of supporting a uniform live load of a minimum 250 pounds per square foot with a deflection not to exceed 0.040 inch. Floor shall also be capable of supporting a minimum 1,000-pound load concentrated on 1 square inch at any point on the panel area without deflecting more than 0.080 inch with a safety factor of not less than 3 based on yield strength of the material being used. Floor system shall be laterally stable in all directions whether panels are in place or not. Finished assembly shall be rigid and free of vibration and rocking panels.

B. Pedestals: Each pedestal with components as assembled for the specified heights shall be capable of carrying a 5,000-pound axial load without permanent deformation.

C. Bonding Strength of Pedestal Adhesive: Adhesive for anchoring pedestal bases shall have a bonding strength capable of resisting an overturning moment of 1,000 inch-pounds when a force is applied to the top of the pedestal in any direction.

D. Stringers: shall provide seating for panels to preclude tilting, rocking, or vibrating when a live load is applied. Stringers shall be provided that can be added or removed after floor is in place. Each stringer shall support at least 650 pounds at mid-span without failure when tested. The yield strength of the material being used shall be at least 250 pounds at mid-span without failure when tested.

1.4 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Manufacturer's Catalog Data shall be submitted for the following items:

Floor Panels
Die-Formed Steel Panels
Finish Flooring
Registers and Grills
Cutouts
Stringers
Edge Strips
Pedestals

B. Drawings

1. Fabrication Drawings shall be submitted for Elevated Floor Systems consisting of fabrication and assembly details to be performed in the factory.

2. Installation Drawings shall be submitted for Elevated Floor Systems in accordance with the paragraph entitled, "Installation," of this section.

3. Location Drawings shall show location of pedestals, ventilation openings, cable cutouts, and the panel installation pattern.

4. Detail Drawings shall show details of the pedestals, pedestal-floor interlocks, floor panels, panel edging, floor openings, floor opening edging, floor registers, floor grilles, cable cutout treatment, perimeter base, expansion joints, and peripheral support facilities.

C. Certificates of Compliance shall be submitted for the following:

1. Load-bearing capabilities of pedestals, floor panels, and pedestal adhesive resisting force

2. Supporting independent laboratory test reports. For panel loads, test results shall include concentrated loads at center of panel, panel edge midpoint, and uniform loads.

3. Floor electrical characteristics.

4. Material requirements

5. Elevated floor system will be free of defects in materials, fabrication, finish, and installation and that it will remain so for a period of not less than 3 years after completion.

D. Samples

1. Three complete Floor Panels.

2. Three separate samples of the specified Finished Flooring.

3. Three complete Pedestal-Stringer Assemblies

4. Full-sized samples may be installed in the work when they are properly identified and approved.

1.5 DELIVERY, HANDLING, AND STORAGE: Materials shall be protected from weather, soil, and damage during delivery, storage, and construction. Materials shall be delivered in the original unopened packages, containers, or bundles bearing the brand name and the name of the material.

1.6 FIELD MEASUREMENTS: Field measurements shall be taken prior to the preparation of shop drawings and fabrication to ensure proper fits.

1.7 PEDESTAL LOAD TEST: A static axial load of 5,000 pounds shall be imposed on the pedestals. Should there be failure of any component of any pedestal, the remaining pedestals shall be so tested, and pedestals that have a component failure shall be replaced with pedestals that have withstood the 5,000-pound axial load test.

1.8 ELECTRICAL RESISTANCE: Electrical resistance between an individual stringer and pedestal shall be less than [100] [_____] microhms. Range of electrical resistance of the floor covering to ground shall be 0.5 to 20,000 megohms for humidity from 40 to 60 percent relative humidity. [A signal reference grid shall be provided as an equipotential surface for high frequency, low digital signals.]

PART 2 - PRODUCTS

2.1 FLOOR SYSTEM

A. Design and workmanship shall be such that the floor, as installed, shall be completely planar within plus or minus 0.060 inch in 10 feet, 0.100 inch for the entire floor, and 0.030 inch across panel joints.

B. Floor-panel joint-width tolerances shall be 0.008 inch as measured with a feeler gage at any point in any joint when the panels are in the pressure contact required in final installation.

C. System assembly shall be based upon an interference fit of connections.

2.2 PANELS: Panel design shall provide for convenient panel removal for underfloor servicing and for openings for new equipment. Design shall also provide necessary panel support where required openings entail cutting panels. Floor panels shall be machined square to within plus or minus 0.005 inch with edge straightness plus or minus 0.0025 inch. Tolerances shall apply to the panel before the plastic edging is applied. Panels may be any one of the following at the option of the Contractor.

A. Plywood Core Floor Panels: Floor panels shall be fabricated from plywood conforming to NIST PS 1 or particle board conforming to ANSI A208.1, structurally bonded to 24-gage (0.0276-inch) zinc-coated sheet steel on both top and bottom. Plywood or particle board shall be 1 inch thick and shall extend to the nominal panel dimension allowing a maximum void at panel edge of 0.125 inch. Sheet shall conform to the requirements of ASTM A 526/A 526M. Exposed edges of the panels shall be sealed with shellac conforming to FS TT-S-300.

B. Die-Formed Steel Panels: Floor panels shall be constructed of die-formed steel of physical properties and thickness to satisfy the load-bearing requirements of these specifications. A flat upper sheet, a die-formed lower sheet, and any auxiliary reinforcing shall be spot-welded into a rigid composite which shall withstand specified tests without failure of any weld. When the panels are to be grid-supported, panels shall be further tested by supporting them at two opposite edges and applying a 500-pound load at the center of a panel selected; the panel shall be similarly tested while supported at the other two edges. There shall be no weld failure at any point under this loading. This additional test shall be applied to one panel 500 square feet of floor in the system, but in no case less than two panels. When any weld fails, that number of panels designated by the Construction Manager shall be similarly tested, and those that have a weld failure shall be replaced at no cost to the Institute.

1. Before fabrication, steel used in constructing floor panels shall have been cleaned in accordance with FS TT-C-490 and given a Type I pretreatment. After fabrication, surfaces except those to receive floor covering shall be primed with 2 mils of epoxy polyamide conforming to MS MIL-P-23377 followed by a top coat of 2 mils of MS MIL-C-22750.

2.3 FINISH FLOORING: Panels shall be covered with short pile carpeting conforming to FS DDD-C-001799, Type 1, Class [4] [5] [6], without cushion. Carpet shall be static dissipative designed for elevated floor panels.

2.4 PANEL LIFTERS: Contractor shall provide two floor lifters, and wall hangers for them, per 600 square feet of flooring.

2.5 REGISTERS AND GRILLES: Registers and grilles and shall be [_____] inches by [_____] inches long with a minimum free area of [_____] square inches. Construction shall be extruded aluminum, in mill finish, to sustain point loads of 250 pounds per vane without failure or permanent deformation. No part of a grille or register shall project more than 1/8 inch above the floor.

2.6 CUTOUTS:

A. Cable cutouts shall be finished with rigid polyvinylchloride or molded polypropylene edging to conform to the appearance level of the floor surface and to cover raw edges of the cutout panel. This extrusion shall be of a configuration to permit its effective and convenient use when new cable openings are required. At least 24 feet of additional extrusion shall be provided for future use.

B. Non-metallic adapter shall be provided for openings less than 4 inches wide. Adapter shall be adhesively secured in cutout to preclude removal from panel. At least two adapters per 1000 square feet shall be provided for future use.

C. Opening larger than 4 inches wide shall use the rigid polyvinylchloride or molded polypropylene edging.

D. Cutting of panels, including cutouts, shall be performed outside of the building.

E. When size of cutout reduces the performance requirement of panel, the Contractor shall provide intermediate stringers adjacent to cutouts.

2.7 STRINGERS

A. Stringers shall be [roll-formed painted] [galvanized steel channel sections] [extruded aluminum channels], having either conductive vinyl rib or a flat conductive vinyl gasket cemented on top surface of stringers to effect a complete air seal between the panels and the stringers and prevent slippage of floor panels horizontally.

B. Self-threading machine screws or clip nuts are not acceptable, only unistrut-type bolts and nuts shall be used for connection. Method of mechanical fastening of stringer to pedestal shall not cause buckling of the stringer cross section. Bolted connection shall attach the bottom of the stringer to the pedestal. Provisions shall be made to allow equipment located on the floor to be bonded to the stringer.

2.8 EDGE STRIPS: An extruded rigid [polyvinylchloride] [vinyl] conductive edge strip less than 3 ohms shall be mechanically secured to the panel in a manner to preclude detachment under foot and wheel traffic after metal fabrication and machining have been completed. Top of the strip shall be flush with the top of the floor covering. Dimensional accuracy of the floor panel with the edge strip in place shall be such that, when installed, jointing shall be characterized by the interference fit of panel to panel.

2.9 PEDESTALS

A. Pedestals shall consist of a square steel base at least [4 by 4] inches that is designed to be attached to the subfloor with the manufacturer's recommended adhesive or by mechanical fasteners for the intended installation.

B. Vertical adjustment of pedestals shall be by threaded steel rod with a positively locking vibration proof elevating nut to control the height of the pedestal head.

C. Pedestal rods shall be cast-in with the base or welded to the base. Mechanical connections will not be permitted. All sliding surfaces in the elevating mechanism, such as threads, collars, sockets, and shafts, shall be machined to an interference fit. All welds shall be cleaned and a corrosion preventative coating applied.

D. Pedestal components, except rods and bearing pads, shall be diecast aluminum alloy or steel. Rods shall be rustproofed, after machining, by galvanizing in accordance with manufacturer's standards.

E. Pedestal cap shall be [die form] [a flat steel bracket] with suitable arrangements for fastening, floor stringers to pedestal cap, where the bolt and nut is installed from below the pedestal cap.

F. Pedestal design shall include devices for securely anchoring floor panels and supporting or stabilizing members of the system. Such devices shall be characterized by interference fits to preclude any metal-to-metal impact noises.

G. Any nonmetallic pads used on pedestal heads as bearing surfaces for floor panels shall be rigid conductive polyvinylchloride or vinyl.

H. Bolts, nuts, washers, and screws shall be cadmium-plated items.

I. At the periphery of the floor, full support shall be provided to the floor's extreme edge to ensure continuance of the specified strengths. Support system provided for this purpose shall not interfere with the free removal of affected panels.

2.10 ACCESSORIES

A. Access grommets, underfloor service holes, core base and panel lifters shall be as shown. All accessories shall be provided by flooring manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Layout for the installation shall keep to a minimum the number of cut panels at the floor's periphery.

B. Panel assembly shall be scribed into place at the periphery so that no voids result between the floor panels and the contiguous vertical surface trim. Pedestal position shall be accurately located, and any necessary changes in subfloor surfaces shall be made before other installation work is started.

C. Pedestal heads and stringers must be cleaned before assembly to assure the proper electrical resistance between stringer and pedestals.

D. Before installation proceeds, the subfloor shall be cleared of dust and construction debris, including a final cleaning with high-suction industrial vacuum equipment. No cutting, trimming, or other debris-producing operation shall be conducted within the room where the floor is being installed. As the installation of floor panels proceeds, the area under the installed floor shall be vacuum cleaned as each row of panels is completed. Cleaning shall extend at least 4 feet back from the completed edge where possible.

E. Pedestals shall be installed with an epoxy adhesive recommended by the elevated-floor manufacturer. Installation shall provide a full bearing of the pedestal base on the subfloor. Where the contour of the floor does not permit this, the floor and the base shall be primed with adhesive, a grout made by filling adhesive with clean sand shall be applied over the primed floor area, and the pedestal base shall be firmly seated in the grout.

F. Installation shall be such that a surveyor's level shall show the floor to be level within 0.10 inch.

G. After installation has been completed, the floor shall be vacuum cleaned and covered with a continuous sheet of paper or plastic of sufficient strength to withstand traffic which may be imposed upon the floor before the final acceptance. Should any break in this covering occur, the covering shall be immediately repaired or the entire covering shall be immediately replaced.

3.2 CLEANING

A. Surplus Material Removal: Surfaces of the work, and adjacent surfaces soiled as a result of the work, shall be cleaned. Equipment, surplus materials, and rubbish from the work shall be removed from the site.

B. Testing: Installed floor system shall be tested for required electrical resistance by the Contractor before acceptance by the Construction Manager. Unacceptable and damaged portions of the elevated floor system shall be corrected, removed and replaced at no additional expense to the Institute.

END OF SECTION

SECTION 10500

LOCKERS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 525	(1991b) Standard Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
ASTM A 526	(1990) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Commercial Quality
ASTM B 456	(1991a) Standard Specification for Electrodeposited Coatings of Copper Plus Nickel Plus Chromium and Nickel Plus Chromium
ASTM D 2092	(1986) Standard Practice for Preparation of Zinc-Coated Galvanized Steel Surfaces for Painting

FEDERAL SPECIFICATIONS (FS)

FS AA-L-00486	(Rev H; Am 1, Notice 1) Lockers, Clothing, Steel

MILITARY SPECIFICATIONS (MS)

MS MIL-C-22750	(Rev E; Am 1) Coating, Epoxy, VOC Compliant
MS MIL-C-22751	(Rev D; Notice 1) Coating System, Epoxy-Polyamide, Chemical and Solvent Resistant, Process for Application of
MS MIL-P-23377	(Rev F) Primer Coatings: Epoxy, Chemical and Solvent Resistant

1.2 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Manufacturer's Catalog Data shall be submitted for the following items, including material qualities, locking devices, handles, finish assembly instructions, and other similar items.

Locker Materials
Hardware and Accessories

b. Drawings

1. Fabrication Drawings shall be submitted for Lockers consisting of fabrication and assembly details to be performed in the factory.

2. Installation Drawings shall be submitted for Lockers indicating the locker type required, location, locker-number sequence, and installation details.

C. Certificates of Compliance showing Lockers will be free of defects in materials, fabrication, finish, and installation, and that they will remain so for a period of not less than 2 years after completion.

D. Samples: Three Color Chips, not less than 12-inches square, of each color schedule shall be submitted.

1.3 DELIVERY, HANDLING, AND STORAGE: Materials shall be protected from weather, soil, and damage during delivery, storage, and construction. Materials shall be delivered in their original packages, containers, or bundles bearing the brand name and the name of the material.

1.4 FIELD MEASUREMENTS: To ensure proper fits, field measurements shall be taken prior to the preparation of drawings and fabrication.

1.5 FIELD TESTS: The Construction Manager may request performance-characteristic tests on assembled lockers. Tests and results shall conform to FS AA-L-00486. Lockers not conforming will be rejected.

1.6 LOCKER TYPES: Locker shall be the following type and size in the location and quantities indicated. Locker finish colors shall be as scheduled.

1.7 DOUBLE-TIER LOCKERS: Double-tier lockers shall be 15 inches wide, 15 inches deep, and 72 inches high, attached to 6-inch-high legs

PART 2 - PRODUCTS

2.1 LOCKER MATERIALS

A. Galvanized Steel Sheet used for fabrication of lockers shall be hot-dipped commercial quality minimized spangle material conforming to ASTM A 526 with not less than a 1.25-ounce zinc coating conforming to ASTM A 525. Surface preparation of material for finishing shall conform to ASTM D 2092, Method A. Sheet thickness indicated shall be the uncoated sheet-steel thickness.

B. Chromium Coating shall be nickel and chromium electrodeposited on the specified base metal. Coating shall conform to ASTM B 456, SC-3, as applicable to the base metal.

C. Locker Finish: Primer shall conform to MS MIL-P-23377 and topcoat as specified in MS MIL-C-22750. Application shall conform to MS MIL-C-22751. Color shall be as indicated on the finish schedule.

2.2 LOCKER FABRICATION

A. Locker Bodies: Locker-body fabrication including the back, sides, top, and bottom shall conform to FS AA-L-00486 and as herein modified. Locker bodies shall be fabricated from not less than 0.0239-inch thick steel sheet.

B. Sloping Locker Tops shall be provided in addition to the locker-section flat tops. Sloping tops shall be continuous in length. Fillers or closures shall be provided at the exposed end of sloping tops. Sloping tops shall be fabricated from not less than 0.0478-inch thick steel sheet.

C. Locker Legs shall conform to FS AA-L-00486 and shall be fabricated from not less than 0.0598-inch thick steel sheet.

D. Locker Finish: Application of the locker finish, including surface preparation, priming, and enameling, shall conform to FS AA-L-00486.

E. Doors, Door Frames, and Door Louvers: Doors, door frames, and door louvers shall conform to FS AA-L-00486 as herein modified. Doors, door frames, and door louvers shall be fabricated from not less than 0.0598-inch thick steel sheet.

F. Latch Strikes shall conform to FS AA-L-00486 as herein modified. Latch strikes shall be fabricated from not less than 0.0747-inch thick steel sheet.

G. Hinges shall conform to FS AA-L-00486 as herein modified. Hinges shall be not less than the 5-knuckle type welded to the door frame and bolted to the door. Hinges shall be fabricated from not less than 0.0747-inch thick steel sheet.

H. Latching Mechanisms shall conform to FS AA-L-00486.

I. Door Handles shall conform to FS AA-L-00486 as herein modified. Zinc alloy or steel handles shall have a chromium coating as specified.

J. Coat Hooks shall conform to FS AA-L-00486. Hooks shall be chromium coated.

K. Number Plates shall conform to FS AA-L-00486.

L. Label Holders shall conform to FS AA-L-00486.

M. Fastening Devices shall conform to FS AA-L-00486.

PART 3 - EXECUTION

3.1 ASSEMBLY: Lockers shall be assembled according to the locker manufacturer's instructions. Lockers shall be carefully assembled, lined up horizontally and vertically, and rigidly screwed to the base and wall. Adjacent lockers shall be bolted together. Doors shall be adjusted to operate freely without sticking or binding and shall close tightly.

3.2 ACCEPTANCE PROVISIONS

A. Repairing: Damaged and unacceptable portions of completed work shall be removed and replaced with new work at no additional cost to the Institute.

B. Cleaning: Surfaces of the work, and adjacent surfaces soiled as a result of the work, shall be cleaned in an approved manner. Equipment, surplus materials, and rubbish from the work shall be removed from the site.

END OF SECTION

SECTION 13001

FACILITY MONITORING AND CONTROL SYSTEMS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

A. The work shall conform to all codes, rules, ordinances, and regulations of the Authority Having Jurisdiction and their interpretations which are in effect at the site of the work.

B. The latest issue of applicable standards and recommended practices of the following agencies in effect shall form a part of the specification to the extent each agency's relative standards or recommended practices apply to the Systems and its components as specified herein.

Federal Communications Commission (FCC)
American National Standards Institute (ANSI)
American Society of Mechanical Engineers (ASME)
Electronic Industries Association (EIA)
Institute of Electrical and Electronics Engineers (IEEE)
National Electrical Manufacturers Association (NEMA)
National Fire Protection Association (NFPA)
Underwriters Laboratories (UL)
Occupational Safety and Health Administration (OSHA)
American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)

C. Comply with all health and safety regulations, performing the work in a safe and competent manner, and use industry accepted installation procedures required for the work as outlined in these documents.

1.2 RELATED WORK

A. The following items are specified in Division 15. Under this section, provide necessary supervision and coordination.

1. Automatic valves, including all reducers and fittings necessary to install smaller than pipe size valves.

2. Automatic dampers:

3. Piping penetration: water pressure and differential taps, valve manifolds, flow switches, thermal wells.

B. The following itemsa re specified in Division 16. Under this section, provide necessary supervision and coordination.

1. Control wiring, including all control wiring greater than 100 volts in accordance with approved wiring diagrams.

2. Power source wiring, including all 120 volt AC power source wiring.

1.3 GENERAL REQUIREMENTS: Section 16003, "General Electrical Provisions," applies to work specified in this section. Section 15003 "General Mechanical Provisions" applies to work specified in this section.

1.4 SYSTEM DESCRIPTION: The Facility Monitoring and Control system, hereinafter referred to as FMS, shall fully integrate the following subsystems which shall be capable of operating in a stand-alone mode, yet software integrated to comprise the complete FMS:

A. ATC/EMS (Automatic Temperature Control and Energy Management System)
B. FCS (Fire Control System)
C. ACS (Access Control System)
D. LCS (Lighting Control System)
E. Video surveilance

1.5 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Product data sheets describing all aspects of the hardware, hardware configuration, software and functional operation of the proposed FMS.

B. Wiring and piping interconnection diagrams including panel and device power, and sources.

C. List of materials of all proposed devices and equipment.

D. Software documentation:

1. Sequence of operation, in text form.
2. Application programs

E. Point schedules

F. Controls schematics and system diagrams

G. Operation and maintenance manuals

1.6 STORAGE AND HANDLING

A. Openings shall be sealed after manufacturing and inspection, until ready for installation.

B. Instruments and equipment shall be carefully handled, shall not be subjected to shock, and shall be protected from weather, dust, construction materials, and damage.

1.7 QUALITY ASSURANCE

A. Single source responsibility of the FMS contractor shall include installation, calibration, and check-out of the stand-alone subsystems, as well as the complete operation of the integrated FMS.

B. The systems manufacturer shall have an in-place, local support facility with technical staff, spare parts inventory, and all necessary test diagnostic equipment.

C. All systems equipment, components, accessories, and installation hardware shall be UL listed where applicable. All components shall be standard product of the system or device manufacturer. Each component shall bear the make, model number, device tag number (if any), and the UL label as applicable. All Systems components of a given type shall be the product of the same manufacturer.

PART 2 - PRODUCTS

2.1 GENERAL DESCRIPTION

A. The Facility Management System shall be capable of integrating multiple building functions including equipment supervision and control, alarm management, energy management, fire management, access control, lighting control, information management, and historical data collection and archiving.

B. The facility management system shall consist of the following:

1. Standalone DDC panels
2. Application specific controllers (HVAC etc.)
3. Local Display Devices
4. Portable Operator's Terminals
5. Personal Computer Operator Workstations.

C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, standalone DDC panels, and operator devices.

D. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC panel shall operate independently by performing its own specified control, alarm management, operator I/O, and historical data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

E. Standalone DDC panels shall be able to access any data from, or send control commands and alarm reports directly to any other DDC panel or combination of panels on the network without dependence upon a central processing device, such as a central file server. Standalone DDC panels shall also be able to send alarm reports to multiple operator workstations, terminals, and printers without dependence upon a central processing device or File Server.

2.2 NETWORKING/COMMUNICATIONS: The design of the FMS shall network operator workstations and Standalone DDC Panels as shown on the attached system configuration drawing. Inherent in the system's design shall be the ability to expand or modify the network either via a local area network, or auto-dial telephone line modem connections, or via a combination of the two networking schemes.

A. Local Area Network

1. Workstation/DDC Panel Support: Operator workstations and DDC panels shall directly reside on a single shared high speed local area network such that communications may be executed directly between controllers, directly between workstations, and between controllers and workstations on a peer-to-peer basis.

2. Dynamic Data Access: All operator devices, either network resident or connected via dial-up modems, shall have the ability to access all point status and application report data, or execute control functions for any and all other devices via the local area network. Access to data shall be based upon logical identification of building equipment.

a. Access to system data shall not be restricted by the hardware configuration of the facility management system. The hardware configuration of the FMS network shall be transparent to the user when accessing data or developing control programs.

3. General Network Design: Network design shall include the following provisions:

a. High speed data transfer rates for alarm reporting, quick report generation from multiple controllers, and upload/download efficiency between network devices. The minimum baud rate shall be 1 Megabaud.

b. Support of any combination of controllers and Operator Workstations directly connected to the local area network.

c. Detection and accommodation of single or multiple failures of either workstations, DDC panels or the network media. The network shall include provisions for automatically re-configuring itself to allow all operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures.

d. Message and alarm buffering to prevent information from being lost.

e. Error detection, correction, and re-transmission to guarantee data integrity.

f. Default device definition to prevent loss of alarms or data, and ensure alarms are reported as quickly as possible in the event an operator device does not respond.

g. Commonly available, multiple sourced, networking components shall be used to allow the FMS to coexist with other networking applications. The following are acceptable technologies: ARCNET and/or ETHERNET and/or SERVICE TELEPHONE PAIRS and/or BROADBAND.

h. Communications must be of a deterministic nature to assure calculable performance under worst-case network loading. When a collision-based network is proposed, the Contractor shall provide detailed calculations showing worst-case network response times.

i. Automatic synchronization of the real-time clocks in all DDC panels shall be provided.

B. Dial-Up Communications: Auto-dial/auto-answer communications shall be provided to allow standalone DDC panels to communicate with remote operator devices on an intermittent basis via telephone lines.

1. Dial-Up Standalone DDC Panels: Auto-Dial panels shall automatically place calls to workstations to report critical alarms, or to upload trend and historical information for archiving.

a. Standalone DDC Panels shall analyze and prioritize all alarms to minimize the initiation of calls. Non-critical alarms shall be buffered in memory and reported as a group of alarms, or until an operator manually requests an upload of all alarms.

b. The auto-dial program shall include provisions for handling busy signals, "no-answers," and incomplete data transfers. Default devices shall be called when communications cannot be established with primary devices.

2. Dial-Up Workstations: Operators at dial-up workstations shall be able to perform all control functions, all report functions, and all database generation and modification functions as described for workstations connected via the local area network. Routines shall be provided to automatically answer calls, and either file or display information sent from remote DDC panels.

a. An operator shall be able to access remote buildings by selection of any facility by its logical name. The PC Dial-Up program shall maintain a user-definable cross-reference of buildings and associated telephone numbers, so the user shall not be required to remember or manually dial telephone numbers.

b. A PC workstation may serve as an operator device on a local area network, as well as a dial-up workstation for multiple auto-dial DDC panels or networks. Alarm and data file transfers handled via dial-up transactions shall not interfere with local area network activity, nor shall local area network activity keep the workstation from handling incoming calls.

3. Modem Characteristics: Dial-up communications shall make use of Hayes compatible 1200 or 9600 baud modems and voice grade telephone lines. Each standalone DDC panel may have its own modem, or a group of Standalone DDC panels may share a modem.

2.3 STANDALONE DDC PANELS

A. General: Standalone DDC panels shall be microprocessor based, multi-tasking, multi-user, real-time digital control processors. Each standalone DDC panel shall consist of modular hardware with plug-in enclosed processors, communication controllers, power supplies, and input/output modules. A sufficient number of controllers shall be supplied to fully meet the requirements of this specification and the attached point list.

B. Memory: Each DDC panel shall have sufficient memory to support its own operating system and databases including:

1. Control processes
2. Energy Management Applications
3. Alarm Management
4. Historical/Trend Data for all points
5. Maintenance Support Applications
6. Custom Processes
7. Operator I/O
8. Dial-Up Communications
9. Manual Override Monitoring

C. Point types: Each DDC panel shall support the following types of point inputs and outputs:

1. Digital Inputs for status/alarm contacts
2. Digital Outputs for on/off equipment control
3. Analog Inputs for temperature, pressure, humidity, flow, and position measurements
4. Analog Outputs for valve and damper position control, and capacity control of primary equipment
5. Pulse Inputs for pulsed contact monitoring

D. Expandability: The system shall be modular in nature, and shall permit easy expansion through the addition of software applications, workstation hardware, field controllers, sensors, and actuators. The system architecture shall support % expansion capacity of all types of DDC panels, and all point types included in the initial installation.

E. Serial Communication Ports: Standalone DDC panels shall provide at least two RS-232C serial data communication ports for simultaneous operation of multiple operator I/O devices such as industry standard printers, laptop workstations, PC workstations, and panel mounted or portable DDC panel Operator's Terminals. Standalone DDC panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers, or network terminals.

F. Hardware Override Switches: As indicated in the point schedule, the operator shall have the ability to manually override automatic or centrally executed commands at the DDC panel via local, point discrete, onboard hand/off/auto operator override switches for binary control points and gradual switches for analog control type points. These override switches shall be operable whether the panel is powered or not.

G. Hardware Override Monitoring: DDC panels shall monitor the status or position of all overrides, and include this information in logs and summaries to inform the operator that automatic control has been inhibited. DDC panels shall also collect override activity information for daily and monthly reports.

H. Local Status Indicator Lamps: The DDC panel shall provide local status indication for each binary input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.

I. Integrated On-Line Diagnostics: Each DDC panel shall continuously perform self-diagnostics, communication diagnosis and diagnosis of subsidiary equipment. The DDC panel shall provide both local and remote annunciation of any detected component failures, or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each DDC panel, and shall not require the connection of an operator I/O device.

J. Surge and Transient Protection: Isolation shall be provided at all network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standard 587-1980.

K. Powerfail Restart: In the event of the loss of normal power, there shall be an orderly shutdown of all standalone DDC panels to prevent the loss of database or operating system software. Non-Volatile memory shall be incorporated for all critical controller configuration data, and battery back-up shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.

1. Upon restoration of normal power, the DDC panel shall automatically resume full operation without manual intervention.

2. Should DDC panel memory be lost for any reason, the panel will automatically receive a download via the local area network, phone lines, or connected computer. In addition, the user shall have the capability of reloading the DDC panel via the local area network, via the local RS-232C port, or via telephone line dial-in.

2.4 SYSTEM SOFTWARE FEATURES

A. General

1. All necessary software to form a complete operating system as described in this specification shall be provided.

2. The software programs specified in this section shall be provided as an integral part of the DDC panel and shall not be dependent upon any higher level computer for execution.

B. Control Software Description:

1. Pre-Tested Control Algorithms: The DDC panels shall have the ability to perform the following pre-tested control algorithms:

a. Two Position Control
b. Proportional Control
c. Proportional plus Integral Control
d. Proportional, Integral, plus Derivative Control
e. Automatic Control Loop Tuning

2. Equipment Cycling Protection: Control software shall include a provision for limiting the number of times each piece of equipment may be cycled within any one-hour period.

3. Heavy Equipment Delays: The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.

4. Powerfail Motor Restart: Upon the resumption of normal power, the DDC panel shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling, and turn equipment on or off as necessary to resume normal operation.

C. Energy Management Applications:

1. DDC Panels shall have the ability to perform any or all of the following energy management routines:

a. Time of Day Scheduling
b. Calendar Based Scheduling
c. Holiday Scheduling
d. Temporary Schedule Overrides
e. Optimal Start
f. Optimal Stop
g. Night Setback Control
h. Enthalpy Switch Over (Economizer)
i. Peak Demand Limiting
j. Temperature Compensated Load Rolling
k. Fan Speed/CFM Control
l. Heating/Cooling Interlock
m. Cold Deck Reset
n. Hot Deck Reset
o. Hot Water Reset
p. Chilled Water Reset
q. Condenser Water Reset
r. Chiller Sequencing

2. All programs shall be executed automatically without the need for operator intervention, and shall be flexible enough to allow operator customization. Programs shall be applied to building equipment as described in the Execution portion of this specification.

D. Custom Process Programming Capability: DDC panels shall be able to execute custom, job-specific processes defined by the operator, to automatically perform calculations and special control routines.

1. Process Inputs and Variables: It shall be possible to use any of the following in a custom process:

a. Any system-measured point data or status
b. Any calculated data
c. Any results from other processes
d. User-Defined Constants
e. Arithmetic functions (+,-,*,/, square root, exponential, etc.)
f. Boolean logic operators (and, or, exclusive or, etc.)
g. On-delay/Off-delay/One-shot timers

2. Process Triggers: Custom processes may be triggered based on any combination of the following:

a. Time interval
b. Time of day
c. Date
d. Other processes
e. Time programming
f. Events (e.g., point alarms)

3. Dynamic Data Access: A single process shall be able to incorporate measured or calculated data from any and all other DDC panels on the local area network. In addition, a single process shall be able to issue commands to points in any and all other DDC panels on the local area network.

4. Advisory/Message Generation: Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device, buffer the information in a follow-up file, or cause the execution of a dial-up connection to a remote device such as a printer.

5. Custom Process Documentation: The custom control programming feature shall be self-documenting. All interrelationships defined by this feature shall be documented via graphical flowcharts and English language descriptors.

E. Alarm Management: Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each DDC panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall the DDC panel's ability to report alarms be affected by either operator activity at a PC Workstation or local I/O device, or communications with other panels on the network.

1. Point Change Report Description: All alarm or point change reports shall include the point's English language description, and the time and date of occurrence.

2. Prioritization: The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of three priority levels shall be provided. Each DDC panel shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.

a. The user shall also be able to define under which conditions point changes need to be acknowledged by an operator, and/or sent to follow-up files for retrieval and analysis at a later date.

3. Report Routing: Alarm reports, messages, and files will be directed to a user-defined list of operator devices or PC disk files used for archiving alarm information. Alarms shall also be automatically directed to a default device in the event a primary device is found to be off-line.

4. Alarm Messages: In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 65-character alarm message to more fully describe the alarm condition or direct operator response.

a. Each standalone DDC panel shall be capable of storing a library of at least 250 Alarm Messages. Each message may be assignable to any number of points in the panel.

5. Auto-Dial Alarm Management: In Dial-up applications, only critical alarms shall initiate a call to a remote operator device. In all other cases, call activity shall be minimized by time-stamping and saving reports until an operator scheduled time, a manual request, or until the buffer space is full. The alarm buffer must store a minimum of 50 alarms.

6. Transaction Logging: Operator commands and system events shall be automatically logged to disk in Personal Computer industry standard database format. Operator commands initiated from Direct-connected workstations, dial-up workstations, and local DDC panel Network Terminal devices shall all be logged to this transaction file. This data shall be available at the Operator Workstation. A utility shall be provided to allow the user to search the transaction file using standard database query techniques, including searching by dates, operator name, data point name, etc. In addition, this transaction file shall be accessible with standard third party database and spreadsheet packages.

F. Historical Data and Trend Analysis: A variety of Historical data collection utilities shall be provided to automatically sample, store, and display system data in all of the following ways:

1. Continuous Point Histories: Standalone DDC panels shall store Point History Files for all analog and binary inputs and outputs. The Point History routine shall continuously and automatically sample the value of all analog inputs at half hour intervals. Samples for all points shall be stored for the past 24 hours to allow the user to immediately analyze equipment performance and all problem-related events for the past day. Point History Files for binary input or output points and analog output points shall include a continuous record of the last ten status changes or commands for each point.

2. Control Loop Performance Trends: Standalone DDC panels shall also provide high resolution sampling capability in one-second increments for verification of control loop performance.

3. Extended Sample Period Trends: Measured and calculated analog and binary data shall also be assignable to user-definable trends for the purpose of collecting operator-specified performance data over extended periods of time. Sample intervals of 1 minute to 2 hours shall be provided. Each standalone DDC panel shall have a dedicated buffer for trend data, and shall be capable of storing a minimum of 5000 data samples.

4. Data Storage and Archiving: Trend data shall be stored at the Standalone DDC panels, and uploaded to hard disk storage when archival is desired. Uploads shall occur based upon either user-defined interval, manual command, or when the trend buffers become full. All trend data shall be available in disk file format compatible with Third Party personal computer applications.

G. Runtime Totalization: Standalone DDC panels shall automatically accumulate and store runtime hours for binary input and output points as specified in the Execution portion of this specification.

1. The Totalization routine shall have a sampling resolution of one minute or less.

2. The user shall have the ability to define a warning limit for Runtime Totalization. Unique, user-specified messages shall be generated when the limit is reached.

H. Analog/Pulse Totalization: Standalone DDC panels shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.

1. Totalization shall provide calculation and storage of accumulations of up to 99,999.9 units (e.g. KWH, gallons, KBTU, tons. etc.).

2. The Totalization routine shall have a sampling resolution of one minute or less.

3. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

I. Event Totalization: Standalone DDC panels shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly, or monthly basis.

1. The Event Totalization feature shall be able to store the records associated with a minimum of 9,999,999 events before reset.

2. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

2.5 HVAC DIGITAL CONTROLLERS

A. Each Standalone DDC Controller shall be able to extend its performance and capacity through the use of remote Application Specific Controllers (ASCs).

B. Each ASC shall operate as a standalone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor.

C. Each ASC shall have sufficient memory to support its own operating system and data bases including:

1. Control Processes
2. Energy Management Applications
3. Operator I/O

D. The operator interface to any ASC point data or programs shall be through any network-resident PC workstation, or any PC or portable operator's terminal connected to any DDC panel in the network.

E. Application Specific Controllers shall directly support the use of a portable terminal. The capabilities of the portable terminal shall include but not be limited to the following:

1. Display temperatures
2. Display status
3. Display setpoints
4. Display control parameters
5. Override binary output control
6. Override analog setpoints
7. Modification of gain and offset constants

F. Powerfail Protection: All system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the controller.

G. Configuration and Download: The ASCs shall have the capability of receiving configuration and program loading by both of the following: 1) locally, via a direct connect portable laptop service tool, 2) over the network, from the portable laptop service tool, and; 3) from the Operator Workstation, via the communication networks.

H. Continuous Zone Temperature Histories: Application Specific Controllers shall have the capability to automatically and continuously maintain a history of the associated zone temperature to allow users to quickly analyze space comfort and equipment performance for the past 24 hours. A minimum of two samples per hour shall be stored.

I. HVAC Application Descriptions:

1. VAV Terminal Unit Controllers:

a. VAV Terminal Unit Controllers shall support, but not be limited to, the control of the following configurations of VAV boxes to address current requirements as described in the Execution portion of this specification, and for future expansion:

1) Single Duct Only (Cooling Only, or Cooling with Reheat).
2) Fan Powered (Parallel/Side Pocket, Series/On-Off Logic)
3) Dual Duct (Constant Volume, Variable Volume)
4) Supply/Exhaust

b. VAV Terminal Unit Controllers shall support the following types of point inputs and outputs:

1) Proportional Cooling Outputs
2) Box and Baseboard Heating Outputs (Proportional, or 1 to 3 Stages)
3) Fan Control Output (On/Off Logic, or Proportional Series Fan Logic)

c. The modes of operation supported by the VAV Terminal Unit Controllers shall minimally include, but not be limited to, the following:

1) Day/Weekly Schedules
2) Comfort/Occupancy Mode
3) Economy Mode (Standby Mode, Unoccupied, etc.)
4) Temporary Override Mode

d. Occupancy-Based Standby/Comfort Mode Control: Each VAV Terminal Unit Controller shall have a provision for occupancy sensing overrides. Based upon the contact status of either a manual wall switch or an occupancy sensing device, the VAV Terminal Unit Controller shall automatically select either Standby or Comfort mode to minimize the heating and cooling requirements while satisfying comfort conditions.

e. Occupancy-Based Zone Lighting Control: VAV Terminal Unit Controllers shall provide an auxiliary binary output to serve as the interface to an associated lighting relay. Based upon the status of either an occupancy sensing device, or manual wall switch, the VAV Terminal Unit Controller shall provide a contact output to automatically adjust the lighting level to accommodate occupant requirements while reducing electrical consumption. Standby/Comfort (described in the previous section) and Lighting overrides shall be served by the same occupancy override input.

f. Alarm Management: Each VAV Terminal Unit Controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

2. Unitary Controllers:

a. Unitary Controllers shall support, but not be limited to, the following types of systems to address specific applications described in the Execution portion of this specification, and for future expansion:

1) Unit Vents (ASHRAE Cycle I, II, III, or IV)
2) Heat Pumps (Air-to-Air, Water-to-Air)
3) Packaged Rooftops
4) Fan Coils (Two-Pipe, Four-Pipe)

b. Unitary Controllers shall support the following types of point inputs and outputs:

1) Economizer Switch Over Inputs

Drybulb
Outdoor Air Enthalpy
Differential Temperature
Binary Input from a separate controller

2) Economizer Outputs

Integrated Analog with minimum position
Binary output to enable self-contained economizer actuator

3) Heating and Cooling Outputs

1 to 3 Stages
Analog Output with two-pipe logic
Reversing valve logic for Heat Pumps

4) Fan Output

On/Off Logic Control

c. Unitary controllers shall support the following library of control strategies to address the requirements of the sequences described in the Execution portion of this specification, and for future expansion:

1) Daily/Weekly Schedules
2) Comfort/Occupancy Mode
3) Economy Mode

Standby Mode/Economizer Available
Unoccupied/Economizer Not Available
Shutdown
Lighting Logic Interlock to Economy Mode

4) Temporary Override Mode

Temporary Comfort Mode (Occupancy-Based Control)
Boost (Occupant Warmer/Cooler Control)

d. Occupancy-Based Standby/Comfort Mode Control: Each Unitary Controller shall have a provision for occupancy sensing overrides. Based upon the contact status of either a manual wall switch or an occupancy sensing device, the Unitary Controller shall automatically select either Standby or Comfort mode to minimize the heating and cooling requirements while satisfying comfort conditions.

e. Occupancy-Based Zone Lighting Control: Unitary Controllers shall provide an auxiliary binary output to serve as the interface to an associated lighting relay. Based upon the status of either an occupancy sensing device, or manual wall switch, the Unitary Controller shall provide a contact output to automatically adjust the lighting level to accommodate occupant requirements while reducing electrical consumption. Standby/Comfort (described in the previous section) and Lighting overrides shall be served by the same occupancy override input.

f. Alarm Management: Each Unitary Controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

3. AHU Controllers

a. AHU Controllers shall support, but not be limited to, the following configurations of systems to address current requirements as described in the Execution portion of this specification, and for future expansion:

1) Large Air Handling Units

Mixed Air-Single Path
Mixed Air-Dual Path
100% Single Path
100% Dual Path

b. AHU Controllers shall support all the necessary point inputs and outputs to perform the specified control sequences in a totally standalone fashion.

c. AHU controllers shall have a library of control routines and program logic to perform the sequence of operation as specified in the Execution portion of this specification.

d. Occupancy-Based Standby/Comfort Mode Control: Each AHU Controller shall have a provision for occupancy sensing overrides. Based upon the contact status of either a manual wall switch or an occupancy sensing device, the AHU Controller shall automatically select either Standby or Comfort mode to minimize the heating and cooling requirements while satisfying comfort conditions.

e. Alarm Management: Each AHU Controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

4. Lab and Central Plant (LCP) Controllers:

a. LCP controllers shall support, but not be limited to, the following configurations of systems to address current requirements described in the "Execution" portion of this specification, and for future expansion.

1) Single boiler or chiller plants with pump logic
2) Cooling towers
3) Zone pressurization of labs
4) Generic system interlocking through hardware.

b. LCP controllers shall support all the necessary point inputs and outputs to perform the specified control sequences in a totally standalone fashion.

c. LCP controllers shall have a built-in status and adjust panel interface to allow for the local adjustment of all setpoints, temporary override of any input or output points and status of any points in alarm.

d. Alarm Management: Each LCP controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

5. HVAC Application Specific Controller Configuration

a. The Application Specific Controllers shall be configured using an intuitive, easy-to-use configuration tool. Standard, pre-tested, HVAC applications will be "built-in" the tool. It is the intent that a non-programmer, fluent with HVAC systems, and not necessarily with computer programming, be capable of using the configuration tool with minimal training.

b. The tool will utilize a question and answer format to aid the user in configuration. The tool will automatically query the user for desired operational characteristics, along with desired fail-safe and fault condition configurations, in order to assure proper HVAC system operation and protection.

c. Systems that require free-form programming will not be acceptable.

2.6 FIRE ALARM CONTROLLERS

A. General: The equipment and installation shall comply with the current applicable provisions of the following standards:

1. National Electric Code, Article 760

2. National Fire Protection Standards

NFPA 71	Central Station Signaling Systems-Protected Premises Unit
NFPA 72	Protective Signaling Systems
NFPA 72E	Automatic Fire Detectors
NFPA 72F	Emergency Voice/Alarm Communication Systems

3. Local and state building codes: All requirements of the Local Authority Having Jurisdiction.

4. Underwriters Laboratories, Inc.: The system and all components shall be listed by Underwriters Laboratories, Inc. for use in Fire Protective Signaling Systems under the following standards as applicable:

UL 864	Control Units for Fire Protective Signaling Systems
UL 268	Smoke Detectors for Fire Protective Signaling Systems
UL 268A	Smoke Detectors for Duct Applications
UL 217	Smoke Detectors, Single and Multiple Station
UL 521	Heat Detectors for Fire Protective Signaling Systems
UL 228	Door Closers-Holders for Fire Protective Signaling Systems
UL 464	Audible Signaling Appliances
UL 1638	Visual Signaling Appliances
UL 38	Manually Actuated Signaling Boxes
UL 346	Waterflow Indicators for Fire Protective Signaling Systems
UL 1481	Power supplies for Fire Protective Signaling Systems

B. Functions

1. Mechanical Design

a. The fire panel shall be housed in a cabinet designed for mounting directly to a wall or vertical surface. Its door shall provide a key lock and include transparent openings for viewing of panel indicators. The door shall be capable of opening from either side to provide for easy access. The control unit shall be modular in structure for ease of installation, maintenance, and future expansion.

b. Fire System Capacity and General Operation: The control panel shall provide, or be capable of expansion to, the following minimum capacities:

1)	Intelligent/Addressable Loops	10
2)	Intelligent Detectors per Loop	99
3)	Addressable Modules per Loop	99
4)	Total Intelligent Detectors	990
5)	Total Addressable Monitor or Control Modules	990
6)	Total Intelligent/Addressable devices per control panel	1980
7)	Remote Annunciators per System	32
8)	Points per Annunciator	64
9)	Total Annunciator Points per system	2048
10)	Remote Printers per System	2
11)	Remote CRTs per System	49

c. The Fire Alarm Control Panel shall include a fully-featured operator interface control and annunciation panel which shall include a backlit Digital Interface Assembly (DIA). The DIA shall include an English Language Display, individual color coded system status LEDs,

and an alphanumeric keypad for field configuring and control of the Fire Alarm System. All new programming or editing of the existing program in the system may be achieved without special equipment and without interrupting the alarm monitoring functions of the Fire Alarm Control Panel. The use of local or remote EPROM burners is unacceptable.
The Fire Alarm Control Panel shall contain and execute control-by-event programs for specific actions to be taken if an alarm condition is detected by the system. Such control-by-event programs shall be held in non-volatile programmable memory, and shall not be lost even if system primary and secondary power failure occurs.

d. The system shall be programmable, configurable and expandable in the field without the need for special tools or electronic equipment and shall not require field replacement of electronic integrated circuits. All programming shall be accomplished through the standard common control panel keyboard or through the use of an optional CRT with keyboard. All field defined programs shall be stored in non-volatile memory. The programming function shall be enabled with a password that may be defined specifically for the system when it is installed. This password shall be modifiable on line to a new value at any time by authorized personnel. The system shall provide means for automatic programming of its operation to conform with applicable N.F.P.A. standards through internal software.

e. The operator shall have the option for a graphical or text based display on the FMS Operator Workstations (OWS). The OWS shall provide a consistent graphical or text based display of all system points and zones. The graphical interface shall have dynamic visual indication of the status of each detector. The graphical interface display shall be dynamically updated. Color indication of the status of each device and zone shall be shown on the OWS for easy reference. On alarm or trouble the OWS shall allow the operator to view the alarm condition directly, both graphically and in text. The following information, at a minimum shall be provided at the OWS: individual device status, description, application, value, analog reading, verify count, default sensitivity, day/night adjustment flag, and device address.

f. From the OWS, local CRT, and DIA, the operator shall be able to change the sensitivity parameter of each intelligent sensor.

g. The operator shall have the option to modify the detector sensitivity to vary with the time of day through the OWS, CRT and Display Interface Assembly at the panel.

h. The operator shall have the option to enable/disable the detector verification of each sensor through the OWS, CRT, and Display Interface Assembly at the panel.

i. The system shall have the capability to continually monitor all of the devices that are connected to the signaling line circuit for alarm and trouble conditions. The system shall be able to distinguish between malfunction and required maintenance of an intelligent sensors.

j. The system shall have the capability to provide interlocking with other FMS operations, including HVAC and lighting..

k. The system shall have the capability to provide intelligent detector drift compensation technology. The system shall provide accurate and stable readings of true smoke, rejecting long term drift caused be dust contamination and slow environmental effects. This measurement accuracy method should be sufficient to achieve UL listing for the panel as a calibrated smoke test instrument meeting NFPA 72E standards. The user shall not be required to periodically measure each chamber with a calibrated meter, the panel shall do this automatically, subject to the approval of the Authority Having Jurisdiction. When the detector has been compensated so far that its performance may not meet UL standards a trouble report shall be produced as a maintenance alert function.

l. The system shall provide the capability for a one person walk test of the detectors. The panel shall be capable of providing this walk test in the silent or audible mode of operation. All information shall be stored within the control panel for printout of hardcopy report at the completion of the test. Walk test shall identify those devices that are physically installed but not programmed; devices that are programmed but not physically installed; devices set to the wrong address; and two or more devices set to the same address with the count shown.

m. The system shall be able to generate and hardcopy a summary of all of the Detectors, Modules, Pull Stations, and Zones which are currently active in the System. This printout will require password protection to prevent unauthorized user access. No computer expertise will be required to initiate the System Report sequence. The following information will be printed for all installed system points whenever a "System Report" is requested:

1) Custom 20 character detector/module label
2) Detector/module type. Detector sensitivity
3) Control-by-Event equation assignments
4) Waterflow Zone select
5) Supervisory Zone select
6) Verified Detector select
7) Verification Tally Counter Silenceable Indicating Circuit
8) 8 1/2" x 11" fan fold paper, no thermal

n. The system shall be capable of generating and optionally printing upon command from a password-authorized operator a system configuration report. The system configuration report shall show a minimum of the following items:

1) The number of Loops in the system
2) The operating Style of each installed Loop
3) The Alarm Verification Time for the System
4) The Signal Silence Inhibit
5) Time for the system
6) The Automatic Signal Silence Time
7) The Supervisory Status of the CRT
8) CRT status line function
9) Local Piezo signal function
10) Local Mode Module and Detector functionally
11) Installed Annunciators list

C. Intelligent Sensor Devices: The detectors shall be intelligent analog/addressable detectors, and shall connect with two wires to one of the Fire Alarm Control Panel Signaling Line Circuit Loops. The detectors shall on a command from the control panel send data to the panel representing the analog level of smoke density. The detectors shall be ceiling-mount and shall include a twist-lock base. The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. The system shall be capable of initiating the test at the detector itself, or remotely on command from the control panel. The detectors shall provide address-setting using the decimal numbering system without any conversion charts. No formal training of personal shall be required to set the addresses of the detectors. The detectors shall also store an internal identifying code that the control panel shall use to identify the type of detector. The detectors shall provide dual alarm and power LEDs. Both LEDs shall flash under normal conditions, indicating that the detector is operational and in regular communication with the control panel. Both LEDs shall be placed into steady illumination by the control panel, indicating that an alarm condition has been detected. If required, the flashing mode operation of the detector LEDs shall be controlled through the system field program. An output connection shall also be provided in the base to connect an external remote alarm LED. The detector sensitivity shall be set through the Fire Alarm Control Panel, and shall be adjustable in the field through the field programming of the system.

2.7 ACCESS CONTROL CONTROLLERS

A. General: The Access Control capabilities shall include, but not be limited to: access controllers, terminal interfaces, card readers, conduit, wire and accessories required to provide a complete operational system.

1. The equipment and installation shall comply with the current applicable provisions of the following standards:

a. National Electric Code
b. Local and state building codes
c. All requirements of the local authority having jurisdiction
d. Underwriters Laboratories, Inc.

2. The system and all components shall be listed by Underwriters Laboratories, Inc. for use in Access Control Systems under UL 294 Access Control System Unit, as applicable.

B. Functions

1. All access controller panels shall be housed in a cabinet designed for mounting directly to a wall or vertical surface. Its door shall contain a key lock.

2. The integrated intelligent access controller shall provide, or be capable of expansion to, the following capacities:

Card Readers	16
Card Capacity	16,000
Alarm Points	128
Access Levels	Unlimited
Time Zones	8
Password Levels	2
Card Issue Levels	8
Reports	5

3. The system shall be capable of storing 16,000 cards per intelligent access control panel.

4. The system shall be capable of storing a maximum of 640,000 card transactions on a single operator workstation file. A user definable limit shall cause the operator interface to warn the operator when the number of transactions in the file has exceeded that limit.

5. Operator Interface

a. Items in this section should be included in the Operator Interface section of the Facilities Management System specification.

b. The entire database of the intelligent central access controller shall be definable at the Operator Workstation.

6. Operator Commands: The operator interface shall allow the operator to perform commands including, but not limited to the following:

a. Override All Doors to the Access Mode of Operation
b. Release overrides
c. Command Door to Access Mode
d. Command Door to Secure Mode
e. Command Door to Temporarily Open
f. Silence Local Alarms

7. System operators shall, from the operator interface, be able to manually unlock controlled doors for a variable time period, or program an event to automatically unlock and lock doors during a particular time period.

8. Logs and Summaries: Reports shall be generated automatically or manually, and directed to either OWS displays, printers, or disk files. At minimum, the system shall allow the user to easily obtain the following:

a. List of all cardholders
b. List of all transactions currently available

9. The system shall provide on-line query generation which can be used to obtain specific information from the above logs based on user defined parameters. These queries, once defined, may be stored and used again when needed.

10. System Configuration and Definition: The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following additional functions:

a. Add/Delete/Modify Access Control Panels
b. Add/Delete/Modify Smart Terminal Interfaces/Readers
c. Add/Delete/Modify Cardholder User Data

11. Graphical programming shall be used to define processes whereby other FMS functions may be controlled by a valid card transaction. Up to 64 cardholder groups shall be definable per intelligent access control panel connected.

12. Access Controllers

a. The Access Controller shall communicate with the Smart Terminal Units of the system. Failure of a Smart Terminal Unit shall be detected and reported to the printer connected to the OWS. When a card is read at a reader, the card number and issue level are sent to the controller. If the reader is equipped with a keypad, a 4 or 5 digit PIN number may be entered and verified at the reader. The controller, which shall be programmed to control access by both location and time periods, shall verify all information and immediately grant or deny access, and record the transaction, including date, time, and location. The option of having the transactions printed as they occur shall also be provided. If access is granted, the controller shall send a signal to the appropriate reader to activate the door lock. If access is denied, the transaction will be recorded and/or printed identifying the reason.

b. The system shall be capable of supporting Wiegand, barium ferrite, magnetic stripe, or proximity technology cards.

c. The system shall be designed to maintain access control through two levels of degradation. The intelligent terminal controller shall continue to provide, using its local data base, a full level of access control upon loss of communications with the Facilities Management System. Upon loss of communications with the intelligent terminal controller, the readers shall continue to control access using verification of the facility code in the card and, if used, a PIN entry.

d. The system shall be able to designate certain readers to control only entry or exit, and shall require a cardholder using a card at an entry reader to subsequently use it at an exit reader before again entering the secured area. This shall prevent "passing back" a card to an unauthorized second user.

e. Individual cards may be programmed for special privileges to override access level and time zone parameters.

f. The controller shall provide an interface which permits data to be stored on a tape cartridge.

g. In the event of a power loss, a backup battery shall provide full controller operation for up to eight hours, and memory retention up to 24 hours.

h. Cards shall be programmed into the controller individually; additions, deletions, and changes shall be completed rapidly.

i. Alarms may be programmed by the user for suppression during specific time periods.

j. The intelligent terminal controller shall provide an output for annunciation of alarms.

k. The intelligent terminal controller shall provide a buffer to store 1000 historical transactions if communication is lost with the Facilities Management System.

13. Card Reader(s) and Intelligent Interface(s)

a. The card readers shall consist of an intelligent terminal interface and one or more of the following reader types: (barium ferrite, magnetic stripe, Wiegand, or proximity).

b. The intelligent terminal interface shall control the electric door lock, visual access indicators, access and shunt timers, and an auxiliary access input.

c. The intelligent terminal interface shall monitor door status via a door or lock contact. An alarm shall be reported when the door is not closed and locked, and when the door is forced open.

d. All readers (except proximity) shall provide a red and green visual indicator for granted and denied access, and tamper detection capability.

e. Readers shall be surface or flush mounted.

f. Outdoor readers shall be supplied with special weather-resistant housings.

g. Where required, readers shall be configured with integral 16-position keypads.

h. Readers with 16-position keypads shall be able to verify PIN codes even during loss of communications with the intelligent terminal controller.

i. If the readers lose communications with the intelligent terminal controller, they shall be able to determine authorized access based on the facility code and PIN, if used, which shall be verified at the reader.

j. Proximity readers that are capable of proper operation without the need of standoffs when mounted to walls containing substantial amounts of metal construction shall be available.

C. Devices

1. Wiegand Cards

a. The cards for this security system shall be constructed of top quality, highly durable and resilient PVC plastic material for use with Wiegand ferrite readers.
Cards shall be encoded solely by the manufacturer using the Wiegand pulse generating effect with a highly secure encryption algorithm. Each card shall be encoded with a facility code unique to the security system, an individual card number, and one of eight issue level numbers.

b. The encoded information shall be highly secure from alteration by external magnetic fields.

c. Cards shall be manufactured such that they shall withstand flexing, twisting, and other physical distortion without affecting the integrity of the encoded data.

d. Standard cards shall be available with minimal printing and hot stamped with the facility code and card number. Optionally, hot stamping may be omitted for either or both the facility code and card number.

e. The manufacturer shall provide custom print cards, in accordance to the manufacturer's guidelines, to meet the needs specified by the system owner.

f. Cards shall be the size of a standard credit card and have the feature to laminate a photo or other identifying information.

g. Cards shall be slot-punched at one end to accept a strap clip to attach the card to the user's clothing.

2. Passive Proximity Cards

a. The cards for this security system shall be constructed of top quality, highly durable, and resilient material designed for use with passive proximity readers.

b. Each card shall be encoded with a facility code unique to the security system, an individual card number, and one of eight issue level numbers.

c. Standard cards shall be available with minimal printing and permanently marked with the respective card number and reference code. Optionally, marking either or both the card number and reference code may be omitted.

d. The manufacturer shall provide custom print cards, in accordance to the manufacturer's guidelines, to meet the needs specified by the system owner.

e. Cards shall be the size of a standard credit card and have the feature to laminate a photo or other identifying information.

f. Cards shall be slot-punched at one end to accept a strap clip to attach the card to the user's clothing.

3. Electrostatic Proximity Cards

a. The cards for this security system shall be constructed of top quality, highly durable and resilient material designed for use with active proximity readers.

b. Each card shall be encoded with a facility code unique to the security system, an individual card number, and one of eight issue level numbers.

c. Cards shall be encoded solely by the manufacturer, using a secure and unalterable design which assures reliable reads. At the system owner's request, the manufacturer shall provide the equipment necessary for the system owner to encode only proximity cards for use in the owner's system.

d. Card design shall utilize reliably powered electronics to provide immunity from data alteration by outside forces, and to ensure accurate performance for a minimum of five years.

e. Standard cards shall be available with minimal printing, and permanently marked with the respective card number and reference code. Optionally, marking either or both the card number and reference code may be omitted.

f. The manufacturer shall provide custom print cards, in accordance to the manufacturer's guidelines, to meet the needs specified by the system owner.

g. Cards shall be the size of a standard credit card and have the feature to laminate a photo or other identifying information.

h. Cards shall be slot-punched at one end to accept a strap clip to attach the card to the user's clothing.

4. Magnetic Stripe Cards

a. The cards for this security system shall be constructed of top quality, durable, and resilient PVC laminated with a magnetic stripe of high coercivity material designed for use with magnetic stripe readers.

b. Each card shall be encoded with a facility code unique to the security system, an individual card number, and one of eight issue level numbers. At the system owner's request, the manufacturer shall provide the equipment necessary for the system owner to encode magnetic stripe cards for use only in the owner's system.

c. Standard cards shall be available with minimal printing and permanently marked with the respective card number and reference code. optionally, marking either or both the card number and reference code may be omitted.

d. The manufacturer shall provide custom print cards, in accordance to the manufacturer's guidelines, to meet the needs specified by the system owner.

e. Cards shall be the size of a standard credit card and have the feature to laminate a photo or other identifying information.

f. Cards shall be slot-punched at one end to accept a strap clip to attach the card to the user's clothing.

g. Contractor shall provide (quan.) cards, of (type[s]).

2.8 LIGHTING CONTROLLERS

A. General: Each Standalone DDC Controller shall be able to extend its performance and capacity through the use of remote Application Specific Controllers (ASCs) dedicated to controlling lighting. Lighting Control ASCs shall provide standalone remote control of building lighting circuits, including weekly and holiday time programming, local overrides, and local status indication.

B. Functions: Each Lighting Control ASC shall operate as a standalone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each Lighting Control ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor.

C. Each Lighting Control ASC shall have sufficient memory to support its own operating system and databases, including:

1. Weekly Scheduling
2. Energy Management Applications
3. Local Overrides

D. Devices

1. Occupancy-Based Lighting Control: Each lighting circuit shall have an associated binary override input for monitoring motion detectors, wall switches, photocells, or similar devices. Based upon the contact status of an occupancy sensing device, the AHU Controller shall automatically override normal scheduled control to reduce electricity consumption, while satisfying occupant lighting requirements.

2. The operator interface to any Lighting Control ASC point data or programs shall be through any network resident PC workstation, or any PC or portable operator's terminal connected any DDC panel in the network.

2.9 INTEROPERABILITY WITH EQUIPMENT CONTROLLERS

A. General

1. The Facility Management System (FMS) shall be capable of interoperating with multiple building systems supplied by different manufacturers. The FMS shall be able to receive, react to, and in some cases, return information from multiple building systems.

2. Point inputs and outputs from the third-party controllers shall have real-time interoperability with FMS software features such as: Control Software, Energy Management, Custom Process Programming, Alarm Management, Historical Data and Trend Analysis,

Totalization, and Dial-Up and Local Area Network Communications, as mentioned earlier in the specification.

B. Networking/Communications:

1. The FMS shall support any combination of third-party controllers (if more than one third-party manufacturer is being integrated) on a single network.

2. A minimum of 100 third-party controllers shall be supported on a single network.

3. Integration shall be by RS-232 or RS-485 technologies.

C. Diagnostics/Verification: The installer/operator shall have the ability to verify, and diagnose communication messages and point information between third-party controllers and the Facility Management System.

D. Point Inputs and Outputs: The FMS shall be able to monitor and control the following third-party controller point inputs and outputs:

2.10 HOST COMPUTER INTERFACE WITH FMS

A. General

1. The Facility Management System (FMS) shall be capable of interoperating with a host computer that uses Allen-Bradley PLC-5 commands. The host computer shall be able to monitor and control the FMS through a networked device (e.g., Network Port (NP)).

2. By commanding user-defined points, the host computer shall be able to perform many common FMS tasks over the interface. Such tasks include starting and stopping fans, opening and closing dampers, and adjusting setpoints.

B. Networking/Communications

1. Communications: The FMS shall be capable of communicating with a host computer that uses Allen-Bradley PLC-compatible commands (DF/1 protocol). The following operator commands shall be accepted: Word Range Write, Word Range Read, and Read-Modify-Write.

2. Communication between the host computer and the NP shall occur over a standard RS-232 connection. The communication rate will be at least 9600 baud.

3. The NP shall be able to communicate with other controllers that are monitoring and controlling other segments of the FMS.

4. Local Communication Ports: The NP shall provide at least two RS-232C serial data communication ports for simultaneous operation of two operator I/O devices such as industry standard printers, laptop workstations, and PC workstations.

5. Database Definition: The NP shall be capable of being configured either off-line or on-line.

C. Diagnostics/Verification: The installer/operator shall be able to analyze, verify, and diagnose communication between the host computer and the Facility Management System. The general status of the NP (i.e., on-line/off-line, error state if any) shall be indicated on the front panel for easy reading.

D. Point Inputs and Outputs

1. Capacity: The number of analog data objects which can be defined on the NP shall be expandable to at least 800. The minimum number of binary data objects shall be 3200.

2. Readable Attributes: The host system shall be able to obtain the status of every readable analog or binary point defined in the FMS.

3. Writeable Attribute: The host system shall be able to command a subset of all the writeable analog and binary points defined in the FMS.

4. The Hi-Speed LAN protocol (COMM & DATA) shall also be available (as published document) should it be necessary to accomplish other host-based integration(s).

2.11 OPERATOR INTERFACE

A. Basic Interface Description:

1. Command Entry/Menu Selection Process: Operator Workstation interface software shall minimize operator training through the use of English language prompting, English language point identification, and industry standard PC application software. The operator interface shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device, and "point and click" approach to menu selection. For example, users shall be able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or similar pointing device.

2. Graphical and Text-Based Displays: At the option of the user, Operator Workstations shall provide consistent graphical or text-based displays of all system point and application data described in this specification. Point identification, engineering units, status indication, and application naming conventions shall be the same at all operator devices.

3. Multiple, Concurrent Displays: The Operator Interface shall provide the ability to simultaneously view several different types of system displays in a windowing environment to speed facility operation and analysis. For example, the interface shall provide the ability to simultaneously display a graphic depicting an air handling unit, while displaying the trend graph of several associated space temperatures to allow the user to analyze system performance. If the interface is unable to display several different types of displays at the same time, the FMS contractor shall provide at least two operator stations.

4. Password Protection: Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as he deems appropriate for each user, based upon an assigned password.

a. Passwords shall be exactly the same for all operator devices, including DDC panel portable or panel-mounted network terminals. Any additions or changes made to password definition shall automatically cause passwords at all DDC panels on a network to be updated and downloaded to minimize the task of maintaining system security. Users shall not be required to update passwords for DDC panels individually.

b. A minimum of five levels of access shall be supported:

c. A minimum of 50 passwords shall be supported at each DDC panel.

d. Operators will be able to perform only those commands available for their respective passwords. Menu selections displayed at any operator device, including portable or panel mounted devices, shall be limited to only those items defined for the access level of the password used to log-on.

e. User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line.

5. Operator Commands: The operator interface shall allow the operator to perform commands including, but not limited to, the following:

a. Start-up or shutdown selected equipment
b. Adjust setpoints
c. Add/Modify/Delete time programming
d. Enable/Disable process execution
e. Lock/Unlock alarm reporting for each point
f. Enable/Disable Totalization for each point
g. Enable/Disable Trending for each point
h. Override PID Loop setpoints
i. Enter temporary override schedules
j. Define Holiday Schedules
k. Change time/date
l. Enter/Modify analog alarm limits
m. Enter/Modify analog warning limits
n. View limits
o. Enable/Disable Demand Limiting for each meter
p. Enable/Disable Duty Cycle for each load

6. Logs and Summaries: Reports shall be generated automatically or manually, and directed to either CRT displays, printers, or disk files. As a minimum, the system shall allow the user to easily obtain the following types of reports:

a. A general listing of all points in the network
b. List all points currently in alarm
c. List of all off-line points
d. List all points currently in override status
e. List of all disabled points
f. List all points currently locked out
g. List of all items defined in a "Follow-Up" file
h. List all Weekly Schedules
i. List all Holiday Programming
j. List of Limits and Deadbands

Summaries shall be provided for specific points, for a logical point group, for a user-selected group of groups, or for the entire facility without restriction due to the hardware configuration of the facility management system. Under no conditions shall the operator need to specify the address of hardware controller to obtain system information.

7. Third Party Interface System data, including transactions, alarms, totalization files, etc., shall be stored on the workstation disk drive in an industry standard database format (e.g., dBase IV) such that it is compatible with off the shelf third party database and spreadsheet programs.

8. Live FMS Data Exchange: The Facility Management System shall interface to off-the-shelf personal computer software programs (e.g., Microsoft Word for Windows,

Microsoft Excel, Lotus, etc.) This interface shall conform to Microsoft Corporation's Dynamic Data Exchange (DDE) protocols and standards. The user shall have the ability to "link" the computer programs directly to live, real-time Facility Management System data values. Systems that offer data exchange using only historical, disk resident information will not be acceptable. FMS data value "reads" and "writes" shall both be permissible.

B. Dynamic Color Graphic Displays: Color graphic floor plan displays, and system schematics (for each piece of mechanical equipment, including air handling units, chilled water systems, and hot water boiler systems,) shall be provided as a part of this contract. The total quantity shall be ______.

1. System Selection/Penetration: The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, or text-based commands.

2. Dynamic Data Displays: Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations, and shall automatically update to represent current conditions without operator intervention.

3. Windowing: The windowing environment of the PC Operator Workstation shall allow the user to simultaneously view several graphics at the same time to analyze total building operation, or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

4. Graphics Definition Package: Graphic generation software shall be provided to allow the user to add, modify, or delete system graphic displays.

a. The FMS contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g. fans, cooling coils, filters, dampers, etc.), complete mechanical systems (e.g. constant volume-terminal reheat, VAV, etc.) and electrical symbols.

b. The graphic development package shall use a mouse or similar pointing device in conjunction with a drawing program to allow the user to perform the following:

1) Define symbols
   Position and size symbols
   Define background screens
2) Define connecting lines and curves
3) Locate, orient and size descriptive text
4) Define and display colors for all elements
5) Establish correlation between symbols or text and associated system points or other displays.

C. System Configuration and Definition: All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.

1. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:

a. Add/Delete/Modify Standalone DDC Panels
b. Add/Delete/Modify Operator Workstations
c. Add/Delete/Modify Application Specific Controllers

d. Add/Delete/Modify points of any type, and all associated point parameters, and tuning constants
e. Add/Delete/Modify alarm reporting definition for each point
f. Add/Delete/Modify control loops
g. Add/Delete/Modify energy management applications
h. Add/Delete/Modify time- (and calendar-) based programming
i. Add/Delete/Modify Totalization for every point
j. Add/Delete/Modify Historical Data Trending for every point
k. Add/Delete/Modify custom control processes
l. Add/Delete/Modify any and all graphic displays, symbols, and cross-references to point data
m. Add/Delete/Modify dial-up telecommunication definition
n. Add/Delete/Modify all operator passwords
o. Add/Delete/Modify Alarm Messages

2. Programming Description: Definition of operator device characteristics, DDC panels, individual points, applications and control sequences shall be performed through fill-in-the-blank templates and graphical programming approach. Graphical programming shall allow the user to define the software configuration of DDC control logic for HVAC system control sequences, fan interlocks, pump interlocks, PID control loops, and other control relationships through the creation of graphical logic flow diagrams.

a. Graphical Programming: Control sequences are created by using a mouse input device to draw interconnecting lines between symbols depicting inputs, operators (comparisons and mathematical calculations), and outputs of a control sequence. As a minimum, graphic symbols shall be used to represent:

1) Process Inputs, such as temperature, humidity, or pressure values, status, time, date, or any other measured or calculated system data.

2) Mathematical Process Operators, such as addition, subtraction, multiplication, or greater than, equal to, less than, etc.

3) Logical Process Operators such as AND, OR, Exclusive OR, NOT, etc.

4) Time Delays

5) Process Control Outputs such start/stop control points, analog adjust points, etc.

6) Process Calculation Outputs

7) Text file Outputs and Advisories

b. Network-Wide Strategy Development: Inputs and outputs for any process shall not be restricted to a single DDC panel, but shall be able to include data from any and all other DDC panels to allow the development of network-wide control strategies. Processes shall also allow the operator to use the results of one process as the input to any number of other processes (cascading).

c. Sequence Testing and Simulation: A software tool shall be provided, which allows a user to simulate control sequence execution and test strategies before they are actually applied to mechanical systems. Users shall be able to enter hypothetical input data, and verify desired control response and calculation results via graphical displays and hardcopy printouts.

3. System Definition/Control Sequence Documentation: All portions of system definition shall be self-documenting to provide hardcopy printouts of all configuration and application data. Control process and DDC control loop documentation shall be provided in logical, graphical flow diagram format to allow control sequences to be easily interpreted and modified at any time in the future.

4. Database Save/Restore/Back-Up: Back-up copies of all standalone DDC panel databases shall be stored in at least one Operator Workstation.

5. Continuous supervision of the integrity of all DDC panel data bases shall be provided. In the event that any DDC panel on the network experiences a loss of its data base for any reason, the system shall automatically download a new copy of the respective data base to restore proper operation. Data base back-up/Download shall occur over the local area network without operator intervention. Users shall also have the ability to manually execute downloads of any or all portions of a DDC panels data base.

D. Personal Computer Operator Workstation Description: Personal Computer Operator Workstations shall be provided for command entry, information management, network alarm management, and database management functions. All real-time control functions shall be resident in the Standalone DDC panels to facilitate greater fault tolerance and reliability.

1. Workstations shall be general purpose, commercially available, personal computers with sufficient memory and processor capacity to perform all functions described in this specification.

2. Sufficient hard disk storage shall be provided to accommodate all fully configured point data bases, all application databases, all graphics data bases, all user-defined reports, and all historical data archival as described in this specification.

3. The display provided for system operation shall have a diagonal screen measurement of no less than 14," and a minimum display resolution of no less than 640 x 480 pixels. Separate controls shall be provided for contrast and brightness. The screen shall be non-reflective.

E. Laptop PC Workstation Description: Laptop Personal Computer Operator Workstations shall be provided for command entry, alarm management, information management, and data base management functions. Laptop PCs may be directly connected to Standalone DDC panels on a temporary basis. All real-time control functions shall be resident in the Standalone DDC panels to facilitate greater fault tolerance and reliability.

1. Laptop PC Operator Workstations shall be general purpose, commercially available, personal computers with sufficient memory and processor capacity to perform all functions described in this specification.

2. The Laptop display shall have a diagonal screen measurement of no less than 9," and a minimum display resolution of no less than 640 x 480 pixels. The screen shall be non-reflective.

F. Standalone DDC panel Local or Portable Operator's Terminals: Each DDC panel shall be capable of supporting an operator's terminal for local command entry, instantaneous and historical data display, and program additions and modifications.

1. There shall be a provision for both permanently mounting the standalone DDC panel Operator Terminal, or using it as a portable hand-held unit.

2. The DDC panel Operator Terminal shall simultaneously display a minimum of 6 points with full English identification to allow an operator to view single screen dynamic displays depicting entire mechanical systems.

3. The operator functions provided by the DDC panel Operator Terminal shall include, but not be limited to, the following:

a. Start and Stop Points
b. Modify Setpoints
c. Modify PID Loop Setpoints
d. Override PID Control
e. Change Time/Date
f. Add/Modify Start/Stop Weekly Scheduling
g. Add/Modify Setpoint Weekly Scheduling
h. Enter Temporary Override Schedules
i. Define Holiday Schedules
j. View Analog Limits
k. Enter/Modify Analog Warning Limits
l. Enter/Modify Analog Alarm Limits
m. Enter/Modify Analog Differentials
n. View Point History Files

4. The DDC panel Operator Terminal shall provide access to all real or calculated points in the controller to which it is connected, or any other controller in the network. This capability shall not be restricted to a set of predefined "global points," but shall provide totally open exchange of data between the operator terminal and any DDC panel in the network.

5. Operator access at all DDC panel Operator Terminals shall be identical to each other, as well as identical to the PC or Laptop Operator Workstations. Any password changes shall automatically be downloaded to all DDC controllers on the network.

6. The DDC panel operator terminal shall provide English language prompting to eliminate the need for the user to remember command formats or point names. Prompting shall be provided consistent with a user's password clearance and the types of points being displayed, to eliminate the possibility of operator error.

7. A multi-function touchpad shall be provided for point and command selection, as well as parameter entry. To minimize the possibility of operator error, the DDC panel Operator Terminal shall change and limit touchpad functions based upon an operator's password clearance, the function being performed, and types of points being displayed. Screen displays shall clearly indicate only valid touchpad functions.

8. Context-Sensitive Help: On-line, interactive user's "Help" manuals and tutorials shall be provided. Based upon operator request, the "help" function shall provide general system operating instructions, and specific descriptions of commands available in the currently displayed menus.

9. Identification for all real or calculated points shall be consistent for all network devices. The same English language names used at PC workstations shall be used to access points at the DDC panel Operator's Terminal to eliminate cross-reference or look-up tables.

10. In addition to instantaneous summaries, the DDC panel Operator's Terminal shall allow a user to view a Point History file for system points. Point History files shall provide a record of value of analog points over the last 24 hours, at 30-minute intervals, or a record of the last ten status changes for binary type points.

G. Telephone Interface: The Operator Workstation shall have an optional telephone interface feature that allows users to control lighting and HVAC equipment from a telephone. This interface shall be convenient, easy to use, and available to all tenants who work after hours or during the weekend.

1. The user shall access the telephone interface by dialing the prescribed number on a Touch Tone phone and entering a series of numbers, including a password. Password protection shall protect the telephone interface from intruders. A password shall also be required by those who manage the telephone interface database.

2. The user shall control lights and HVAC equipment by simply entering digits. (For example, pressing "1" shall turn on the lights in your area.)

3. For monitoring purposes, all telephone interface transactions shall be recorded in a text file for later reference.

4. For consistency, the user interface portion of the telephone interface shall resemble the other parts of the Operator Workstation PMI.

5. The user shall be able to make at least eight different commands for a particular location.

6. The telephone interface shall be capable of supporting a minimum of four telephone lines.

7. The user shall be able to print out summaries that show the contents of the telephone interface database.

8. On-line help screens shall be provided to assist the user who manages the database.

H. Staff Workstation (Customizable User Interface) The Operator Workstation shall have optional custom user interfaces that are specifically designed for particular vertical markets, such as Hospitals or Schools/Universities. These user interfaces shall be in addition to the standard Operator Workstation PMI. The customer or the factory shall be able to modify the user interface to match the individual needs of the customer. Most operations shall be performed with a mouse, which will make the interface simple and obvious to operate.

I. VT100 Compatible PC Workstation Description:

1. The FMS shall have an easy-to-use, VT100 interface device that shall allow the operator to monitor the facility, control the facility, and access current and archived FMS data. The device shall be either direct connected to the network unit or remote connected with a pair of Hayes-compatible modems.

2. The operator shall be able to use the VT100 interface device to:

a. Command points

b. Display the following summaries: System, Object, Alarm, Override, Devices, Report/Access Group, Click-related, Password, Alarm Message, Feature-related

c. Display detailed information about a point

d. Perform trending operations on a point

e. Perform totalization operations on a point

f. Perform scheduling operations on a point

g. Generate and display passwords

h. Generate and display alarm messages

i. Set the clock functions

PART 3 - EXECUTION

3.1 INSTALLATION

A. All wiring and tubing shall be properly supported and run in a neat and workmanlike manner.

1. All wiring and tubing exposed in equipment rooms shall run parallel to or at right angles to the building structure.

2. All piping and wiring within enclosures shall be neatly bundled and anchored to prevent restriction to devices and terminals.

B. The FMS contractor shall be responsible for all electrical installation which is necessary to a fully functional system (and which may or may note be shown on the electrical plans, or required by the electrical specifications). All wiring shall also be in accordance with applicable local and national codes.

1. All wiring shall be installed in conduit and be in accordance with the electrical specifications, Division 16.

2. Electrical power for FMS panels and OWS shall be provided via dedicated circuits at the emergency power panel.

C. Pneumatic Piping

1. Air piping: Hard copper tubing, type L with soldered joints or, where allowed by code, in accessible locations, polyethylene tubing with brass or rigid, unplasticized polyvinyl chloride fittings.

a. Provide copper tubing or polyethylene tubing in conduit for air piping in equipment rooms and air handling units except inside control panels.

b. Size in accordance with manufacturer's recommendations.

c. Use compression fittings on copper tubing only at connections to valves, damper motors, etc.

2. Polyethylene tubing: Virgin black polyethylene

a. Molecular weight: Not less than 25,000

b. Melt index: Not more than 0.3 decigram per minute.

c. Tube strength: To withstand 48 hour immersion in 100 percent IGEPAL solution at 73 deg. F (22 deg. C) in accord with ASTM-D1693.

d. Tube bundle configuration: in lieu of racking groups of tubes, individually numbered or color coded black tubes factory assembled in a parallel lay and wrapped with Mylar or nylon tape. Provide outer jacket of polyvinyl chloride or polyethylene for mechanical protection.

3. Adequately strap and support copper air piping, however do not attach to ductwork, conduit or other systems. Do not use wire to support tubing.

4. In equipment rooms and non-accessible locations, install polyethylene tubing in conduit. Use standard electrical boxes at junction points with covers so no portion of plastic tubing is exposed to physical damage.

D. Control wiring:

1. Include low voltage wiring (100 volts and less) required for temperature control systems under this section.

2. Conductors for control signals: No. 18 or 19 AWG copper conductors as required.

a. Connector may be assembled in cable with PVC insulation minimum of 0.016 IN thick.

b. Cable outer sheathing standard with manufacturer.

c. Line voltage wire for temperature control suitable for 600 volts, 168 deg. F temperature with Type THW plastic covering, minimum of No. 18 AWG.

3. Conduit:

a. Conduit: Electrical metallic tubing.
b. Couplings: Set screw.
c. Flexible conduit: Steel armor.
d. Provide conduit for all control wiring.

4. Supporting devices:

a. Conduit supports must conform to seismic restraint criteria established by governing authority.

b. Single runs: Galvanized conduit straps or ring bolt type hangers with specialty spring clips. Do not use plumber's perforated straps.

c. Multiple runs: Conduit rack with 25 percent spare capacity.

d. Vertical runs: Channel support with conduit fittings.

5. Anchor methods:

a. Hollow masonry: Toggle bolts or spider type expansion anchors.
b. Solid masonry: Lead expansion anchors or present inserts.
c. Metal surfaces: Machine screws, bolts, or welded studs.
d. Wood surfaces: Wood screws.
e. Concrete surfaces: Self drilling anchors or power driver studs.

E. Equipment

1. Temperature sensing wells: Provide list with shop drawing of well locations.

2. In general, locate temperature sensors, humidity sensors, thermostats and humidistats for room control immediately inside of door, above light switch, or where shown.

a. Where light switch is in an entryway to room, locate sensor and/or stat on wall within room so it is capable of sensing true space conditions.

b. Prior to installation, coordinate sensor and/or thermostat locations with Construction Manager.

3. Mount local control panels at convenient locations adjacent to equipment served.

a. Mount all relays, PE switches, pressure switches, etc., internal to the temperature control panels

b. Tag each instrument corresponding to symbols used on control diagrams..

c. Make fully compensated capillaries connected to instruments of sufficient length to allow them to be run in neat and workmanlike manner and placed in such position so that they will not obstruct service on equipment controlled.

4. Mounting of field microprocessors on air handling units shall not be allowed.

3.2 COMMISSIONING

A. Control system to be set up and checked out by factory trained competent technicians skilled in the setting and adjustment of FMS equipment used in this project. This technician to be experienced in the type of systems associated with this FMS.

B. At time of final observation, demonstrate the sequence of operation for each system to Construction Manager. Perform system demonstration as directed by Construction Manager.

3.3 TRAINING

A. Provide a minimum of (TBD) hours of instructions to Owner's personnel in the operation and maintenance of the control system. Provide training after the system has been installed and checked out.

B. Provide a paid tuition for (TBD) student to attend a minimum 5 day factory training course as selected from the FMS Supplier's catalogue.

3.4 WARRANTY

A. At completion of final test of installation and acceptance by Owner, provide any service incidental to proper performance for a period of one year.

B. Equipment shall be warranted for one year (including defects in workmanship and material) under normal use and service. During warranty period supplier shall also replace or repair, free of charge, any equipment proven to be defective in workmanship or material.

C. Certain electronic devices not manufactured by the FMS supplier, such as computers, printers and CRT's display, shall carry the original manufacturers warranty. Pass any registration and warranty documents and warranty rights to the Owner.

END OF SECTION

SECTION 14620

MONORAIL SYSTEMS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

ANTI-FRICTION BEARING MANUFACTURERS ASSOCIATION, INC. (AFBMA)

AFBMA 11(1990)	Load Ratings and Fatigue Life for Roller Bearings
AFBMA 9	(1990) Load Ratings and Fatigue Life for Ball Bearings

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI B18.22.1	(1965; R 1981) Plain Washers
ANSI B30.16	( ) Overhead Hoists
ANSI B30.10	( ) Hooks
ANSI HST-4M	( ) Overhead Electric Wire Rope Hoists
ANSI C80.1	(1990) Rigid Steel Conduit - Zinc Coated

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 307	(1992) Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength
ASTM A 36	(1991) Standard Specification for Structural Steel

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1	(1992) Structural Welding Code - Steel

FEDERAL SPECIFICATIONS (FS)

FS FF-B-171	(Rev A; Am 1) Bearings, Ball, Annular (General Purpose)
FS FF-B-185	(Basic; Am 4) Bearings, Roller, Cylindrical; and Bearings, Roller, Self and Aligning
FS RR-W-410	(Rev D; Am 1) Wire Rope and Strand

MONORAIL MANUFACTURERS ASSOCIATION (MMA)

MMA-01	(1981) Underhung Cranes and Monorail Systems

NATIONAL ELECTRICAL MANUFACTURER'S ASSOCIATION (NEMA)

NEMA 250	(1991) Enclosures for Electric Equipment (1000 Volts Maximum)
NEMA KS 1	(1990) Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1993) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 50	(1992; 10th Ed) UL Standard for Safety - Enclosures for Electrical Equipment

1.2 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Manufacturer's Catalog Data shall be submitted for the following items:

Wire Rope
Rope Drums
Load Block and Sheaves
Hook and Gear Assemblies
Bearings
Lubrication
Frame and Housing
Paint Materials
Hoists
Trolleys
Monorail Tracks

B. Drawings

1. Fabrication Drawings shall be submitted for Monorail and Hoist Systems consisting of fabrication and assembly details to be performed in the factory.

2. Installation Drawings shall be submitted for Monorail and Hoist Systems in accordance with the paragraph entitled, "Installation of Monorail Track," of this section. Drawings shall indicate loadings and structural support for the hoist assembly, location and size of beam or track, power source, location of controls, headroom, clearance, and lift requirements. Drawings shall also indicate capacity, weights, dimensions, hoisting rope or chain, shafts, bearings, drums, blocks, reeving, motor description and characteristics, limit switches, controller and brakes, trolley speed, safety factor of hoist and trolley, wiring, and nonsparking, noncorroding qualities when applicable.

C. Instructions: Manufacturer's Instructions shall include details of installation, operation, maintenance, and repair of Monorail and Hoist Systems. Repair section shall contain replacement part numbers for the entire assembly.

D. Reports: The following Test Reports shall be submitted for the monorail electrification system in accordance with the paragraph entitled, "Testing," of this section.

Continuity Tests
Insulation Tests

E. Certificates: The following Certificates of Compliance shall be submitted:

1. Certification that each hoist, hoist trolley and track, and hoist control has been factory tested for rated load capacity and operation; and that each hoist complies with the requirements specified

2. Certification that a sample hoist of each type specified has been factory tested for the tests specified in "Acceptance Provisions"

3. Certified results of thermal monitoring of motor components during tests

4. Certification that electric hoists, trolleys, wiring, contact conductors, controls, overcurrent protection, and grounding conform to NFPA 70, and to UL standards. Label or listing with reexamination by the UL will be accepted as evidence that the materials conform to this requirement and to NFPA 70.

F. Samples: A Preproduction Sample Hoist of each specified type shall be provided immediately after the award of the contract and prior to submission of complete units for final acceptance. Sample hoist shall be inspected to determine conformance with this specification. Approval of the sample shall not relieve the Contractor of his obligation to supply equipment conforming to this specification. No changes or deviations from the preproduction sample hoist will be acceptable without written approval.

1.3 DEFINITIONS

A. Capacity shall mean the rated load in pounds, or tons of 2,000 pounds each, specified by the manufacturer for the hoist and marked plainly on the hoist and loadblock so as to be clearly legible. In determining the applied load, handling devices shall be included.

B. Hoisting speed shall mean the velocity in feet per minute (fpm) at which the hoist will lift the rated load. Actual lifting speed shall be within plus or minus 10 percent of the manufacturer's rating.

C. Rated lift shall mean the distance between the upper and lower elevations of travel of the load block.

D. Headroom shall be measured with the load hook in the highest position with full load; it is the distance between the saddle of the load hook and the bottom of the beam when S-shape runways are used

E. Trolley speed shall mean the velocity in fpm at which a motordriven trolley with hoist will travel carrying the rated load on level track; actual speed shall be within plus or minus 10 percent of the manufacturer's rating.

1.4 WELDING: Section 05055, "Welding Steel Construction," applies to work specified in this section. Welding shall conform to AWS D1.1.]

1.5 HOIST CHARACTERISTICS

A. [Hoist shall be an electric wire-rope hoist of type, H3 or H4, control, suspension, lift, and operating characteristics specified.]

B. Each hoist shall have the capacity, lift-height, suspension, power source, and operating characteristics indicated and as follows:

C. Hoist capacity shall be 5 tons.

D. Hoist shall be a standard lift with a minimum lift of 26'-6".

E. [Hoist shall be the lug-suspension type mounted on an electric-motor-driven trolley.

F. Hoist and suspension shall be the minimum] headroom type.

G. Components of the hoist shall be designed and constructed for safety of operation and durability of components. Replacement parts shall be interchangeable and readily accessible.

1.6 ACCEPTANCE PROVISIONS

A. General

1. Hoists of each type specified shall be factory load tested for static overload and tests as specified.Hoists shall be subjected to continuous-operating tests and dynamic-overload tests. Installed hoists shall also be tested. Certificates of compliance shall be presented with factory test results.

2. Hoists and accessories shall be free of manufacturing defects, abrasions, and damage.

3. Moving parts of each hoist shall be factory lubricated. Enclosed gear trains shall have a full charge of lubricant.

B. Static-Overload Test:

1. Hoist shall support a static load of 125 percent of the rated capacity for not less than 5 minutes. Load shall be suspended with the wire rope extended to the limit of the specified lift. No breakage or permanent distortion of the hoist parts shall occur during or after this test.

2. Hoists shall not drift or slip after stopping when the power supply is cut off, and shall raise and lower the rated load without jerk or hesitation. Load shall remain suspended when the power source is shut off and shall not lower without application of power. When released, controls shall return, without sticking, to the closed position.

3. After completion of the tests, motors, gears, bearings, chain, wire rope, sprockets, and other wearing parts shall be examined for excessive wear. Excessive wear is defined as that which is sufficient to impair safe operation of the hoist.

C. Dynamic Overload Test

1. Each hoist delivered to the project site shall be subjected to a dynamic overload test of 125 percent of the rated capacity.

2. Required test weights shall be provided by the Contractor.

3. Contractor shall provide labor and transportation as required to pick up and transport weights to the test area and to return test weights to storage.

4. Hoist shall be loaded to 125 percent of rated capacity and operated by hoisting and lowering a minimum of 24 inches. Trolley type hoists shall be operated back and forth over a section of suitable track, 8 or more feet in length with the 125 percent load in suspension.

This test shall be performed 15 times at the highest rate of speed of which the operator is capable. Hoists shall operate satisfactorily without evidence of permanent distortion or damage to any part, drift at stationary suspended elevation, and dropping or override when lowering. Notice shall be taken of the condition of thrust washers and friction brakes (spur-geared hoists) after this test. Excessive wear of these parts shall be cause for rejection.

D. Monorail Electrification System Factory Tests

1. Factory tests on monorail electrification systems and associated fittings shall be made in accordance with the applicable provisions of the referenced standards.

2. Routine tests shall include dielectric tests on monorail electrification system. Certification of dielectric tests shall be submitted and shall show compliance with the referenced standard.

PART 2 - PRODUCTS

2.1 WIRE ROPE

A. Wire rope for standard applications shall be extra flexible, preformed, improved plow steel, 6 by 37 fiber core sealed construction wire conforming to FS RR-W-410, Type I, Class 3.

B. Wire rope for single line application shall be preformed, improved plow steel 18 by 7, fiber core, nonrotating wire conforming to FS RR-W-410, Type IV, Class 2.

C. Wire rope for noncorroding, nonsparking hoist application shall be preformed AISI Type 304, 18-8 corrosion-resistant steel, 6 by 19, bright finish, conforming to FS RR-W-410, Type I, Class 2.

D. Wire rope shall be anchored to drum or dead end. Anchoring shall be of captive type, easily detached for changing and repair.

E. Wire rope shall have a factor of safety of not less than 5, based on the minimum ultimate tensile strength of the material.

2.2 ROPE DRUM

A. Wire rope drum shall be hardened steel or special grade alloy ductile iron. Minimum diameter of the drum shall be in accordance with ANSI B30.16. Drum shall have accurate, machine-cut grooves, cut to full depth of wire rope diameter, with rounded corners of dimension as required for the specified lift. In addition, the drum shall have not less than two complete turns of rope around it when the hook is in its lowest position. Drum shall be flanged at each end and shall have enclosed tops and sides to preclude cable binding and jamming.

B. Cable reeving shall be arranged for double reeving. Hook shall remain centered under the drum at all times.

2.3. LOAD BLOCK AND SHEAVES

A. Cable load block shall be an enclosed, safety type that will shroud the sheave and protect the operator. Sheave assembly shall be mounted on a steel axle and carried on sealed, prelubricated antifriction bearings.

B. Wire rope sheaves shall be machine-grooved, hardened steel or cast iron with chilled groove surfaces. Pitch diameter for running sheaves shall be not less than 18 times the diameter of the wire rope, and the diameter of the idler and equalizer sheaves shall be not less than 16 times the diameter of the rope used.

2.4 HOOK ASSEMBLY

A. Hooks and hook swivels shall conform to ANSI B30.10 and shall be heat-treated alloy steel forgings. Yokes, crossheads, and bars shall be of suitable strength steel or cast iron.

B. Hook assembly for electric hoists shall be carried on antifriction bearings to permit free swivel under rated capacity load without twisting load chain or wire.

C. Each hook shall have a spring-loaded safety latch.

D. Each hook assembly shall include a machined and threaded shaft and swivel locknut with an effective locking device to prevent nut from backing off.

2.5 GEAR ASSEMBLY

A. Gears shall be spur, helical, spiral, or bevel type, accurately machined, and conforming to AGMA standards for this type of service.

B. Gear shafts shall be manufactured from high carbon-steel or alloy steel, machined and ground for accurate fit, and splined for fitting to the mating gear.

C. Gear train assembly shall be totally enclosed in the hoist frame casting and shall operate in a sealed oil bath. Frame casting shall be provided with lubrication fittings and inspection ports.

2.6 BEARINGS

A. Bearings in the hoist mechanism of electric hoists shall be antifriction bearings, either needle-type roller bearings or end- and radial-thrust ball bearings operating in an oil bath.

B. Sprocket bearings, motor bearings, and load-block bearings shall be prelubricated factory sealed bearings.

C. Minimum bearing life rating shall be 3,000 hours as defined by AFBMA 9, or AFBMA 11, as applicable.

2.7 LUBRICATION

A. Adequate lubrication shall be provided for moving parts of the hoist and trolley and for filling, draining, and checking the level of the lubricant.

B. Hoist reduction gearing, load brake, and trolley wheel gears with electric motor drive shall operate in an oil bath.

C. Lubrication and mechanism housing shall prevent leaking and lubricant from coming into contact with electrical motors and equipment. Drip pans shall be provided for all locations where leakage or drips could occur.

2.8 FRAME AND HOUSING

A. Operating parts of the hoist shall be mounted and enclosed in a sealed, factory-painted metal frame of malleable iron, cast steel, welded steel, or aluminum.

B. Welded or bolted frames shall carry loads on the fabricated pieces. Welds or bolts shall be used only to hold the fabricated parts in position.

2.9 PAINT FINISH: Each hoist, lift block hook, and accessory shall receive a factory-applied paint finish.

2.10 ELECTRIC HOIST

A. General:

1. Electric hoist, wiring, contact conductors, controls, overcurrent protection, and grounding shall conform to NFPA 70, and to the applicable UL standards and specified requirements.

2. Electric hoist shall be of capacity, lift, type, suspension, headroom, and materials specified.Each unit shall be factory wired and ready for operation.

3. Load-carrying parts of the hoist shall be designed so that the calculated static stress of the material, based on the rated capacity, will not exceed 20 percent of the average theoretical strength of the material.

4. Each hoist shall be factory lubricated and shall be complete and ready for operation with the specified controls and accessories.

B. Electric Wire-Rope Hoists shall be equipped with a noncorroding, nonsparking wire-rope and hook assembly.

C. Hoist Speed and Horsepower

1. Each wire-rope electric hoist shall be of variable hoist speed with maximum 25 fpm.

2. Hoist motor shall be of horsepower as recommended by manufacturer for capacity and lift speed of hoist.

D. Hoist Motors: Hoist motor shall be a high-starting torque, high-slip, 30-minute time rated, reversible electric motor specifically designed for hoist duty and capable of operation at the specified duty class, capacity, and speed. Voltage, phase, and frequency requirements shall be as indicated.

E. Motor Type: Hoist motors shall be totally enclosed, nonventilated type, certified for 30-minute, time-rated operation at full identification plate power output in an ambient temperature of 40.0 degrees C.

F. Motor Bearings

1. Motor bearings shall be heavy-duty ball or roller antifriction type with full provision for the type of thrust imposed by the specific duty load. Bearings shall have a minimum 90-percent bearing rating of 30,000 hours as defined by AFBMA 9 or AFBMA 11 as applicable.

2. Pressure relief shall be to the outside of the housing. Lubrication fittings shall be fitted with color-coded plastic or metal dust caps.

3. Bearings in any motor lubricated at the factory for extended duty periods shall be so identified with labels or tags. Tag shall state that the motor shall not be lubricated for a given number of operating hours.

G. Motor Controller

1. Motor controller shall be a reversing-type magnetic starter with thermal-overload protection, molded case circuit breaker, and low-voltage transformer, operated by a pushbutton control station. Controller and control station shall be mechanically or electrically interlocked to preclude possibility of operating opposing control circuits simultaneously.

2. Contactor fingers shall be adjustable and shall have renewable tips.

3. Transformer shall reduce the control-circuit voltage to 120 volts alternating current (ac) or to 24 volts ac.

4. Motor controller shall be mounted in a gasketed cast-metal or sheet-metal enclosure with hinged door conforming to the requirements of UL 50.

5. Motor controller enclosure shall be NEMA 250, [Type 1 - general purpose.

H. Pushbutton Control Station

1. Each hoist shall have a pendant-mounted conductor cable and pushbutton station with a strain-reliever chain or cable permanently attached to the hoist frame and integral with the pendant conductor cable.

2. Control station shall be a full-guarded, momentary-contact, pushbutton type with each button clearly marked to indicate its function. A separate button or a single button providing steps for each speed of multispeed hoists or trolleys shall be provided. Pushbuttons shall return to the off position when pressure is released by operator.

3. Pushbutton station shall be grounded to the hoist. Strain reliever chain or cable shall not be used as a grounding circuit.

I. Limit Switches

1. Adjustable upper-limit switch shall be provided to prevent overtravel of the hook or load block in the hoisting direction. Limit switch shall be arranged to stop the hoist motor and apply the motor brake before reaching the uppermost safe limit of travel. In case of hook overtravel, the motor shall be automatically and momentarily reversed.

2. Adjustable lower-limit switch shall be provided to stop the hoist motor and apply the motor brake when the load hook reaches a predetermined lower limit.

J. Wiring: Each hoist shall be completely wired by the manufacturer in accordance with NEC and UL standards. Exposed flexible wiring from controller housing to hoist and trolley motors shall be Type SO, flexible, neoprene, oil-resistant cable.

K. Load Brake shall be a totally enclosed, automatic, mechanical-type brake with a hardened-steel, Weston-type ratchet and pawl mechanism that will hold the capacity load of the hoist at any point when the motor is stopped.

L. Motor Brake

1. Motor brake shall be an externally adjustable, electrically-operated shoe or multiple friction disk brake that shall apply automatically when the power is off.

2. Motor brake shall be capable of holding the capacity load of the hoist at any point independent of the load brake in addition to stopping and safely holding 125 percent of the rated load from any operating speed. Brake shall hold a static load equal to 150 percent of the rated capacity of the hoist.

2.11 TROLLEYS

A. Each trolley assembly shall be factory painted, designed specifically for use with the specified hoist, and shall be furnished by the hoist manufacturer. Paint finish shall be the same type and quality specified for the hoist.

B. Each trolley assembly shall have not less than four wheels. Sufficient wheels shall be provided to properly distribute the load.

C. Wheels shall be single-flange type manufactured from forged alloy steel with machined, hardened treads and flanges, or high-strength cast or nodular iron with machined flanges and treads, chill-hardened not less than 1/16-inch deep. Flanged wheels for motor-driven trolleys shall have treads and flanges hardened to not less than No. 320 Brinell hardness.Manually driven, trolley-wheel treads shall be hardened to not less than No. 245 Brinell hardness as defined in ASTM E 10. Wheels shall be designed to operate on either sloped or flat flange I-beams.

D. Trolley wheels shall be carried on sealed, permanently lubricated, antifriction bearings designed for axial and thrust loading. Minimum bearing rating life shall be 3,000 hours, as defined by AFBMA 9 or AFBMA 11 as applicable. Bearings shall be provided with fittings for pressure lubrication.

E. Side plates shall be fabricated from structural-quality rolled-steel plate milled to the required profile with integral bosses where necessary to support equalizing pins; side plates shall be fitted with steel end bumpers.

F. Equalizing pins and axles shall be heat-treated alloy steel, machined and finish ground to the required size.

G. Gears shall be cut from heat-treated alloy steel accurately machined into spur, helical, and pinion gears, conforming to AGMA requirements.

H. Drive pinions shall be carburized alloy steel, malleable iron, or bronze, with cut or cast teeth, conforming to AGMA requirements.

I. Safety hangers or lugs shall be steel and shall be integral with, or fastened to, each hoist frame or to trolley frame. They shall ride free above the bottom flange of the beam. Hanger shall be of sufficient capacity to hold the hoist, fully loaded, in the I-beam in case of wheel or axle failure.

J. Safety factor of each part of trolley assembly shall be not less than 5, based on the ultimate strength of the material used.

2.12 TROLLEY TYPE

A. Electric-Motor-Driven Trolleys

1. Electric trolleys, wiring, contact conductors, controls, overcurrent protection, and grounding shall conform to NFPA 70, and to the specified requirements.

2. Trolley shall be an electric-motor-driven geared type conforming to NFPA 70, the specified general trolley requirements, and the requirements specified.

3. Trolley motor shall be a single-speed, totally enclosed, nonventilated, high-starting-torque, 30-minute time-rated, reversible, electric motor specifically designed for monorail trolley operation at an ambient temperature of 40.0 degrees C.

4. Motor controller shall be a reversing-type, magnetic starter with overload protection and a low-voltage transformer operated by means of a full-guarded, momentary-contact, pushbutton, pendant control station.

5. Pushbutton control station shall be integrated with the pendant pushbutton control of the hoist.

6. Trolley unit shall have an automatic, adjustable, solenoid-operated, electric brake designed for trolley application. Brake shall apply and release smoothly during starts and stops to minimize pendulum action of the load. Braking torque shall be not more than 50 percent of motor torque and shall match motor torque characteristics.

7. Trolley speed shall be 20 and 80 fpm.

B. Monorail Electrification System

1. Monorail electrification system for power distribution from the source of supply to mobile tap-off devices shall consist of an approved, three-wire festooned conductor system of a type listed in the UL-05 for the quality of materials and type of service.

2. System shall be complete with festooned system, and power-interrupting sections; disconnect switch; and conduit and wiring to source of supply.

3. Power feed sections shall be clamped or bolted to conductors as required for the type of conductor and ampere load capacity.

4. Support brackets, hanger clamps, and fasteners shall be steel with electrogalvanized finish conforming to ASTM A 591/A 591M, Class C, or an electrodeposited cadmium finish. Brackets shall be spaced at a maximum of 5 feet on center for straight sections.

5. Disconnect switch shall be a surface-mounted, heavy-duty, single-throw, air-break, enclosed type conforming to NEMA KS 1 as indicated and as follows:

a. Disconnect switch shall be nonfused].

b. Enclosure shall be NEMA 250, Type 12, - industrial use, dusttight, and driptight].

6. Enclosure shall be installed with centerline 66 inches above the finished floor and in the approximate center of the monorail.

2.13 MONORAIL TRACK

A. General

1. Monorail track, splice plates, and hangers shall be painted, hot-rolled structural steel I-beam and wide-flange shapes and plates conforming to ASTM A 36/A 36M, of size and weight as required for the specified hoist.

2. Track shall be designed with a minimum safety factor of 5. Deflection of track shall not exceed 1/450 of the span, as determined by total load of trolley, track, hoist, and full capacity load.

3. Necessary clamps, hanger rods, hangers, track splice plates, end stops, fasteners, and fittings shall be provided as required for a complete system.

4. Web-type splice plates or other suitable couplings shall be installed at track joints to provide flush and level connections, with maximum gap between adjacent ends at load carrying ends not exceeding 1/16 inch; 3/16 inch. Splice fasteners shall be regular hexagon or special, flat-head fasteners.

5. Safety stops capable of withstanding the impact of a fully loaded hoist and trolley shall be provided.

B. Fasteners: Unfinished threaded fasteners shall consist of regular hexagon-head carbon steel bolts and nuts and special flathead bolts and nuts conforming to ASTM A 307, Grade A. Washers shall be plain carbon steel conforming to ANSI B18.22.1, Type B.

C. Paint Finish: Finished monorail shall be inspected after erection, and fasteners, welds, abrasions, and handling marks shall be painted in the finish color. Brackets and hangers of the monorail electrification system shall be painted in the finish color of the monorail track.

PART 3 - EXECUTION

3.1 INSTALLATION OF MONORAIL TRACK

A. Monorail tracks shall be installed in accordance with the applicable requirements of MMA-01, "Specification for Underhung Cranes and Monorail Systems."

B. Tracks shall be accurately assembled to the lines and elevations indicated. Fastening of splices shall be performed after the abutting surfaces have been brought completely in contact.

C. Connections shall be bolted or welded connections.

D. Splices will be permitted only when indicated. Erection bolts used in welded construction may be tightened securely and left in place when they form no interference to trolley operation. If erection bolts are removed, the holes shall be plug welded and ground smooth.

E. Monorail track shall be installed plumb and level to a tolerance of not more than 1 inch in 100 feet from the indicated elevation. Track shall be free of burrs, kinks, and deformation. Curves shall be smooth and even with no kinks or sharp bends.

F. Track flanges shall be smooth and level.Welded joints and connections shall be ground smooth and offer no obstruction to trolley-wheel movement.

3.2 ON-SITE MONORAIL ELECTRIFICATION SYSTEM TESTS

A. Monorail electrification system shall be given continuity and insulation tests after the installation has been completed but before equipment is energized.

B. Contractor shall provide necessary test equipment, labor, and personnel to perform the tests as specified. Insulation testing instruments shall consist essentially of a direct-reading ohmmeter and a motor-driven direct current (dc) generator. Continuity tests shall be conducted using a dc device with bell or buzzer.

C. Monorail electrification system equipment shall be completely isolated from all extraneous electrical connections. Substation and switchboard feeder breakers, circuit breakers in panelboards, and other disconnecting devices shall be used to isolate the equipment under test.

D. Insulation tests on 480-volt, monorail equipment shall be conducted using a 1,000-volt, insulation-testing instrument. Readings shall be recorded every minute and until three equal and consecutive readings are obtained. Resistance between phase conductors and between phase conductors and ground shall be not less than 50 megohms.

E. Insulation tests on monorail equipment 300 volts or less shall be conducted using a 500-volt, insulation-testing instrument. Reading shall be recorded after 1 minute and until the reading is constant for 15 seconds. Resistance between phase conductors and between phase conductors and ground shall be not less than 25 megohms.

F. Test data shall be recorded and shall include location and identification of busway and megohm readings versus time.

G. Final acceptance shall depend upon satisfactory performance under test. Monorail electrification system shall not be energized until recorded test data are approved.

END OF SECTION

SECTION 14630

HOISTS AND CRANES

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

ANTI-FRICTION BEARING MANUFACTURERS ASSOCIATION, INC. (AFBMA)

AFBMA 9	(1990) Load Ratings and Fatigue Life for Ball Bearings

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)

AGMA 250.04	(1981) Lubrication of Industrial Enclosed Gear Drives

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC S329	(1986) Allowable Stress Design Specification for Structural Joints Using ASTM A 325 or ASTM A 490 Bolts

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI B18.22.1	(1965; R 1981) Plain Washers

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 307	(1992) Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength
ASTM A 325	(1993) Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 KSI Minimum Tensile Strength
ASTM A 36	(1991) Standard Specification for Structural Steel

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1	(1992) Structural Welding Code - Steel

CRANE MANUFACTURERS ASSOCIATION OF AMERICA (CMAA)

CMAA 74	(1987) Specification for Top Running and Under Single Girder Electric Overhead Traveling Cranes Utilizing Under Running Trolley Hoist

FEDERAL STANDARDS (FED-STD)

FED-STD 595	(Rev B) Colors Used in Government Procurement

FEDERAL SPECIFICATIONS (FS)

FS RR-W-410	(Rev D; Am 1) Wire Rope and Strand

JOINT INDUSTRIAL COUNCIL (JIC)

JIC-01	(1967) Electrical Standards for Mass Production Equipment

NATIONAL ELECTRICAL MANUFACTURER'S ASSOCIATION (NEMA)

NEMA 250	(1991) Enclosures for Electric Equipment (1000 Volts Maximum)
NEMA ICS 1	(1988; Rev 1 - May 1989; Rev 2 - Jan 1990) General Standards for Industrial Control and Systems
NEMA KS 1	(1990) Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1993) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 50	(1992; 10th Ed) UL Standard for Safety - Enclosures for Electrical Equipment

1.2 SUBMITTALS

A. Drawings: Installation Drawings shall be submitted for Electric Overhead Crane Systems in accordance with the paragraph entitled, "Erection Procedure," of this section.

1. Drawings shall consist of the following:

a. General arrangement drawings showing location, floor plan, runway layout, span, capacities, duty class, speeds, building sections, and details of all of the main features of the crane or crane complex; and shall include clearances, lifts, speeds, hook approaches to sides and ends, hook loads, maximum wheel loads, and other simultaneous wheel loads without impact and weight breakdown. Weights, as applicable, shall be shown for:bridge girders and rails only; end trucks complete with wheels, axles, and gears; bridge-driving machinery; trolley complete with rope and blocks; total net weight of the crane assembly. Each assembled integral overhead traveling crane shall be shown in plan, elevation, and end view.

b. Drawings indicating the complete electrification system, including: a general drawing of the electrical equipment, raceway conductors, wiring and conduit, showing and identifying electrical equipment, manufacturer's name, model numbers, ratings, ohmic values or resistor segments, wire types and sizes, conduit types and sizes, and diagrams showing connections including manufacturer's panel wiring diagrams with schematics and interconnections of panels.

B. Reports: The following Test Reports shall be submitted for the electric overhead crane systems in accordance with MS MIL-C-28546.

Operation Tests

Temperature Tests
Mechanical Tests
Dielectric Tests
Voltage Drop and Short Circuit Tests
Continuity Tests
Insulation Tests

C. Certificates: The following Certificates of Compliance shall be submitted:

1. Certificate of Compliance that crane and component hoists and controls comply with the requirements specified

2. Certificate of Compliance that crane has been factory tested for the tests specified

3. Certificate of Compliance that electric crane bridge motors, hoist and trolley motors, wiring, contact conductors, controls, overcurrent protection, and grounding conform to NFPA 70, and to UL standards; the label or listing with reexamination of the UL will be accepted as evidence that the materials conform to this requirement and to NFPA 70.

D. Operation and Maintenance Manuals: Contractor shall submit 6 copies of the Operation and Maintenance Manuals 30 days prior to testing the Electric Overhead Crane System. Data shall be updated and resubmitted for final approval no later than 30 days prior to contract completion.

1.3 WELDING: Section 05055, "Welding Steel Construction," applies to work specified in this section. Welding procedures shall be in accordance with AWS D1.1.

1.4 STANDARD PRODUCTS: Crane and its component hoists, electrification system components, parts, attachments, and accessories shall be of size, design, and quality to meet requirements specified herein and shall be the standard, fabricated products of the manufacturer or his supplier, so that prompt and continuing service and the delivery of repair parts and replacement components may be ensured.Parts, assemblies, and components shall be new.

1.5 PREPRODUCTION DESIGN DATA: Contractor shall provide construction drawings and supporting design data before fabrication of each proposed crane assembly.

1.6 DELIVERY, HANDLING, AND STORAGE

A. Crane, crane components, and accessories shall be delivered and unloaded as directed.

B. Crane bridge assembly shall be stored off the ground on platforms, skids, or other supports and shall be protected from weather.

C. Materials shall be kept free from dirt and protected from moisture and corrosion.

1.7 PERFORMANCE REQUIREMENTS

A. Design Safety Factor: Allowable structural design stresses for members of the crane or crane complex shall be limited to a safety factor of 5, based on the ultimate strength of the material used.

B. Design Loads for dead load, horizontal travel load induced by bridge or trolley travel, and impact load shall be as specified for each crane.

C. Allowable Deflection: Bridge girder deflection in combination with whatever applicable camber that may exist in the girder shall be such that the wheel-running surfaces will not deviate above or below a level line connecting the tops of the ends of the surfaces any more than that allowed in the following table under any combination of empty hook or hooks, fully loaded hook or hooks, trolley or trolleys in any work position, bridges in any work position; and with no impact included:

CRANE DUTY CLASS	MAXIMUM ALLOWABLE DEVIATION, INCLUDING DEFLECTION OF BRIDGE GIRDER OR RUNWAY TRACK BEAMS, IN INCH PER INCHES OF SPAN
A	1 in 450

D. Operational Requirements: Performance response to controls shall be instantaneous, except where time delay devices and relays are provided.Operation shall be smooth and quiet.Heat rise in motors, brakes, and transistors during maximum capacity operation shall not exceed the design limitation.Cranes shall be capable of continuous maximum load and speed operation without electrical breakdown or overheating of motors, resistors, or brakes as follows:

CRANE DUTY CLASS	MINIMUM CONTINUOUS HOURS
A	2.5

Safety devices and brakes shall be positive in action without slipping, chattering, or jamming and shall have a fail-safe design.

E. Bearings and Bearing Life

1. Housings (including pillow blocks) shall be dusttight, of cast steel or nodular graphitic cast iron, and secured by not less than four bolts. When practical, housings shall be split. Split-bearing housings shall be fastened together with not less than four bolts. One-piece housings shall be designed and located to facilitate shaft and bearing removal.

2. Bearings shall be shielded, sealed, and lubricated as specified for the application. Bearings in exposed applications and bearings lubricated with an oil bath shall be sealed to prevent leakage and provided with drip pans.

3. Antifriction bearings, except hook bearings, shall be designed for dead load, direct reactions of the hook load (applied as a dead load), and torque reactions. Hook bearings shall be of the thrust type, designed on the basis of hours of life and load for the applicable hoist duty class at an arbitrary speed of 10 revolutions per minute. Dead load and hook load shall be reduced to percentage with normal impact, shock, and similar loadings omitted. Antifriction bearings shall be designed for the speeds resulting from operation of the driving motor at its 30-minute rated speed. Percentage of dead load and hook load and the applicable L-10 standard AFBMA 9, rating life of bearings in hours, as applicable to the crane duty class, shall be as follows:

CRANE DUTY CLASS	HOIST		TROLLEY		BRIDGE	
	RATING LIFE	PERCENT LOAD	RATING LIFE	PERCENT LOAD	RATING LIFE	PERCENT LOAD
A	7,000	75	5,000	75	5,000	75

1.8 CRANE CLASSIFICATION

A. Type, Duty Class, and Capacity

1. Crane shall be Type I, Class A1, single-girder, underhung bridge and trolley, and single span.

2. Total rated capacity of the crane assembly shall be not less than 10 tons at the indicated span. Total rated capacity of each transfer crane, or crane complex, shall be as indicated and shall include the dead load and the capacity load of possible combinations of hoist units.

3. Rated capacity shall be shown in tons on not less than two capacity plates, at least one on each side, attached to the crane bridge in fully exposed locations.

1.9 OPERATING CHARACTERISTICS

A. Operating Speeds shall be as follows:

1. Bridge - Variable-speed, approximately 100 fpm maximum

2. Trolley - Variable-speed, approximately 75 fpm, maximum.

3. Hoist - Variable-speed, 15 fpm maximum and lift as indicated

B. Hoist Lift: Hoist shall be standard lift with a minimum hook lift of 26 feet.

C. Number of Hoists Per Crane: Crane assembly shall have one hoist.

D. Hoist Type: Hoist for cranes shall be monorail-type, electric-motor-driven wire-rope hoist.

E. Hoist Suspension: Crane hoist shall have integral, motor-driven trolley suspension. Hoist shall be suspended at right angle to trolley track.

F. Headroom: Hoist and suspension shall be minimum-headroom type.

PART 2 - PRODUCTS

2.1 CRANE BRIDGE MATERIALS

A. Structural Steel: Steel for crane bridges, end truck frames, auxiliary girders, trusses, and reinforcing shall be hot-rolled structural steel I-beam, wide flange beams, channels, and angles and plates not less than ASTM A 36/A 36M. Girders and track beams shall be true, straight, and free of twists with standard mill tolerances for crane use. Runway track beams shall carry rolling loads on the lower flange.

B. High-Strength Threaded Fasteners: High-strength bolts shall be quenched and tempered medium-carbon-steel bolts for structural joints and shall have suitable nuts and hardened washers. Bolts, nuts, and washers shall conform to ASTM A 325,

C. Standard Fasteners: Unfinished, threaded fasteners shall consist of regular hexagon-head carbon steel bolts and nuts and special flathead bolts and nuts conforming to ASTM A 307, Grade A. Washers shall be plain carbon steel conforming to ANSI B18.22.1,

D. Crane Bridge Design and Fabrication

1. Crane bridge and end truck assembly, trolley rails, and beam runways shall be designed and fabricated in accordance with AISC M017 and CMAA 74, "Crane Classifications."

2. High-strength bolt fasteners shall be installed in accordance with AISC S329.

3. Bridge assembly shall be all-welded construction, except for removable subassemblies and girder splices required to maintain shop alignment and for shipment. Removable subassemblies and track beam splices shall be fastened with high-strength bolt fasteners. Splices for bridge girders shall be made by means of continuous, complete penetration butt welds.

E. Maximum Spans and Bridge Arrangement: Single spans shall consist of main girder, trolley and hoist, an auxiliary bracing girder or outrigger beam laterally braced to the main girder with end trucks for each runway track beam. Auxiliary girder hall be fully trussed to top flange of main girder with structural steel shapes.

F. Bridge and Trolley Drive: Mechanical design of bridge and trolley drive, shafts, axles, gears and gearing, bearings, wheels, couplings, brakes, bumpers, and stops shall conform to CMAA 74 and to the requirements specified.

G. End Trucks

1. End trucksshall be of either the rigid or the articulated type and shall be connected to the bridge girders frame by body-bound bolts in reamed holes, by dowels and bolts, or keys and bolts. Trolleys shall be integral with hoist.

2. Each assembly shall have not less than four wheels. Sufficient wheels shall be provided to distribute the load on the track beams.

3. Wheels shall be flanged type, manufactured from forged or wrought alloy steel with machined, hardened treads and flanges or high-strength cast or nodular iron with machined flanges and treads, chill hardened. Wheels shall be designed to operate on either sloped or flat flange I-beams as indicated.

4. Wheels shall be carried on sealed, self-aligning, permanently lubricated antifriction bearings designed for axial and thrust loading. Bearings shall be provided with fittings for pressure lubrication.

5. Wheel gear teeth shall not touch track beams. Wheels shall be readily removable anywhere along the track beams. Provision shall be made for equal bearing of wheels on both sides of bridge girders.

6. Side frames shall be fabricated from structural quality rolled-steel shapes or plate, milled or formed to the required profile with integral bosses where necessary to support equalizing pins and fitted with safety hangers and end bumpers.

7. Wheel base of the end truck assembly for bridges having four pairs of wheels shall be in accordance with CMAA 74. Safety lugs shall be provided to limit the drop to not more than 0.5 inch in case of wheel or axle breakage and to maintain the crane or trolley on the track beam.

2.2 TROLLEYS

A. General Trolley Characteristics: Trolley shall be fabricated as an integral part of the hoist.

B. Trolley Type: Trolley shall be an electric-motor drive, conforming to the requirements specified.

2.3 HOISTS

A. General

1. Hoist assembly shall include hook, load block, wire rope and drum, gearing, brakes, motor drive and controls with integral trolley. Electric hoists wiring, contact conductors, controls, overcurrent protection and grounding shall conform to NFPA 70 and to the applicable UL standards and specified requirements. Each unit shall be factory wired and ready for operation.

2. Electric hoist and trolley unit shall conform to CMAA 74 and shall be of capacity, lift, type, suspension, headroom, and materials specified.

3. Each hoist shall be factory lubricated and shall be complete and ready for operation with the specified controls and accessories.

4. All parts of the hoist shall be designed and constructed for safety of operation and durability of components. Replacement parts shall be interchangeable and readily accessible.

B. Wiring: Each hoist shall be completely wired by the manufacturer in accordance with NFPA 70 and UL standards. Exposed, flexible wiring from controller housing to hoist and trolley motors shall be Type SO flexible neoprene oil-resistant cable.

C. Wire Rope

1. Wire rope for standard applications shall be extra flexible, preformed, improved, plow steel, 6 by 37, fiber-core wire conforming to FS RR-W-410, Type I, Class 3.

2. Wire rope shall be anchored to drum or dead-end. Anchoring shall be of captive type, easily detached for changing and repair.

3. Wire rope shall have a safety factor of not less than 5, based on the minimum ultimate strength of the material used, for Class A and B cranes, and a safety factor of 6 for Class C cranes.

D. Rope Drum

1. Rope drum shall be hardened steel or special-grade cast iron. Drum shall have accurate, machine-cut grooves, cut to full depth of wire-rope radius, with rounded corners of dimension as required for the indicated lift.

2. Drum shall be proportioned to store not more than one layer of rope with the load hook at the upper operating limit and shall have not less than two full turns remaining on the drum in the lowest elevation of the lift. Drum and sheave pitch diameters (in rope diameter units) shall be not less than the following:

CRANE DUTY CLASS	DRUMS	RUNNING SHEAVES	EQUALIZER SHEAVES
A	20	16	12

E. Load Block and Sheaves: Cable load block shall be an enclosed steel safety type which will shroud the sheave and protect the operator. Sheave assembly shall be mounted on a steel axle and carried on sealed, prelubricated antifriction bearings. Wire-rope sheaves shall be machine-grooved, hardened steel or cast iron with chilled groove surfaces.

F. Hook Assembly

1. Hooks and hook swivels shall be heat-treated alloy steel forgings. Yokes, crossheads, and bars shall be of suitable strength steel or cast iron. Hook assembly for electric hoists shall be carried on antifriction bearings to permit free swivel under rated-capacity load without twisting load chain or wire.

2. Each hook assembly shall include a machined and threaded shaft and swivel locknut with an effective locking device to prevent nut from backing off.

3. Each hook shall have a spring-loaded safety latch.

G. Gear Assembly

1. Gears and gearing shall conform to AGMA standards.

2. Gear shafts shall be manufactured from high-carbon steel or alloy steel, machined and ground for accurate fit and splined for fitting to the mating gear.

3. Gear-train assembly shall be carried on antifriction bearings and enclosed in the hoist frame casting. Assembly shall operate in a sealed oil bath. Frame casting shall be provided with lubrication fittings and inspection ports.

H. Bearings: Bearings in the hoist mechanism shall be precision manufactured antifriction bearings, either needle-type roller bearings or end and radial thrust ball bearings, operating in an oil bath and conforming to the requirements specified. Exposed bearings and load block bearings shall be prelubricated and factory sealed.

I. Frame and Housing: Operating parts of the hoist shall be mounted and enclosed in a sealed, factory painted metal frame of malleable iron, cast steel, welded steel, or aluminum. Welded or bolted frames shall be designed to carry loads on the fabricated pieces. Welds or bolts shall be used only to hold the fabricated parts in position.

2.4 LUBRICATION

A. General

1. Means shall be provided for adequate lubrication of moving parts of the crane bridge hoist and trolley, and for filling, draining, and checking the level of the lubricant.

2. Fittings shall be located as required for easy accessibility for lubrication. Pressure lubrication fittings shall not be used where lubricating pressure may damage grease seals or other parts.

3. Bearings shall be provided with a positive oil feed, or shall be grease lubricated, and fitted with shields to prevent entry of grease to gear oil. Worm gear housing shall be integral with that for other gears in the train. Lubricant shall not be permitted to contact motor windings. Exposed bearings shall be fitted with dusttight seals.

B. Factory Lubrication: Where practical, moving parts of hoist, trolley, bridge, and end truck assemblies shall be lubricated prior to delivery. Lubricant shall conform to AGMA 250.04, type as recommended by manufacturer.

2.5 MOTORS AND CONTROLS

A. General

1. Motors and controls shall conform to CMAA 74 and NEMA, and to the requirements specified. Motor mounting, shaft, and keyway dimensions shall conform to manufacturer's standards.

2. Crane, trolley and hoist wiring, conductors, controls, overcurrent protection, and grounding shall conform to NFPA 70 and to the requirements specified.

B. Motor Rating shall be determined by CMAA 74.

C. Voltage Ratings of 3-phase electric motors 1/2 horsepower and larger shall be 230/460-volt, 3-phase 60-hertz.

D. Bridge and End Truck Motors shall be two speed, ac motors with motor brake.

E. Trolley Motor: Each trolley motor shall be a two-speed, ac motor with motor brake.

F. Hoist Motor: Each hoist motor shall be a variable-speed, low-slip, wound-rotor ac motor.

G. Motor Type: Motors shall be totally enclosed, nonventilated type, certified for 30-minute time-rated operation at full identification plate power output in an ambient temperature of 40.0 degrees C, insulation not less than Class B system.

H. Motor Bearings shall be heavy-duty ball or roller antifriction type with full provision for the type of thrust imposed by the specific duty load and meeting the requirements specified. Bearings in motors shall be either factory sealed and lubricated for life or prelubricated. Prelubricated bearing shall be equipped with lubrication service fittings and with provision for automatic positive relief of lubrication pressure. This may be accomplished by either built-in relief devices or automatic ball-and-spring relief fittings at the bottom of the bearing housing. Pressure relief shall be to the outside of the housing. Lubrication fittings shall be fitted with color-coded plastic or metal dust caps. Bearings in any motor that is lubricated at the factory for extended duty periods shall be identified with tags. Tag shall state the lubrication requirements for a given number of operating hours.

I. Motor Brakes:

1. Motor brakes shall be provided on electric-motor-operated hoists, trolleys, and bridges. Motor brake shall be an externally adjustable, electrically operated shoe or multiple friction electromagnetic disk brake which shall apply automatically when the power is interrupted.

2. Torque rating of the bridge and trolley brakes shall be not more than 50 percent of the full-load torque of the bridge and trolley motors and shall be adjustable to 25 percent for all duty classes.

3. Hoist motor brake shall be capable of holding the capacity load of the hoist at any point independent of the load brake and, in addition to stopping and safely holding 125 percent of the rated load from any operating speed, shall hold a static load equal to 150 percent of the rated capacity.

J. Hoist Load Brake

1. Each hoisting unit shall be provided with two means of braking. One brake shall be an electric motor brake as specified. The other brake shall be a mechanical load brake, directly applied to the hoist motor shaft or other shaft in the hoist gear reduction.

2. Load brake shall be a totally enclosed, automatic, mechanical-type, externally adjustable brake with hardened steel, Weston-type ratchet and pawl mechanism that will hold the capacity load of the hoist at any point when the motor is stopped.

K. Motor Controller

1. Each motor shall be provided with a full magnetic, electrically operated, reversing-type controller with thermal-overload protection, fused disconnect switch, and control-circuit transformer.

2. Controllers for cranes of Duty Class II shall be in accordance with NEMA ICS 1, Part 3-442 and Part 3-443, Service Classes A2 and B.

3. Operating parts of the controllers shall be contained in an enclosure as specified. Enclosure shall be accessible for service. When resistors are mounted in the same enclosure as controllers, air circulation by natural convection shall be provided.

4. Controller component ratings shall conform or be in proportion to the tabulated ratings of NEMA ICS 1. All contactors shall be provided with arc shields or suppressors or the contacts shall be enclosed in an arc box.

5. Contactors for starting, stopping, and reversing shall be mechanically and electrically interlocked. A line contactor shall be provided for each motor controller on the crane or crane complex.

6. An emergency stop button and a reset button shall be provided to operate the main-line contactor.

7. Controllers for variable speed motors shall be provided with five speed points, not less than three of which shall be hand-controlled points. When provided with three hand-controlled points, points one, two, and five shall be the hand-controlled points, and points three and four shall be automatic. Accelerating relays, adjustable from at least 1/4 second to 2 seconds, shall be provided for points above the second.

8. Overcurrent protection shall consist of externally operable, manual reset, thermal-overload relays in each pole of the controller. Thermal overload relays shall be melting alloy or bimetallic, nonadjustable type with continuous current ratings and service-limit current ratings in accordance with Section 2, Part 2-321A of NEMA ICS 1.

9. Magnetic motor controllers shall be capable of interrupting operating overloads up to and including 10 times their normal motor rating. Continuous current ratings shall be based on temperature rise above an ambient temperature of 104 degrees F. Core and coil assembly, auxiliary contacts, and other control-circuit devices shall be rated at 120 volts.

10. Control-circuit transformers shall be provided within the enclosure of all motor controllers when the line voltage is in excess of 120 volts. Transformer shall be dry-type, single-phase, 60-hertz ac with a 120-volt, isolated, secondary winding in accordance with NEMA ST 1. Controls shall operate at 120 volts or less.

11. Rated primary voltage of the transformer shall be not less than the rated voltage of the controller. Rated secondary current of the transformer shall be not less than continuous-duty current of the control circuit.

12. Voltage regulation of the transformer shall be such that with rated primary voltage and frequency, the secondary voltage will be not less than 95 percent nor more than 105 percent of rated secondary voltage.

13. Source of supply for control-circuit transformers shall be taken from the load side of the main disconnecting device. Secondary winding of the transformer and control-circuit wiring shall be protected against overloads and short circuits by fuses selected in accordance with Tables 4-4 and 4-5 of JIC-01. Secondary winding of the control-circuit transformer shall be grounded in accordance with JIC-01.

L. Motor-Controller Enclosure

1. Motor-controller enclosure shall be NEMA 250, Type 3 - dusttight, raintight, and sleet(ice)-resistant sheetsteel case.

2. Cast iron for control enclosures shall conform to ASTM A 48.

3. Sheet steel for control enclosures shall be fabricated from commercial quality uncoated carbon steel conforming to ASTM A 366/A 366M.

4. Control enclosures shall be fabricated from corrosion-resistant, chromium-nickel, steel sheet conforming to ASTM A 167, 300 series, ASM No. 4 finish.

5. Box dimensions and thickness of steel shall conform to UL 50.

6. Sheet steel and cast iron enclosures shall be chemically cleaned, phosphatized, and then painted, both interior and exterior, with the manufacturer's standard finish to a minimum dry-film thickness of 2 mils. Enclosure interiors shall be painted white or light gray.

M. Protective Equipment: Protective devices shall conform to NEMA ICS 1 and shall include a fused circuit switch for each motor controller, a main-line magnetic contactor incorporating undervoltage protection, main overload protection, and motor overload protection. Two overload relays shall be provided for each 3-phase motor winding. Operation of any protective device (overload, undervoltage, control circuit fuse, or stop pushbutton) shall stop motions. Fuses shall be of the nonrenewable cartridge type. Each hoist shall be provided with undervoltage and overload protection in accordance with NEMA ICS 1. Overload relays of inverse-time characteristics shall be provided. Undervoltage protection shall be provided for cranes of Duty Class C. Overload relays shall be connected in each phase of a 3-phase, ac circuit. Control circuit shall be fused.

N. Pushbutton Control Stations

1. Pushbuttons and pushbutton stations for crane control shall be heavy-duty, oiltight, momentary contact devices rated 600 volts with the number of buttons and the marking of identification plates in accordance with NEMA ICS 1. Color code for pushbuttons shall be in accordance with JIC-01.

2. Crane shall be floor controlled with pendant pushbutton, suspended from crane bridge where indicated to provide control at the distance indicated from the point of loading.

3. Unit shall have a pendant-mounted conductor cable with a permanently attached strain-reliever chain or cable integral with the pendant conductor cable.

4. Pushbutton station shall be grounded to the hoist and crane bridge. Strain-reliever chain or cable shall not be used as a grounding circuit.

5. Pushbuttons shall be designed to transmit a distinct notch or step feeling to the operator for each pressure or release action on hand-controlled speed points. Pendant pushbuttons shall be legibly and permanently marked and shall be vertically arranged in the following top to bottom grouped order:TROLLEY FORWARD, TROLLEY REVERSE; BRIDGE FORWARD, BRIDGE REVERSE; UP, DOWN; and RESET, STOP. Stop control shall be a red, plastic-covered, mushroom-head button. A pilot light to indicate that power is available shall be furnished integral with the pushbutton cases.

6. An emergency stop pushbutton and a reset button shall be provided to operate the main line contactor.

7. Bottom of the control station shall be approximately 48 inches above the operating floor level.

O. Limit Switches

1. Adjustable upper limit switch shall be provided to prevent overtravel of the hook or load block in the hoisting direction. Limit switches shall be arranged to stop the hoist motor and apply the motor brake before reaching the uppermost safe limit of travel. In case of hook overtravel, the motor shall be automatically and momentarily reversed.

2. Adjustable lower limit switch to stop the hoist motor shall be provided. Motor brake shall be applied when the load hook reaches a predetermined lower limit.

2.6 ELECTRIFICATION SYSTEM

A. General: Crane, bridge-trolley and hoist wiring, contact conductors, controls, over-current protection, and grounding shall conform to NFPA 70 and to the requirements specified herein.

B. Safety Contact Conductor System

1. Electrification system for power distribution from the source of supply to mobile tapoff devices on crane runway and crane bridge shall consist of an approved, festooned, 3-wire conductor system.

2. System shall be complete with unit length conductors, trolley system, support brackets and fasteners, disconnect switch, and conduit and wiring to power takeoff point.

C. Bridge and Runway Electrification: Maximum voltage drop from the building power takeoff point for the track electrification system to the hoist motor shall not exceed 4 percent, and the equivalent conductance shall not be less than No. 4 American Wire Gage (AWG) copper wire. Size of bridge conductors shall be proportioned to limit the total voltage drop in the conductors to a maximum of 3 percent of the supply voltage when the current on the individual motors is full load. Short-circuit current rating of conductors shall be not less than 10,000 amperes.

D. Disconnect Switch, Conduit, and Wiring

1. Feed-in boxes for the attachment of feeder conductor to runway conductor shall consist of bus tap connections for terminal lugs without overcurrent protection in a protective enclosure.

2. Enclosures shall be formed from cast iron, corrosion-resistant steel, or carbon steel with thickness of metal and box dimensions in accordance with UL 857. Seams and joints shall be closed and reinforced with flanges formed of the same material from which the box is made. Box shall be provided with a screwed-on cover plate. Carbon-steel enclosure shall be zinc coated after fabrication with Type SC3 minimum thickness of coating in accordance with ASTM B 633.

3. Enclosure shall be the same type material and paint finish of NEMA enclosure as specified herein.

4. Disconnect switch shall be a surface-mounted, heavy-duty, single-throw, air-break, enclosed type conforming to NEMA KS 1 as indicated and as follows:

5. Disconnect switch shall be fused.

6. Switch box shall be installed with centerline 66 inches above the finished floor and at the approximate center of the crane runway length.

7. Wiring, except panel wiring, shall be protected by drained or moisturetight, zinc-coated, rigid conduit. Flexible leads, where required, shall be enclosed in moistureproof flexible steel conduit. Crane complex wiring and conduit shall be arranged for a minimum of wiring during assembly and construction on site. Junction boxes shall be provided, where practical.

E. Electromagnetic Interference Characteristics: Equipment shall conform to the electromagnetic characteristic requirements and test limits specified in MS MIL-C-28546.

2.7 PAINT FINISH

A. Crane bridge assembly, trolley and hoist, and electrical and mechanical equipment shall receive a factory-applied paint finish.

B. Finish of the crane bridge and the trolley and hoist assembly shall be inspected after erection. Fasteners, welds, abrasions, and handling marks shall be painted in the finish color; brackets and hangers of electrification system shall be painted in the finish color of the track.

C. Color finish of moving parts of crane and trolley and hoist assembly shall be as selected from manufacturer's standard machinery finish colors. Trolley and hoist assembly and crane bridge shall be in contrasting colors. Other steel work shall be painted to match the color of existing adjacent surfaces.

D. Color finish of all moving parts of crane and trolley and hoist assembly shall be of color selected from FED-STD 595.Other steel work shall be painted to match the color of existing adjacent surfaces.

E. Hook blocks and pendant pushbutton stations shall be brilliant yellow, Color No. 13538, of FED-STD 595. Other steel work shall be painted to match the color of existing adjacent surfaces.

2.8 CRANE IDENTIFICATION PLATES: Identification plates shall be in accordance with CMAA 74.

PART 3 - EXECUTION

3.1 GENERAL

A. Crane manufacturer shall provide a qualified erection superintendent to supervise the delivery, unloading, assembly, and erection of the crane; to inspect and approve the installation; and to place the crane in operation.

B. Crane shall be assembled at the factory, properly wired, tested without load, and disassembled only as required for shipment. Each disassembled part shall be matchmarked for field assembly.

C. Adequate and safe erection equipment and tackle shall be provided as required to mount crane assembly on crane runway.

3.2 CRANE RAILS AND RUNWAYS

A. Previously erected runway assembly shall be inspected before erection of crane.

B. Runways shall be level, in straight alignment, and true to span.

C. Gage tolerance for span shall be plus or minus 1/8-inch. Runway shall be held to an alignment and elevation tolerance of plus or minus 1/8-inch.

D. Joints shall be smooth, level, and in true alignment to offer no obstruction to end truck movement. Welded joints shall be ground smooth.

3.3 ERECTION PROCEDURE: Crane shall be erected in accordance with the manufacturer's printed instructions and as directed by the manufacturer's erection superintendent and in his presence.

3.4 FACTORY TESTS BEFORE SHIPMENT: Crane manufacturer shall assemble, wire, and test each overhead crane assembly at the point of manufacture in accordance with the requirements of CMAA 74.

3.5 CRANE TESTS AFTER ERECTION: Completed crane complex, erected, adjusted, lubricated, and made ready for operation, shall be tested by the Contractor in the presence of the Construction Manager in accordance with CMAA 74.

3.6 CRANE ELECTRIFICATION SYSTEM FACTORY TESTS

A. Factory tests on crane electrification systems and associated fittings shall be made in accordance with the applicable provisions of the referenced standards.

B. Temperature, mechanical, and dielectric tests shall be in accordance with UL 857.Voltage-drop and short-circuit tests shall be in accordance with "Testing Standards" of NEMA BU 1.

C. Routine tests shall include dielectric tests on crane electrification system.Certification of dielectric tests shall be submitted and shall show compliance with the referenced standard.

3.7 ON-SITE COMPLEX ELECTRIFICATION SYSTEM TESTS

A. Crane complex electrification system shall be given continuity and insulation tests after the installation has been completed but before equipment is energized.

B. Contractor shall provide necessary test equipment, labor, and personnel to perform the tests as herein specified. Insulation testing instruments shall consist essentially of a direct-reading ohmmeter and a motor-driven dc generator. Continuity tests shall be conducted using a dc device with bell or buzzer.

C. Electrification-system equipment shall be completely isolated from all extraneous electrical connections. Substation and switchboard feeder breakers, circuit breakers in panelboards, and other disconnecting devices shall be used to isolate the equipment under test.

D. Insulation tests on 480-volt equipment shall be conducted using a 1,000-volt, insulation-testing instrument. Readings shall be recorded every minute and until three equal and consecutive readings are obtained. Resistance between phase conductors and between phase conductors and ground shall be not less than 50 megohms.

E. Insulation tests on equipment, 300 volts or less, shall be conducted using a 500-volt, insulation-testing instrument. Readings shall be recorded after 1 minute or until the reading is constant for 15 seconds. Resistance between phase conductors and between phase conductors and ground shall be not less than 25 megohms.

F. Test data shall be recorded and shall include location and identification of busway and megohm readings versus time.

G. Final acceptance shall depend upon satisfactory performance under test. No electrification system shall be energized until recorded test data are approved.

END OF SECTION

SECTION 15003

GENERAL MECHANICAL PROVISIONS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A13.1	(1981; R 1985) Scheme for the Identification of Piping Systems

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 123	(1989a; E1) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM B 766	(1986) Electrodeposited Coatings of Cadmium

MILITARY SPECIFICATIONS (MS)

MS MIL-T-704	(Rev J) Treatment and Painting of Material

SHEET METAL AND AIR CONDITIONING CONTRACTORS NATIONAL ASSOCIATION, INC. (SMACNA)

SMACNA-08	(1982) Guidelines of Seismic Restraints of Mechanical Systems (Available only from 401 Shatto Place, No. 101, Los Angeles, CA 90020) Sheet Metal Industry Fund (SMIF)

UNDERWRITERS LABORATORIES (UL)

UL-02	(1992) Building Materials Directory
UL-06	(1993) UL Standard for Safety Rigid Metal Conduit

1.2 COORDINATION: Contractor shall coordinate the work of the different trades so that interference between piping, equipment, structural, and electrical work will be avoided. All necessary offsets in piping and all fittings, etc., required to install the work properly shall be furnished complete in place at no additional cost to the Government.

1.3 MECHANICAL SYSTEMS IDENTIFICATION

A. Diagrams

1. Chart listing of equipment shall be by designation numbers and capacities such as flow rates, pressure and temperature differences, heating and cooling capacities, horsepower, pipe sizes, and voltage and current characteristics. This requirement shall not apply for accessories or minor equipment items, such as vents, but is required for such equipment as pumps, water heaters, air-handling system equipment, refrigeration compressors, heat exchangers, and boilers.

2. Diagrams shall be neat mechanical drawings provided with extruded aluminum frames and 1/8-inch acrylic plastic protection. Location shall be as directed by the Construction Manager. The number of charts and diagrams shall be equal to or greater than the number of mechanical equipment rooms. Where more than one chart per space is required, these shall be mounted in edge pivoted, swinging leaf, extruded aluminum frame holders which open to 170 degrees.

B. Identification Tags

1. Identification tags made of brass or aluminum indicating function of a control or similar component shall be installed on such system devices. Tags shall be 2 inches in diameter and marking shall be stamped.

2. Equipment shall be provided with metal identification tags displaying an equipment designation number matching drawing or control diagram designation.

3. Tags shall be wired to valve or equipment items with No. 12 AWG 0.0808-inch diameter corrosion-resistant steel wire.

C. Service Labeling:

1. All piping, including that concealed in accessible spaces; exposed, bare and painted; and insulated, shall be labeled to designate service. Each label shall include an arrow or arrows to indicate flow direction. Labels and valve tag schedule shall be in accordance with the typical examples below:

SERVICE	LABEL AND TAG DESIGNATION
Cold potable water	COLD POT. WATER
Hot potable water supply	HOT POT. WATER SUPPLY
Hot potable water return	HOT POT. WATER RETURN
Rain water leader	RAIN WATER
Sanitary sewer	SAN. SEWER
Sanitary waste	SAN. WASTE
Sanitary drain	SAN. DRAIN
Sanitary vent	SAN. VENT
Corrosion resistant sewer	COR. RES. SEWER
Corrosion resistant waste	COR. RES. WASTE
Corrosion resistant drain	COR. RES. DRAIN
Corrosion resistant vent	COR. RES. VENT
Automatic temperature control	AUTO. TEMP. CONTROL
Chilled water-supply	CHILLED WATER-SUPPLY

Chilled water-return	CHILLED WATER-RETURN
Control and instrument air	CONTROL AND INSTR.
Condensate drain	COND. DRAIN
Compressed air supply	100 PSI SUPPLY AIR

2. Similar services with different temperatures or pressures shall be identified. Where pressures may exceed 125 pounds per square inch, gage, the maximum system pressure shall be included in the label.

3. Piping shall be labeled and arrowed in accordance with the following:

a. Each point of entry and exit of pipe passing through walls

b. Each change in direction, i.e., elbows, tees

c. In congested or hidden areas and at all access panels at each point required to clarify service or indicated hazard

d. In long straight runs, labels shall be located at distances within eyesight of each other but in no case shall the distance between labels exceed 75 feet. All labels shall be visible and legible from the primary service and operating area.

For Bare or Insulated Pipes for Outside Diameters of	Lettering
1/2 thru 1-3/8 inch	1/2 inch
1-1/2 thru 2-3/8 inch	3/4 inch
2-1/2 inch and larger	1-1/4 inch

e. Labels shall be made of self-sticking, plastic film designed for permanent installation.

1.5 COLOR CODING: Color coding of all piping systems shall be in accordance with [ANSI A13.1.

1.6 APPROVAL REQUIREMENTS

A. Except as otherwise specified, approval of materials and equipment will be based on manufacturer's published data.

B. Where materials and equipment are specified to conform to the standards of the Underwriters Laboratories, the label of or listing with reexamination in UL-02, and UL-06 will be acceptable as sufficient evidence that the items conform to Underwriters Laboratories requirements. In lieu of such label or listing, the Contractor may submit a written certificate from any nationally recognized testing agency, adequately equipped and competent to perform such services, stating that the items have been tested and that the units conform to the specified requirements. Methods of testing used by the specified agencies shall be outlined.

C. Where materials or equipment are specified to be constructed or tested, or both, in accordance with the standards of the American Society for Testing and Materials (ASTM), the American Society of Mechanical Engineers (ASME), or other standards, a manufacturer's certificate of compliance of each item will be acceptable as proof of compliance.

D. Conformance to such agency requirements does not relieve the item from compliance with other requirements of these specifications.

1.7 PREVENTION OF CORROSION: Metallic materials shall be protected against corrosion. Equipment enclosures shall be given rust-inhibiting treatment and standard finish by the manufacturer. Aluminum shall not be used in contact with earth, and where connected to dissimilar metal, shall be protected by approved fittings, barrier material, or treatment. Ferrous parts such as anchors, bolts, braces, boxes, bodies, clamps, fittings, guards, nuts, pins, rods, shims, thimbles, washers, and miscellaneous parts not of corrosion-resistant steel or nonferrous materials shall be hot-dip galvanized in accordance with ASTM A 123 for exterior locations and cadmium-plated in conformance with ASTM B 766 for interior locations.

PART 2 - PRODUCTS

2.1 IDENTIFICATION PLATES

A. In addition to standard manufacturer's identification plates, engraved laminated phenolic identification plates shall be provided for each piece of mechanical equipment. Identification plates shall designate the function of the equipment. Designation shall be submitted with the shop drawings.

B. Identification plates shall be three layers, black-white-black, engraved to show white letters on black background. Letters shall be upper case. Identification plates 1-1/2-inches high and smaller shall be 1/16-inch thick, with engraved lettering 1/8-inch high; identification plates larger than 1-1/2-inches high shall be 1/8-inch thick, with engraved lettering of suitable height. Identification plates 1-1/2-inches high and larger shall have beveled edges. Identification plates shall be installed using a compatible adhesive.

2.2 ANCHOR BOLTS: Anchor bolts shall be provided for equipment placed on concrete equipment pads or on concrete slabs. Bolts shall be of the size and number recommended by the equipment manufacturer and shall be located by means of suitable templates. Installation of anchor bolts shall not degrade the surrounding concrete.

2.3 SEISMIC ANCHORAGE: Equipment shall be anchored in accordance with applicable seismic criteria for the area and as defined in SMACNA-08.

2.4 PAINTING: Equipment units shall be painted in accordance with approved equipment manufacturer's standards unless specified otherwise. Field retouching shall be accomplished only if approved; otherwise equipment shall be returned to the factory for refinishing.

PART 3 - EXECUTION

3.1 INSTALLATION: Materials and equipment shall be installed in accordance with the requirements of the contract drawings and approved recommendations of the manufacturers. Installation shall be accomplished by workers skilled in this type of work. Installation shall be made so that there is no degradation of the designed fire ratings of walls, partitions, ceilings, and floors. Except as otherwise indicated, emergency switches and alarms shall be installed in conspicuous locations.

3.2 EQUIPMENT PADS: Equipment pads shall be provided and shall be of dimensions shown or, if not shown, they shall conform to the shape of each piece of equipment served with a minimum 3-inch margin around the equipment and supports.

3.3 CUTTING AND PATCHING

A. Contractor shall install his work in such a manner and at such time as will require a minimum of cutting and patching of the building structure.

B. Holes in exposed locations, in or through existing floors, shall be drilled and smoothed by sanding. Use of a jackhammer will be permitted only where specifically approved.

C. Holes through masonry walls to accommodate sleeves shall be made with an iron pipe masonry core saw.

3.4 CLEANING: In addition to the requirements of Division 1, exposed surfaces of piping and equipment that have become covered with dirt, plaster, or other material during handling and construction shall be thoroughly cleaned before such surfaces are prepared for final finish painting or are enclosed within the building structure. Before final acceptance, mechanical equipment, including piping, ducting, and fixtures, shall be clean and free from dirt, grease, and finger marks.

END OF SECTION

SECTION 15050

BASIC MECHANICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC S328	(1986) Specification for Structural Steel Buildings Load and Resistance Factor Design

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A112.18.1M	(1989) Plumbing Fixture Fittings
ANSI B40.1	(1991) Gauges - Pressure Indicating Dial Type - Elastic Element

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 105	(1991) Standard Specification for Forgings, Carbon Steel, for Piping Components
ASTM A 106	(1991) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A 126	(1984) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A 183	(1983; R 1990) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A 197	(1987) Standard Specification for Cupola Malleable Iron
ASTM A 216	(1989) Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service
ASTM A 234	(1994) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
ASTM A 276	(1990) Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes
ASTM A 278	(1985; R 1991) Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650 Degrees F
ASTM A 307	(1992) Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength

ASTM A 312	(1991) Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipe
ASTM A 480	(1991) Flat Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip, General Requirements for
ASTM A 53	(1993) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM A 563	(1993) Standard Specification for Carbon and Alloy Steel Nuts
ASTM A 6	(1992; Rev A) Standard Specification for Rolled Steel Plates, Shapes, Sheet Piling and Bars for Structural Use
ASTM A 74	(1987) Standard Specification for Cast Iron Soil Pipe and Fittings
ASTM B 32	(1989) Specification for Solder Metal
ASTM B 370	(1988) Standard Specification for Copper Sheet and Strip for Building Construction
ASTM B 62	(1990) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B 749	(1991) Standard Specification for Lead and Lead Alloy Strip, Sheet and Plate Products
ASTM B 88	(1992) Standard Specification for Seamless Copper Water Tube
ASTM C 109	(1992) Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)
ASTM C 190	(1985) Standard Test Method for Tensile Strength of Hydraulic Cement Mortars
ASTM C 404	(1993) Standard Specification for Aggregates for Masonry Grouts
ASTM C 476	(1991) Standard Specification for Grout Masonry
ASTM C 564	(1988) Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
ASTM C 67	(1992) Standard Test Methods of Sampling and Testing Brick and Structural Clay Tile
ASTM C 920	(1987) Standard Specification for Elastomeric Joint Sealants

ASTM D 2000	(1990) Standard Classification System for Rubber Products in Automotive Applications
ASTM D 2308	(1990) Standard Specification for Polyethylene Jacket for Electrical Insulated Wire and Cable
ASTM E 1	(1991; Rev A) Standard Specification for ASTM Thermometers
ASTM F 104(1988)	Standard Classification System for Nonmetallic Gasket Materials

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A112.19.2M	(1990) Vitreous China Plumbing Fixtures
ASME B1.20.7	(1966; R 1983) Hose Coupling Screw Threads (Inch)
ASME B16.1	(1989) Cast Iron Pipe Flanges and Flanged Fittings
ASME B16.11	(1991) Forged Steel Fittings, Socket-Welding and Threaded
ASME B16.22	(1989) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.25	(1992) Buttwelding Ends
ASME B16.26	(1988) Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.3	(1992) Malleable-Iron Threaded Fittings, Classes 150 and 300
ASME B16.39	(1986) Malleable Iron Threaded Pipe Unions, Classes 150, 250, and 300
ASME B16.4	(1985) Cast-Iron Threaded Fittings Classes 125 and 250
ASME B16.5	(1988; Errata) Pipe Flanges and Flanged Fittings
ASME B16.9	(1993) Factory-Made Wrought Steel Buttwelding Fittings
ASME B31.3	(1990; Errata) Chemical Plant and Petroleum Refinery Piping
ASME B36.10M	(1985) Welded and Seamless Wrought Steel Pipe
ASME-16	(1992) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage
ASME-17	(1992) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8	(1989) Specification for Filler Metals for Brazing
AWS-02	(1991) Welding Handbook; Vol Two - Welding Process

FEDERAL SPECIFICATIONS (FS)

FS HH-I-558	(Rev C) Insulation, Blocks, Boards, Blankets, Felts, Sleeving (Pipe and Tube Covering), and Pipe Fitting Covering, Thermal (Mineral Fiber, Industrial Type)
FS FF-S-325	(Int Amd 3) Shield, Expansion; Nail, Expansion; and Nail, Drive Screw (Devices, Anchoring, Masonry)
FS WW-P-541/5	(Rev B; Am 1) Plumbing Fixtures (Sinks, Kitchen, Service, and Laundry Trays) ~\

FLUID SEALING ASSOCIATION (FSA)

FSA-01	(1979; 5th Ed; Rev 1980) Rubber Expansion Joints and Flexible Rubber Pipe Connectors Handbook

INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS (IEEE)

IEEE Std 515	(1989) Recommended Practice for the Testing, Design, Installation, and Maintenance of Electrical, Resistance Heat Tracing for Industrial Applications

MILITARY SPECIFICATIONS (MS)

MS MIL-C-18480	(Rev B; Notice 1) Coating Compound, Bituminous, Solvent, Coal-Tar Base
MS MIL-E-17813	(Rev F) Expansion Joints, Pipe, Metallic Bellows

MANUFACTURER'S STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(1988) Pipe Hangers and Supports - Materials, Design and Manufacture
MSS SP-67	(1990) Butterfly Valves
MSS SP-69	(1991) Pipe Hangers and Supports - Selection and Application
MSS SP-70	(1990) Cast Iron Gate Valves, Flanged and Threaded Ends
MSS SP-72	(1987) Ball Valves with Flanged or Butt-Welding Ends for General Service

1.2 GENERAL REQUIREMENTS: Section 15003, "General Mechanical Provisions," applies to work specified in this section. Section 15245, "Vibration Isolation for Air Conditioning Equipment," applies to work specified in this section. Section 15055, "Welding Mechanical," applies to work specified in this section.

1.3 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data:

1. Design Analysis and Calculations shall be submitted for the following items consisting of surface resistance, rates of flow, head losses, inlet and outlet design, required radius of bend, and pressure calculations. Data shall also include pipe size, shape, and dimensions, as well as temperature ratings, vibration and thrust limitations minimum burst pressures, shut-off and non-shock pressures and weld characteristics.

Pipe and Fittings
Piping Specialties
Valves

2. Equipment and Performance Data shall be submitted for the following items consisting of corrosion resistance, life expectancy, gage tolerances, and grade line analysis.

Pipe and Fittings
Piping Specialties
Valves
Miscellaneous Materials
Supporting Elements

3. Equipment Foundation Data for Piping Systems shall include plan dimensions of foundations and relative elevations, equipment weight and operating loads, horizontal and vertical loads, horizontal and vertical clearances for installation, and size and location of anchor bolts.

4. Manufacturer's Catalog Data shall be submitted for the following items:

Pipe and Fittings
Piping Specialties
Valves
Miscellaneous Materials
Supporting Elements
Spare Parts

B. Drawings

1. Connection Diagrams shall be submitted for Pipes, Valves, and Specialities indicating the relations and connections of devices and apparatus by showing the general physical layout of all controls, the interconnection of one system (or portion of system) with another, and internal tubing, wiring, and other devices.

2. Coordination Drawings shall be submitted for Pipes, Valves, and Specialties showing coordination of work between different trades and with the structural and architectural elements of work. Drawings shall be in sufficient detail to show overall dimensions of related items, clearances, and relative locations of work in allotted spaces. Drawings shall indicate where conflicts or clearance problems exist between various trades.

3. Fabrication Drawings shall be submitted for Pipes, Valves, and Specialities consisting of fabrication and assembly details to be performed in the factory.

4. Installation Drawings shall be submitted for Pipes, Valves, and Specialties in accordance with the paragraph entitled, "Pipe Installation," of this section. Drawings shall include the manufacturer's design and construction calculations, forces required to obtain rated axial, lateral, or angular movements, installation criteria, anchor and guide requirements for equipment, and equipment room layout and design. Drawing shall specifically advise on procedures to be followed and provisions required to protect expansion joints during specified hydrostatic testing operations.

5. As-Built Drawings shall be submitted for Pipes, Valves, and Accessories providing current factual information including deviations and amendments to the drawings, and concealed and visible changes in the work.

C. Schedules: Material, Equipment, and Fixture Lists shall be submitted for Pipes, Valves, and Specialties including manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information. A complete list of construction equipment to be used shall be provided.

D. Statements: Listing of Product Installations for Piping Systems shall include identification of at least 5 units, similar to those proposed for use, that have been in successful service for a minimum period of 5 years. List shall include purchaser, address of installation, service organization, and date of installation.

E. Reports: Test Reports on the following tests shall be submitted for pipes, valves, and specialities.

Hydrostatic Tests
Air Tests
Valve-Operating Tests
Drainage Tests
Pneumatic Tests
Non-Destructive Electric Tests
System Operation Tests

F. Certificates of Compliance shall be submitted for pipes, valves and specialties showing conformance with test requirements as contained in the reference standards contained in this section.

Surface Resistance
Shear and Tensile Strengths
Temperature Ratings
Bending Tests
Flattening Tests
Transverse Guided Weld Bend Tests

G. Samples: Manufacturer's Standard Color Charts shall be submitted for Pipes, Valves, and Specialties showing the manufacturer's recommended color and finish selections.

H. Records of Existing Conditions shall be submitted consisting of the results of Contractor's survey of work area conditions and features of existing structures and facilities within and adjacent to the jobsite. Commencement of work shall constitute acceptance of existing conditions.

I. Operation and Maintenance Manuals shall be consistent with manufacturer's standard brochures, schematics, printed instructions, general operating procedures and safety precautions. Test data shall be legible and of good quality.

PART 2 - PRODUCTS

2.1 ELECTRICAL HEAT TRACING

A. Heat trace systems for pipes, valves, and fittings shall be in accordance with IEEE Std 515 and shall be UL listed. System shall consist of all necessary components, including heaters and controls to prevent freezing.

B. Self-regulating heaters shall consist of two 16 AWG tinned-copper bus wires embedded in parallel in a self-regulating polymer core that varies its power output to respond to temperature along its length. Heater shall be able to be crossed over itself without overheating and shall be approved before used directly on plastic pipe. Heater shall be covered by a radiation cross-linked modified polyolefin dielectric jacket in accordance with ASTM D 2308.

C. For installation on plastic piping, the heater shall be applied using aluminum tape. Heater shall have an outer braid of tinned-copper and an outer jacket of modified polyolefin in accordance with ASTM D 2308, to provide a good ground path and to enhance the heater's ruggedness. Heater shall have a self-regulating factor of at least 90 percent, in order to provide energy conservation and to prevent overheating.

D. Heater shall operate on line voltages of 120 volts without the use of transformers.

E. Heater shall be sized according to the following table:

Heater Output at Minimum Ambient Temperatures

Pipe Size (Inch, Diameter)	Minus 10 degrees F	Minus 20 degrees F
3 inches or less	5 watts per foot (wpf)	5 wpf
4 inch	5 wpf	8 wpf
6 inch	8 wpf	8 wpf
8 inch	2 strips/5 wpf	2 strips/8 wpf
12 inch to 14 inch	2 strips/8 wpf	2 strips/8 wpf

F. System shall be controlled by an ambient sensing thermostat set at 40 degrees F either directly or through an appropriate contactor.

2.2 PIPE AND FITTINGS

A. Type BCS, Black Carbon Steel

1. Pipe (1/8 through 12 inches) shall be Schedule 40 black carbon steel, conforming to ASTM A 53.

2. Pipe (1/8 through 10 inches) shall be Schedule 40 seamless or electric-resistance welded black carbon steel, conforming to ASTM A 53, Type E, Grade B (electric-resistance welded)

3. Fittings (2 inches and under) shall be 150-pounds per square inch, gage (psig) working steam pressure (wsp) banded black malleable iron screwed, conforming to ASTM A 197 and ASME B16.3.

4. Unions (2 inches and under) shall be 250 pounds per square inch, wsp female, screwed, black malleable iron with brass-to-iron seat, and ground joint, conforming to ASME B16.39.

5. Fittings (2-1/2 inches and over) shall be Steel butt weld, conforming to ASTM A 234/A 234M and ASME B16.9 to match pipe wall thickness.

6. Flanges (2-1/2 inches and over) shall be 150-pound forged-steel conforming to ASME B16.5, welding neck to match pipe wall thickness.

B. Type BCS-125, (125-psi Service)

1. Pipe (1/8 through 1-1/2 inches) shall be Schedule 40 steam, Schedule 80 condensate, furnace butt weld, black carbon steel, conforming to ASTM A 53, Type F (furnace butt welded, continuous welded) and ASME B36.10M.

2. Pipe (2 through 10 inches) shall be Schedule 40 steam, Schedule 80 condensate, seamless or electric-resistance welded black carbon steel, conforming to ASTM A 53 Type E, Grade B (electric-resistance welded) Type S (seamless) and ASME B36.10M.

3. Fittings (2 inches and under) shall be 125-psig wsp, cast iron, screwed end, conforming to ASTM A 126 Class A and ASME B16.4.

4. Fittings (2-1/2 inches and over) shall be wall thickness to match pipe, long radius butt weld, black carbon steel, conforming to ASTM A 234/A 234M, Grade WPB and ASME B16.9.

5. Couplings (2 inches and under) shall be commercial standard weight for Schedule 40 pipe and commercial extra heavy weight for Schedule 80 pipe, black carbon steel where threaded, and 2,000-or 3,000-psi wog forged carbon steel, conforming to ASTM A 105/A 105M and ASME B16.11, where welded.

6. Flanges (2-1/2 inches and over) shall be 150-pound, forged carbon-steel welding neck, with raised face or flat face and concentric serrated finish, conforming to ASTM A 105/A 105M and ASME B16.5.

C. Type GCS, Galvanized Carbon Steel

1. Pipe (1/2 through 10 inches, and where indicated) shall be Schedule 40 seamless or electric-resistance welded galvanized steel conforming to ASTM A 53, Type E, Grade B (electric-resistance welded) or Type S (seamless).

2. Pipe (12 inches and over) shall be 0.375-inch wall, seamless, galvanized steel, conforming to ASTM A 53, Grade B.

3. Fittings (2 inches and under) shall be 150-psig wsp banded galvanized malleable iron screwed, conforming to ASTM A 197 and ASME B16.3.

4. Unions (2 inches and under) shall be 150-psig wsp female, screwed, galvanized malleable iron with brass-to-iron seat and ground joint.

5. Fittings (2-1/2 inches and over) shall be 125-psig wsp cast-iron flanges and flanged fittings, conforming to ASTM A 126, Class A and ASME B16.1.

6. Grooved pipe couplings and fittings shall conform to paragraph entitled, "Grooved Pipe Couplings and Fittings."

7. Contractor has the option of using 150-psig wsp banded galvanized malleable iron screwed fittings, conforming to ASTM A 197 and ASME B16.3.

D. Type CISP-DWV, Cast-Iron Drain, Waste and Vent: Soil pipe drain, waste, and vent bell-and-spigot type pipe shall be cast iron, conforming to ASTM A 74. Joints shall be calked and leaded in lines where necessary to provide proper leaktight support and alignment; other-wise joints may be two-gasket system type chloroprene, conforming to ASTM C 564. Pipe class shall be extra heavy (CISP-DWV-XH).

E. Type CPR, Copper

1. Type CPR-A, Copper Above Ground

a. Tubing (2 inches and under) shall be seamless copper tubing, conforming to ASTM B 88, Type L (hard-drawn for all horizontal and all exposed vertical lines, annealed for concealed vertical lines).

b. Fittings (2 inches and under) shall be 150-psig wsp wrought-copper solder joint fittings conforming to ASME B16.22.

c. Unions (2 inches and under) shall be 150-psig wsp wrought-copper solder joint, conforming to ASME B16.22.

d. Brazing rod shall be Classification BCP-5, conforming to AWS A5.8.

2. Type CPR-U, Copper Under Ground: Piping shall be Type K seamless copper tube, conforming to ASTM B 88. Socket-joint fittings shall be wrought copper, conforming to ASME B16.22. Fittings for connection to corporation cocks shall be cast bronze, flared-type, conforming to ASME B16.26. Joints shall be brazed.

3. Type CPR-INS, Copper Under Ground Insulated

a. Piping shall be insulated Type K seamless copper tube conforming to ASTM B 88. Socket-joint fittings shall be wrought copper, conforming to ASME B16.22. Joints shall be brazed.

b. Insulation shall be not less than 2 inches thick, suitable for continuous service temperatures of not less than 250 degrees F. Insulation shall be factory-molded, closed-cell polyurethane foam of not less than 2.5 pounds per cubic foot density. Insulation shall be waterproofed with an extruded rigid Type II virgin polyvinylchloride, with minimum wall thickness of 60 mils through 4 inches outside diameter (od), 85 mils through 6.625 inches od, and 110 mils through 12.750 inches od. Fitting covers shall be fabricated from same materials and thickness as adjacent pipe cooling according to the manufacturer's directions.

F. Grooved Pipe Couplings and Fittings

1. Couplings shall have a housing, fabricated in two or more parts, of black, ungalvanized malleable iron castings. Coupling gasket shall be molded synthetic rubber,

conforming to ASTM D 2000. Coupling bolts shall be oval-neck, track-head type, with hexagonal heavy nuts conforming to ASTM A 183.

2. All pipe fittings used with couplings shall be fabricated of black, ungalvanized malleable ironcastings. Where a manufacturer's standard-size malleable iron fitting pattern is not available, approved fabricated fittings may be used.

3. Fittings shall be fabricated from Schedule 40 or 0.75-inch wall ASTM A 53, Grade B seamless steel pipe; long radius seamless welding fittings with wall thickness to match pipe, conforming to ASTM A 234/A 234M and ASME B16.9.

2.3 PIPING SPECIALTIES

A. Air Separator

1. Air separated from converter discharge water shall be ejected by a reduced-velocity device vented to the compression tank.

2. Commercially constructed separator shall be designed and certified to separate not less than 80 percent of entrained air on the first passage of water and not less than 80 percent of residual on each successive pass. Shop drawings shall detail piping connections proposed for this work.

3. Air separator shall be carbon steel, designed, fabricated, tested, and stamped in conformance with ASME-16 for service pressures not less than 125 psi.

B. Air Vents

1. Manual air vents shall be 3/8-inch globe valves.

2. Automatic air vents on pumps, mains, and where indicated shall be of ball-float construction. Vent inlet shall be not less than 3/4-inch ips, and the outlet shall be not less than 1/4-inch ips. Orifice shall be 1/8 inch. Trim shall be corrosion-resistant steel conforming to [ASTM A 276] [ASTM A 480/A 480M]. Vent shall be fitted with try-cock.Vent shall discharge air at any pressure to 150 psi. Outlet shall be copper tube routed.

C. Compression Tank

1. Compression tank shall be designed, fabricated, tested, and stamped for a working pressure of not less than 125 psi in accordance with ASME-16. Tank shall be hot-dip galvanized after fabrication to produce not less than 1.5 ounces of zinc coating per square foot of single-side surface.

2. Tank accessories shall include red-lined gage-glass complete with glass protectors and shutoff valves, air charger and drainer, and manual vent.

D. Dielectric Connections: Dissimilar pipe metals shall be electrically insulated from each other by couplings, unions, or flanges commercially manufactured for that purpose and rated for the service pressure and temperature.

E. Expansion Vibration Isolation Joints

1. Single or multiple arch-flanged expansion vibration isolation joints shall be constructed of steel-ring reinforced chloroprene-impregnated cloth materials. Joint shall be

designed to absorb the movement of the pipe sections in which installed with no detrimental effect on pipe or connected equipment. Flanges shall be backed with ferrous-metal backing rings. Control rod assemblies shall be provided to restrict joint movement. All nonmetallic exterior surfaces of the joint shall be coated with chlorosulphinated polyethylene. Grommets shall be provided in limit bolt hole to absorb noise transmitted through the bolts.

2. Joints shall be suitable for continuous-duty working temperature of at least 250 degrees F.

3. Arches shall be filled with soft chloroprene.

4. Joint, single-arch, movement limitations and size-related, pressure characteristics shall conform to Tables I and II of FSA-01.

F. Flexible Pipe

1. Flexible pipe vibration and pipe-noise eliminators shall be constructed of wire-reinforced, rubber-impregnated cloth and cord materials and shall be flanged. Flanges shall be backed with ferrous-metal backing rings. Service pressure-rating shall be minimum 1.5 times actual service. Surge pressure shall be at 180 degrees F.

2. Flexible pipe vibration and pipe noise eliminators shall be constructed of wire-reinforced chloroprene-impregnated cloth and cord materials and shall be flanged. Flanges shall be backed with ferrous-metal backing rings. Nonmetallic exterior surfaces of the flexible pipe shall be coated with an acid- and oxidation-resistant chlorosulphinated polyethylene. Flexible pipe shall be rated for continuous duty at 130 psi and 250 degrees F.

3. Unit pipe lengths, face-to-face, shall be not less than the following:

INSIDE DIAMETER	UNIT PIPE LENGTH
To 2-1/2 inches, inclusive	12 inches
3 to 4 inches, inclusive	18 inches
5 to 12 inches, inclusive	24 inches
To 3 inches, inclusive	18 inches
4 to 10 inches, inclusive	24 inches
12 inches and larger	36 inches

G. Flexible Metallic Pipe

1. Flexible pipe shall be the bellows-type with wire braid cover and shall be designed, constructed, and rated in accordance with the applicable requirements of ASME B31.3.

2. Working pressure minimum rating shall be [50] [100] psi at 300 degrees F.

3. Minimum burst pressure shall be four times working pressure at 300 degrees F. Bellows material shall be AISI Type 316L corrosion-resistant steel. Braid shall be AISI 300 series corrosion-resistant steel wire.

4. Welded end connections shall be Schedule 80 carbon steel pipe, conforming to ASTM A 106, Grade B.

5. Threaded end connections shall be hex-collared Schedule 40, AISI Type 316L corrosion-resistant steel, conforming to ASTM A 312/A 312M.

6. Flanged end connection rating and materials shall conform to specifications for system primary-pressure rating.

H. Metallic Expansion Joints

1. Expansion joints shall be metallic-bellows-type, conforming to MS MIL-E-17813.

2. Expansion joints shall be Type I (corrugated bellows, unreinforced), Class 1 (single bellows, expansion joint).

3. Joints shall be designed and constructed to absorb all of the movements of the pipe sections in which installed, with no detrimental effect on pipe or supporting structure.

4. Joints shall be rated, designed, and constructed for pressures to 125 psig and temperatures to 500 degrees F.

5. Joints shall have a designed bursting strength in excess of four times their rated pressure.

6. Joints shall be capable of withstanding a hydrostatic test of 1.5 times their rated pressure while held at their uncompressed length without leakage or distortion that may adversely affect their life cycle.

7. Life expectancy shall be not less than 10,000 cycles.

8. Movement capability of each joint shall exceed calculated movement of piping by 100 percent.

9. Bellows and internal sleeve material shall be AISI Type 304, 304L, or 321 corrosion-resistant steel.

10. End connections shall require no field preparation other than cleaning.

11. Butt weld end preparation of expansion joints shall conform to the same codes and standards requirements as applicable to the piping system materials at the indicated joint location.

12. Flanges of flanged-end expansion joints shall conform to the same codes and standard requirements as are applicable to companion flanges specified for the given piping system at the indicated joint location.

13. Joints, 2-1/2 inches and smaller, shall have internal guides and limit stops.

14. Joints, 3 inches and larger, shall be provided with removable external covers, internal sleeves, and purging connection. Sleeves shall be sized to accommodate lateral clearance required, with minimum reduction of flow area, and with oversized bellows where necessary. When a sleeve requires a gasket as part of a locking arrangement, the gasket shall be provided by the manufacturer. Joints without purging connection may be provided;

however, these shall be removed from the line prior to, or not installed until, cleaning operations are complete.

15. Cylindrical end portion of the reinforced bellows element shall be provided with a thrust sleeve of sufficient thickness to bring that portion within applicable code-allowable stress. Sleeve shall provide 360 degrees support for the element and end-reinforcing ring.

16. Expansion joints shall have four, equidistant, permanent tram points clearly marked on each joint end. Points shall be located to prevent obliteration during installation. Distance between tram points indicating installed lengths shall be included in shop drawings. Overall dimension after joint installation shall be subject to approval.

17. Each expansion joint shall have adjustable clamps or yokes provided at quarter points, straddling the bellows. Overall joint length shall be set by the manufacturer to maintain joints in manufacturer's recommended position during installation.

18. Each joint shall be permanently and legibly marked with the manufacturer's name or trademark and serial number; the size, series, or catalog number; bellows material; and directional-flow arrow.

I. Hose Faucets: Hose faucets shall be constructed with 1/2-inch male inlet threads, hexagon shoulder, and 3/4-inch hose connection, conforming to ANSI A112.18.1M. Hose-coupling screw threads shall conform to ASME B1.20.7. Vandalproof, atmospheric-type vacuum breaker shall be provided on discharge.

J. Orifice Unions shall be [ferrous] [nonferrous] type, with gasketed corrosion-resistant steel orifice. Flanged unions shall have the orifice size stamped on a tab of the orifice. Screwed unions shall have the orifice size stamped on the coupling nut.

K. Pressure Gages shall conform to ANSI B40.1 and to requirements specified herein. Pressure gages shall be Type I, (for air, steam, and water) [Class 1 (pressure)] [Class 2 (vacuum)] [Class 3 (pressure/vacuum)]. Pressure-gage size shall be 3-1/2 inches nominal diameter. Case shall be corrosion-resistant steel, conforming to any of the AISI 300 series of ASTM A 6/A 6M, with an ASM No. 4 standard commercial polish or better. Gages shall be equipped with adjustable red marking pointer and damper-screw adjustment in inlet connection. Service-pressure reading shall be at midpoint of gage range. All gages shall be equipped with gage isolators.

L. Sight-flow indicators for pressure service on 3-inch ips and smaller shall be constructed of bronze with specially treated single- or double-glass sight windows and shall have a bronze, nylon, or tetrafluoroethylene rotating flow indicator mounted on an AISI Type [304] [316] corrosion-resistant steel shaft. Body may have screwed or flanged end. Assembly shall be pressure- and temperature-rated for the applied service. Flapper flow-type indicators are not acceptable.

M. Sleeve Couplings for plain-end pipe shall consist of one steel middle ring, two steel followers, two chloroprene or Buna-N elastomer gaskets, and the necessary steel bolts and nuts.

N. Thermometers shall conform to ASTM E 1.Thermometers shall be industrial pattern Type I, except red Organic-liquid-filled, Class 3 (well-threaded and seal-welded). Thermometers installed 6 feet or higher above the floor shall have an adjustable angle body. Scale shall be not less than 7 inches long. Case face shall be manufactured from manufacturer's standard polished aluminum or AISI 300 series polished corrosion-resistant steel. Thermometer range shall be 0 degrees F to 100 degrees F for chilled water systems, and 50 degrees F to 250 degrees F for hot water systems. Thermometers shall be provided with nonferrous separable wells. Lagging extension to accommodate insulation thickness shall be provided.

O. Pump Suction Strainers

1. Strainer body shall be cast iron, rated for not less than 25 psig at 100 degrees F, with flanges conforming to ASME B16.1, Class 125. Strainer construction shall be such that there is a machined surface joint between body and basket that is normal to the centerline of the basket.

2. Minimum ratio of open area of each basket to pipe area shall be 3 to 1. Basket shall be AISI 300 series corrosion-resistant steel wire mesh with perforated backing.

3. Mesh shall be capable of retaining all particles larger than 1,000 micrometer, with a pressure drop across the strainer body of not more than 0.5 psi when the basket is two-thirds dirty at maximum system flow rate. Reducing fittings from strainer-flange size to pipe size shall be provided.

4. A differential-pressure gage with 0.25-pound graduations fitted with a two-way brass cock shall be provided across the strainer. Manual air vent cocks shall be provided in cap of each strainer.

P. Line Strainers, Water Service

1. Strainers shall be Y-type with removable basket. Strainers in sizes 2-inch ips and smaller shall have screwed ends. In sizes 2-1/2-inch ips and larger, strainers shall have flanged ends. Body working-pressure rating shall exceed maximum service pressure of system in which installed by at least 50 percent. Body shall have cast-in arrows to indicate direction of flow. All strainer bodies fitted with screwed screen retainers shall have straight threads and shall be gasketed with nonferrous metal. Strainer bodies 2-1/2-inches and larger, fitted with bolted-on screen retainers, shall have offset blowdown holes. All strainers larger than 2-1/2-inches shall be fitted with manufacturer's standard ball-type blowdown valve. Body material shall be cast iron conforming to Class 30 ASTM A 278. Where system material is nonferrous, metal strainer body material shall be nonferrous metal.

2. Minimum free-hole area of strainer element shall be equal to not less than 3.4 times the internal area of connecting piping. Strainer screens shall have perforations not to exceed 0.045-inch. Strainer screens shall have finished ends fitted to machined screen chamber surfaces to preclude bypass flow. Strainer element material shall be AISI Type 316 corrosion-resistant steel.

2.4 VALVES

A. Ball and Butterfly Valves

1. Ball valves shall conform to MSS SP-72. Valves shall be Style 1A and shall be rated for service at not less than 175 psig at 200 degrees F. Valve bodies in sizes 2 inches and smaller shall be screwed-end connection-type constructed of Class A copper alloy. Valve bodies in sizes 2-1/2 inches and larger shall be flanged-end connection type, constructed of Class D material. Balls and stems of valves 2 inches and smaller shall be manufacturer's

standard with hard chrome plating finish. Balls and stems of valves 2-1/2 inches and larger shall be manufacturer's standard Class C corrosion-resistant steel alloy with hard chrome plating. Balls of valves 6 inches and larger may be Class D with 900 Brinell hard chrome plating. Valves shall be suitable for flow from either direction and shall seal equally tight in either direction. Valves with ball seals held in place by spring washers are not acceptable. All valves shall have adjustable packing glands. Seats and seals shall be tetrafluoroethylene.

2. Butterfly valves shall conform to MSS SP-67. Valves shall be wafer type for mounting between specified flanges and shall be rated for 150-psig shutoff and nonshock working pressure.

3. Bodies shall be cast ferrous metal conforming to ASTM A 126, Class B, and to ASME B16.1 for body wall thickness. Seats and seals shall be of the resilient elastomer type designed for field removal and replacement.

B. Drain, Vent, and Gage Cocks

1. Drain, vent and gage cocks shall be T-head, ground key type, with washer and screw, constructed of polished ASTM B 62 bronze, and rated 125-psi wsp. End connections shall be rated for specified service.

2. Pump vent cocks, and where spray control is required, shall be UL umbrella-hood type, constructed of manufacturer's standard polished brass. Cocks shall be 1/2-inch ips male, end threaded, and rated at not less than 125 psi at 225 degrees F.

C. Gate Valves (GAV)

1. Gate valves 2 inches and smaller shall conform to MSS SP-72. Valves located in tunnels, equipment rooms, factory-assembled equipment, and where indicated shall be union-ring bonnet, screwed-end type. Packing shall be made of non-asbestos type materials. Valves shall be rising stem type.

2. Gate valves 2-1/2 inches and larger, shall be Type I, (wedge disk, tapered seats, steam rated); Class I (125-psig steam-working pressure at 353 degrees F saturation); and 200-psig, wog (nonshock), conforming to MSS SP-70 and to requirements specified herein. Valves shall be flanged, with bronze trim and outside screw and yoke (OS&Y) construction. Packing shall be made of non-asbestos type materials.

D. Globe and Angle Valves (GLV-ANV)

1. Globe and angle valves 2 inches and smaller, shall be 125-pound, 125-psi, conforming to MSS SP-72 and to requirements specified herein. Valves located in tunnels, equipment rooms, factory-assembled equipment, and where indicated shall be union-ring bonnet, screwed-end type. Disc shall be free to swivel on the stem in all valve sizes. Composition seating-surface disc construction may be substituted for all metal-disc construction. Packing shall be made of non-asbestos type materials. Disk and packing shall be suitable for pipe service installed.

2. Globe and angle valves 2-1/2 inches and larger, shall be cast iron with bronze trim. Valve bodies shall be cast iron conforming to ASTM A 126, Class A, as specified for Class 1 valves under MSS SP-70. Valve ends shall be flanged in conformance with ASME B16.1. Valve construction shall be outside screw and yoke (OS&Y) type. Packing shall be made of non-asbestos type materials.

E. Standard Check Valves (SCV)

1. Standard check valves in sizes 2 inches and smaller shall be 125-psi swing check conforming to MSS SP-72, except as otherwise specified. Lift checks (lift check horizontal) and 125-psi, conforming to MSS SP-72, shall be provided where indicated. Swing-check pins shall be nonferrous and suitably hard for the service. Discs shall be composition type.

2. Swing-check angle of closure shall be manufacturer's standard unless a specific angle is needed.

3. Check valves in sizes 2-1/2 inches and larger shall be cast iron, bronze trim, swing type. Valve bodies shall be cast iron, conforming to ASTM A 126, Class A. Valve ends shall be flanged in conformance with ASME B16.1. Swing-check pin shall be AISI Type [304] [316] or approved equal corrosion-resistant steel. Angle of closure shall be manufacturer's standard unless a specific angle is needed. Valves shall have bolted and gasketed covers.

4. Check valves shall be provided with external spring-loaded, positive-closure devices and valve ends shall be mechanical joint.

F. Nonslam Check Valves (NSV)

1. Check valves at pump discharges in sizes 2 inches and larger shall be nonslam or silent-check type. Valve disc or plate shall close before line flow can reverse to eliminate slam and water-hammer due to check-valve closure. Valve shall be rated for 200-psi maximum, nonshock pressure at 150 degrees F in sizes to 12 inches. Valves shall be [wafer type to fit between flanges conforming to ASME B16.1] [fitted with flanges conforming to ASME B16.1]. Valve body may be cast iron, conforming to ASTM A 278, Class 40 or equivalent strength ductile iron. Disks shall be manufacturer's standard bronze, aluminum bronze, or corrosion-resistant steel. Pins, springs, and miscellaneous trim shall be manufacturer's standard corrosion-resistant steel. Disk and shaft seals shall be Buna-N elastomer tetrafluoroethylene.

2.5 MISCELLANEOUS MATERIALS

A. Bituminous Coating shall be a solvent cutback, heavybodied material to produce not less than a 12-mil dry-film thickness in one coat, and shall be as recommended by the manufacturer to be compatible with factory-applied coating and rubber joints.

B. Bolting: Flange and general purpose bolting shall be hex-head and shall conform to ASTM A 307, Grade B (bolts, for flanged joints in piping systems where one or both flanges are cast iron). Heavy hex-nuts shall conform to ASTM A 563. Square-head bolts and nuts are not acceptable. Threads shall be coarse-thread series.

C. Elastomer Calk: Polysulfide- or polyurethane-base elastomer calking material shall be two-component type, conforming to ASTM C 920.

D. Escutcheons

1. Escutcheons shall be manufactured from nonferrous metals and shall be chrome-plated except when AISI 300 series corrosion-resistant steel is provided. Metals and finish shall conform to FS WW-P-541/5.

2. Escutcheons shall be one-piece type where mounted on chrome-plated pipe or tubing, and one-piece of split-pattern type elsewhere. All escutcheons shall have provisions consisting of internal spring-tension devices for maintaining a fixed position against a surface.

E. Flashing

1. Sheet lead shall conform to ASTM B 749, Grade B.

2. Sheet copper shall conform to ASTM B 370 and shall be of not less than 16 ounces per square foot weight.

F. Flange Gaskets: Compressed non-asbestos sheet, conforming to ASTM F 104, Type 7-P1161A, coated on both sides with graphite or similar lubricant, with nitrile composition, binder rated to 750 degrees F.

G. Grout:

1. Shrink-resistant grout shall be a premixed and packaged metallic-aggregate, mortar-grouting compound conforming to ASTM C 404 and ASTM C 476.

2. Shrink-resistant grout shall be a combination of premeasured and packaged epoxy polyamide or amine resins and selected aggregate mortar grouting compound conforming to the following requirements:

Tensile strength	ASTM C 190	1,900 psi, minimum
Compressive strength	ASTM C 109	14,000 psi, minimum
Shrinkage, linear		0.00012 inch per inch, maximum
Water absorption	ASTM C 67	0.1 percent, maximum
Bond strength to steel in shear minimum		1,000 psi, minimum

H. Pipe Thread Compounds: Tetrafluoroethylene tape not less than 2 to 3 mils thick shall be used in potable and process water and in chemical systems for pipe sizes to and including 1-inch ips. Tetrafluoroethylene dispersions and other suitable compounds may be used for all other applications upon approval; however, no lead-containing compounds may be used in potable water systems.

2.6 SUPPORTING ELEMENTS

A. General:

1. All necessary piping systems and equipment supporting elements shall be provided, including but not limited to: building structure attachments; supplementary steel; hanger rods, stanchions, and fixtures; vertical pipe attachments; horizontal pipe attachments; anchors; guides; and spring-cushion, variable, or constant supports. All supporting elements shall be suitable for stresses imposed by systems pressures and temperatures and natural and other external forces normal to this facility without damage to supporting element system or to work being supported.

2. Supporting elements shall conform to requirements of ASME B31.3, FS FF-S-325, MSS SP-58, and MSS SP-69 except as noted.

3. Attachments welded to pipe shall be made of materials identical to that of pipe or materials accepted as permissible raw materials by referenced code or standard specification.

4. Supporting elements exposed to weather shall be hot-dip galvanized. Materials shall be of such a nature that their apparent and latent-strength characteristics are not reduced due to galvanizing process. Supporting elements in contact with copper tubing shall be electroplated with copper.

5. Type designations specified herein are based on MSS SP-58 and MSS SP-69. Masonry anchor group-, type-, and style-combination designations shall be in accordance with FS FF-S-325. Support elements, except for supplementary steel, shall be cataloged, load rated, commercially manufactured products.

B. Building Structure Attachments

1. Anchor Devices, Concrete and Masonry: Anchor devices shall conform to FS FF-S-325 for the following types:

Group I - shield, expansion (lead, bolt and stud anchors)

Group II - shield, expansion (bolt anchors)

Type 2 - machine bolt expansion shield anchors

Class 2 - open-end expansion shield anchors

Style 1 - single-end expansion shield anchors

Style 2 - double-end expansion shield anchors

Group III - shield, expansion (self-drilling tubular expansion shell bolt anchors)

Group VIII - anchors, expansion (nondrilling)

Cast-in, floor mounted, equipment anchor devices shall provide adjustable positions.

Masonry anchor devices shall be built-in.

Powder-actuated anchoring devices shall not be used to support any mechanical systems components.

C. Beam Clamps

1. Beam clamps shall be center-loading Type 28.

2. When it is not possible to use center-loading beam clamps, eccentric-loading beam clamps, Type 20 may be used for piping sizes 2 inches and less and for piping sizes 2 through 10 inches, provided two counterbalancing clamps are used per point of pipe support. Where more than one rod is used per point of pipe support, rod diameter shall be determined in accordance with referenced standards.

D. C-Clamps may be used to support piping sizes 1-1/2 inches and smaller. C-clamps shall be FM approved and UL listed with hardened cup-tip setscrew, locknut, and retaining strap. Retaining strap section shall be not less than 1/8 by 1 inch. Beam flange thickness to which clamps are attached shall not exceed 0.60 inch.

D. Inserts, Concrete: Concrete inserts shall be Type 18. When applied to piping in sizes 2 inches ips and larger and where otherwise required by imposed loads, a 1-foot length of 1/2-inch reinforcing rod shall be inserted and wired through wing slots. Proprietary-type continuous inserts may be submitted for approval.

E. Horizontal Pipe Attachments

1. Single Pipes

a. Piping in sizes to and including 2-inch ips shall be supported by Type 6 solid malleable iron pipe rings, except that split-band-type rings may be used in sizes up to 1-inch ips.

b. Piping in sizes through 8-inch ips inclusive shall be supported by Type 1, 3 or 4 attachments.

c. Type 1 and Type 6 assemblies shall be used on vapor-sealed insulated piping and shall have an inside diameter larger than pipe being supported to provide adequate clearance during pipe movement.

d. Where thermal movement of a point in a piping system 4 inches and larger would cause a hanger rod to deflect more than 4 degrees from the vertical or where a horizontal point movement exceeds 1/2 inch, Type 41, 44 through 47 or 49 pipe rolls shall be used.

e. Piping in sizes larger than 8-inch ips shall be supported with Type 41, 44 through 47 or 49 pipe rolls.

f. Type 40 shields shall be used on all insulated piping.Area of the supporting surface shall be such that compression deformation of insulated surfaces does not occur. Longitudinal and transverse shield edges shall be rolled away from the insulation.

g. Insulated piping without vapor barrier on roll supports shall be provided with Type 39a saddles for pipe sizes to 12-inch ips and Type 39b for pipe sizes 12-inch ips and larger.

h. Type 39a or 39b saddles shall be used for pipe guiding.

i. Spring supports shall be as indicated.

F. Parallel Pipes: Trapeze hangers fabricated from approved structural steel shapes, with U-bolts, shall be used in congested areas and where multiple pipe runs occur.

G. Vertical Pipe Attachments: Vertical pipe attachments shall be Type 8. Shop drawing data shall include complete fabrication and attachment details of any spring supports.

H. Hanger Rods and Fixtures

1. Only circular cross section rod hangers may be used to connect building structure attachments to pipe support devices. Pipe, straps, or bars of equivalent strength shall be used for hangers only where approved.

2. Turnbuckles, swing eyes, and clevises shall be provided as required by support system to accommodate temperature change, pipe accessibility, and adjustment for load and pitch. Rod couplings are not acceptable.

I. Supplementary Steel: Where it is necessary to frame structural members between existing members or where structural members are used in lieu of commercially rated supports, such supplementary steel shall be designed and fabricated in accordance with AISC S328.

PART 3 - EXECUTION

3.1 PIPE INSTALLATION

A. Piping systems shall be fabricated and installed in accordance with ASME B31.3, MSS SP-69, and AWS-02.

B. Connections between steel piping and copper piping shall be electrically isolated from each other with dielectric couplings (or unions) or flanged with gaskets rated for the service.

C. Final connections to equipment shall be made with unions or flanges provided every 100 feet of straight run. Unions shall be provided in the line downstream of screwed- and welded-end valves.

D. All pipe ends shall be reamed before joint connections are made.

E. Screwed joints shall be made up with specified joint compound and not more than three threads shall show after joint is made up.

F. Joint compounds shall be applied to the male thread only and care shall be exercised to prevent compound from reaching the unthreaded interior of the pipe.

G. Screwed unions, welded unions, or bolted flanges shall be provided wherever required to permit convenient removal of equipment, valves, and piping accessories from the piping system for maintenance.

H. Piping systems shall be securely supported with due allowance for thrust forces, thermal expansion and contraction, and shall not be subjected to mechanical, chemical, vibrational or other damage as specified in ASME B31.3.

I. Field welded joints shall conform to the requirements of the AWS-02, ASME B31.3, and ASME-17.

J. Piping systems butt weld joints shall be made with backing rings. Backing ring materials shall be compatible with materials being joined.Joint configuration shall conform to ASME B16.25.

K. Preheat and postheat treatment of welds shall be done in accordance with ASME-17 and ASME B31.3.

L. All necessary precautions shall be taken during installation of flexible pipe and hose including flushing and purging with water, steam, and compressed air to preclude bellows failure due to pipe line debris lodged in bellows. Installation shall conform to manufacturer's instructions.

3.2 VALVES

A. Valves shall be provided in piping mains and all branches and at equipment where indicated and as specified.

B. Valves shall be provided to permit isolation of branch piping and each equipment item from the balance of the system.

C. Riser and downcomer drains above piping shutoff valves in piping 2-1/2 inches and larger shall be provided. Shutoff valve body shall be tapped and fitted with a 1/2-inch plugged globe valve.

D. Valves unavoidably located in furred or other normally inaccessible places shall be provided with adequately sized access panels approved for the location.

3.3 SUPPORTING ELEMENTS INSTALLATION

A. Supporting elements shall be provided in accordance with the referenced codes and standards.

B. Piping shall be supported from building structure. No piping shall be supported from roof deck or from other pipe.

C. Piping shall run parallel with the lines of the building. Piping and components shall be spaced and installed so that a threaded pipe fitting may be removed between adjacent pipes and so that there shall be no less than 1/2 inch of clear space between the finished surface and other work and between the finished surface of parallel adjacent piping. Hangers on different adjacent service lines running parallel with each other shall be arranged to be in line with each other and parallel to the lines of the building.

E. Piping support elements shall be installed at intervals specified hereinafter, at locations not more than 3 feet from the ends of each runout, and not over 1 foot from each change in direction of piping.

F. Load rating for all pipe-hanger supports shall be based on insulated weight of lines filled with water and forces imposed. Deflection per span shall not exceed slope gradient of pipe. Supports shall be in accordance with the following minimum rod size and maximum allowable hanger spacing for specified pipe. For concentrated loads such as valves, the allowable span shall be reduced proportionately:

PIPE SIZE INCHES	ROD SIZE INCHES	STEEL PIPE FEET	COPPER PIPE FEET
1 and smaller	3/8	8	6
1-1/4 to 1-1/2	3/8	10	8
2	3/8	12	10
2-1/2 to 3-1/2	1/2	12	12
4 to 5	5/8	16	14

6	3/4	16	16
8 to 12	7/8	20	20
14 to 18	1	20	20
20 and over	1-1/4	20	20

G. Vibration isolation supports shall be provided where needed.Refer to Section 15245, "Vibration Isolation for Air Conditioning Equipment," where A/C equipment and piping is installed.

H. Vertical risers shall be supported independently of connected horizontal piping, whenever practicable, with fixed or spring supports at the base and at intervals to accommodate system range of thermal conditions. Risers shall be guided for lateral stability. For risers subject to expansion, only one rigid support shall be provided at a point approximately one-third down from the top. Clamps shall be placed under fittings unless otherwise specified. Carbon-steel pipe shall be supported at each floor and at not more than 15-foot intervals for pipe 2 inches and smaller and at not more than 20-foot intervals for pipe 2-1/2 inches and larger.

3.4 PENETRATIONS

A. Effective sound stopping and adequate operating clearance shall be provided to prevent structure contact where piping penetrates walls, floors, or ceilings into occupied spaces adjacent to equipment rooms; where similar penetrations occur between occupied spaces; and where penetrations occur from pipe chases into occupied spaces.Occupied spaces shall include space above ceilings where no special acoustic treatment of ceiling is provided. Penetrations shall be finished to be compatible with surface being penetrated.

B. Sound stopping and vapor-barrier sealing of pipe shafts and large floor and wall openings shall be accomplished by packing to high density with properly supported fibrous-glass insulation or, where ambient or surface temperatures do not exceed 120 degrees F, by foaming-in-place with self-extinguishing, 2-pound density polyurethane foam to a depth not less than 6 inches. Foam shall be finished with a rasp.Vapor barrier shall be not less than 1/8-inch thick vinyl coating applied to visible and accessible surfaces.Where high temperatures and fire stopping are a consideration, only mineral wool shall be used and openings shall also be covered with 16-gage sheet metal.

3.5 SLEEVES

A. Sleeves shall be provided where piping passes through roofs, masonry, concrete walls and floors.

B. Sleeves passing through steel decks shall be continuously welded to the deck.

C. Sleeves that extend through floors, roofs, load bearing walls, and fire barriers shall be continuous and fabricated from Schedule 40 steel pipe, with welded anchor lugs. All other sleeves shall be formed by molded linear polyethylene liners or similar materials that are removable. Diameter of sleeves shall be large enough to accommodate pipe, insulation, and jacketing without touching the sleeve and shall provide a minimum 3/8-inch clearance. Sleeve size shall accommodate mechanical and thermal motion of pipe to preclude transmission of vibration to walls and the generation of noise.

D. Space between a pipe, bare or insulated, and the inside of a pipe sleeve or a construction surface penetration shall be packed solid with a mineral fiber conforming to FS HH-I-558, Form B, Type 1 (flexible blanket), Class 8, (451 to 1,000 degrees F). This packing shall be provided wherever the piping passes through firewalls, equipment room walls, floors, and ceilings connected to occupied spaces, and other locations where sleeves or construction-surface penetrations occur between occupied spaces. Where sleeves or construction surface penetrations occur between conditioned and unconditioned spaces, the space between a pipe, bare or insulated, and the inside of a pipe sleeve or construction surface penetration shall be filled with an elastomer calk to a depth of 1/2 inch. All surfaces to be calked shall be oil- and grease-free.

Exterior wall sleeves shall be calked watertight with lead and oakum or mechanically expandable chloroprene inserts with mastic-sealed metal components.

Sleeve height above roof surface shall be a minimum of 12 and a maximum of 18 inches.

3.6 ESCUTCHEONS: Escutcheons shall be provided at all penetrations of piping into finished areas. Where finished areas are separated by partitions through which piping passes, escutcheons shall be provided on both sides of the partition. Where suspended ceilings are installed, plates shall be provided at the underside only of such ceilings. For insulated pipes, the plates shall be large enough to fit around the insulation. Escutcheons shall be chrome-plated in all occupied spaces and of size sufficient to effectively conceal openings in building construction. Escutcheons shall be firmly attached with setscrews.

3.7 FLASHINGS: Flashings shall be provided at penetrations of building boundaries by mechanical systems and related work.

3.8 UNDERGROUND PIPING INSTALLATION

A. Prior to being lowered into a trench, all piping shall be cleaned, visually inspected for apparent defects, and tapped with a hammer to audibly detect hidden defects.

B. Suspect cast-ferrous piping shall be further inspected by painting with kerosene on external surfaces to reveal cracks.

C. Defective materials found shall be distinctly marked using a road-traffic quality yellow paint; defective material shall be promptly removed from the site.

D. After conduit has been inspected, and not less than 48 hours prior to being lowered into a trench, all external surfaces of cast ferrous conduit shall be coated with a compatible bituminous coating for protection against brackish ground water. Application shall be single coat, in accordance with the manufacturer's instructions, to result in a dry-film thickness of not less than 12 mils.

E. Excavations shall be dry and clear of extraneous materials when pipe is being laid.

F. Cutting of piping shall be by wheel cutters or other machines designed specifically for that purpose. Electric-arc and oxyacetylene cutting will not be permitted.

G. Laying of pipe shall begin at the low point of a system. When in final acceptance position, it shall be true to the grades and alignment indicated, with unbroken continuity of invert. Blocking and wedging will not be permitted.

H. Bell or grooved ends of piping shall point upstream.

I. Changes in direction shall be made with long sweep fittings.

J. Necessary socket clamping, piers, bases, anchors, and thrust blocking shall be provided. Rods, clamps, and bolting shall be protected with a coating of bitumen.

K. Underground piping below supported or suspended slabs shall be supported from the slab with a minimum of two supports per length of pipe. Supports shall be protected with a coating of bitumen.

L. On excavations that occur near and below building footings, the backfilling material shall consist of 2,000-psi cured compressive-strength concrete poured or pressure-grouted up to the level of the footing.

M. Vertical downspouts; soil, waste, and vent stacks; water risers; and similar work shall be properly supported on approved piers at the base and provided with approved structural supports attached to building construction.

N. Cleanout, flushing, and observation risers shall be provided.

3.9 HEAT TRACE CABLE INSTALLATION

A. Heater tape shall be field applied and cut to fit as necessary, linearly along the length of pipe after piping has been pressure tested and approved. Secure the heater to piping with cable ties. Thermal insulation shall be labeled on the outside, "Electrical Heat Trace."

B. Power connection, end seals, splice kits and tee kit components shall be installed in accordance with IEEE Std 515 to provide a complete workable system. Connection to the thermostat and ends of the heat tape shall be terminated in a junction box. Cable and conduit connections shall be raintight.

3.10 DISINFECTION: Water piping, including all valves, fittings, and other devices, shall be disinfected with a solution of chlorine and water. Solution shall contain not less than 50 parts per million (ppm) of available chlorine. Solution shall be held for a period of not less than 8 hours, after which the solution shall contain not less than 10 ppm of available chlorine or the piping shall be redisinfected. After successful sterilization, the piping shall be thoroughly flushed before placing into service. Flushing shall be complete when the flush water contains less than 0.5 ppm of available chlorine. Water for disinfected will be furnished by the Institute. Contractor shall be responsible for approved disposal of contaminated flush water.

3.11 HEAT TRACE CABLE TESTS: Heat trace cable system shall be tested in accordance with IEEE Std 515 after installation and before and after installation of the thermal insulation. Heater cable shall be tested using a 1000 vdc megger. Minimum insulation resistance shall be 20 to 1000 megohms regardless of cable length.

END OF SECTION

SECTION 15055

WELDING MECHANICAL

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

NATIONAL BOARD OF BOILER AND PRESSURE VESSEL INSPECTORS (NBBPVI)

NBBPVI-23	(1989) National Board Inspection Code

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B31.1	(1992) Power Piping
ASME B31.3	(1990; Errata) Chemical Plant and Petroleum Refinery Piping
ASME B31.5	(1992; Errata 1993) Refrigeration Piping
ASME-14	(1992) Boiler and Pressure Vessel Code; Section V, Nondestructive Examination
ASME-16	(1992) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage
ASME-17	(1992) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications
ASME-20	(1992) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 2 - Alternatives Rules for Basic Coverage

BUILDING OFFICIALS & CODE ADMINISTRATORS (BOCA)

BOCA-01	(1990; 8th Ed) The BOCA National Plumbing Code

PIPE FABRICATION INSTITUTE (PFI)

PFI ES-1	(1989) Internal Machining and Solid Machined Backing Rings for Circumferential Butt Welds
PFI ES-21	(1989) Internal Machining and Fit-up of GTAW Root Pass Circumferential Butt Welds
PFI ES-3	(1990) Fabricating Tolerances
PFI ES-31	(1988) Standard for Protection of Ends of Fabricated Piping Assemblies
PFI ES-35	(1990) Nonsymmetrical Bevels and Joint Configurations for Butt Welds

PFI ES-7	(1988) Minimum Length and Spacing for Welded Nozzles
PFI TB1	(1988) Pressure Temperature Ratings of Seamless Pipe Used in Power Plant Piping Systems

1.2 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Manufacturer's Catalog Data shall show type, voltage and/or amperage for the following items:

Welding Equipment
Welding Rods and Accessories

B. Statements:

1. Within fifteen days after receipt of Notice to Proceed, the Contractor shall submit for approval review to the Construction Manager the following items:

Certified Welding Procedure Specifications (WPS), two copies
Certified Brazing Procedure Specifications (BPS), two copies
Certified Procedure Qualification Records (PQR), two copies

2. Fifteen calendar days prior to any employee welding on project material, the Contractor shall submit for approval to the Construction Manager the following items:

Certified Welder Performance Qualifications (WPQ), two copies
Certified Brazer Performance Qualifications (BPQ), two copies

C. Reports: Test Reports shall be submitted for Radiographs

D. Samples: Welder's Pre-Qualification Samples shall be submitted.

1.3 QUALITY ASSURANCE

A. Personnel Qualifications: This specification contains the minimum requirements for qualifying welding procedures, welders, and welding operators for making and inspecting welds in mechanical fabrications of carbon steel, low alloy steel, extra-high-strength quenched and tempered low alloy steels, and austenitic stainless steel materials.

1. No pre-qualified welding procedures are allowed.Contractor shall qualify the welding procedures and welders by tests prescribed in accordance with ASME-17, not withstanding the fact the code or specification may allow pre-qualified procedures.

B. Pressure Vessels Qualification: Qualification documents WPS BPS, PQR and WPQ BPQ shall be in accordance with ASME-17.

C. Piping Qualifications

1. High Pressure Piping: Qualification documents for 125 psig or above, (WPS BPS, PQR and WPQ) BPQ shall be in accordance with ASME-17.

2. Low Pressure Piping

a. Refrigeration Piping:Qualification documents for below 125 psig, WPS BPS, PQR and WPQ BPQ for "Refrigeration Piping" shall be in accordance with ASME B31.5.

b. Plumbing: Plumbing work shall be performed by a state licensed plumber.

c. Other Low Pressure Piping: Qualification documents, WPS BPS, PQR and WPQ BPQ shall be in accordance with ASME-17.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 CONSTRUCTION

A. Pressure Vessels: Contractor shall meet the fabrication, welding/brazing and inspection requirements of the ASME-16 and ASME-20.

B. Piping

1. High Pressure (125 Psig or Above)

a. Steam Piping: Piping systems shall be fabricated, assembled and welded/brazed in accordance with ASME B31.1, and Power Piping Codes, PFI ES-1, PFI ES-3, PFI ES-7, PFI ES-21, PFI ES-31, PFI ES-35, and PFI TB1, of the Piping Fabrication Institute's companion code requirements.

b. Other High Pressure Piping:Other high pressure piping systems shall be fabricated, assembled and welded/brazed in accordance with ASME B31.3, and Power Piping Codes, PFI ES-1, PFI ES-3, PFI ES-7, PFI ES-21, PFI ES-31, PFI ES-35, and PFI TB1, of the Piping Fabrication Institute's companion code requirements.

2. Low Pressure (Below 125 Psig)

a. Refrigeration Piping systems shall be fabricated, assembled and welded/brazed/soldered in accordance with the ASME B31.5.

b. Plumbing systems shall be fabricated, assembled and welded/brazed/soldered in accordance with BOCA-01.

c. Other Low Pressure Piping systems shall be fabricated, assembled and welded/brazed/soldered in accordance with the ASME B31.1.

3.2 HEAT INPUT REQUIREMENTS

A. Preheat: Welding shall not be done at ambient temperature below 32 degrees F, or when the surfaces are wet or exposed to rain, snow, or high wind.Temperature of the metals in the area where the welding is to be done shall be not less than 50 degrees F. When the ambient conditions are such that the normal temperature of the base metal is below 50 degrees F, the area surrounding the joint shall be preheated to provide a base metal temperature of 100 degrees F for a distance of at least 3 inches in all directions from the joint to be welded.Preheat shall be in accordance with ASME-16 ASME-20 and ASME-14.

B. Interpass: In a multipass weld, the interpass temperature is the temperature of the weld metal before the next pass is started.Interpass requirements shall be in accordance with ASME-16 ASME-14 ASME-20.

C. Postweld: Weldments shall not be given a postweld heat treatment unless noted in the applicable approved code qualified/certified welding documentation, WPS, PQR and WPQ.

3.3 INSPECTION/NONDESTRUCTIVE TESTING (NDT)

A. General

1. Fabrication/Erection inspection shall be performed prior to assembly, during assembly, during welding and after welding to ensure that materials and workmanship meet the requirements of the contract documents.

2. Each specified radiograph shall, as a minimum, have the following additional information permanently included in the image:

Agency Weld No. (including repair cycle no.)
Agency drawing No.
Agency View No.
Agency Contract No.

3. Final interpretation and acceptance of all radiographs of welded joints, with the exception of code stamped pressure vessel welds, will be by the Construction Manager.

4. Final acceptance of all welded/brazed joints shall be by the Construction Manager.

5. Prior to the Construction Manager's inspection, all slag and scale shall be removed from all welds.Procedure employed shall not produce notches in either the weld metal or adjacent base metal.

6. Unacceptable welds shall be immediately repaired and made ready for the Construction Manager's reinspection at no additional cost to the Institute.

7. After weld joints have been satisfactorily completed by the Contractor and accepted by the Construction Manager, the joint area shall be cleaned to a bright, unpitted, and unscarred surface and then protected in accordance with the contract documents.

B. Pressure Vessels

1. Test Method: All nondestructive testing shall be performed in accordance with the requirements of ASME-14.

2. Acceptance Requirements shall be in accordance with ASME-14 and ASME-20.

C. Piping

1. Test Method: NDT (Nondestructive Testing) of all piping systems, except plumbing systems, shall be performed in accordance with the requirements of ASME-14.

a. For high pressure (125 psig or above) systems.Not less than 10 percent of all butt welds shall be examined fully by random radiography. Welds to be examined shall be selected to ensure that the work product of each welder or welding operator doing the production welding is included. These welds shall satisfy the acceptance standards of the specified code. If any of the butt welds examined reveals an unacceptable indication, all butt welds welded by that welder(s) shall be examined/accepted by radiography.

2. Acceptance Requirements

a. High Pressure (125 psig or above):

1) Steam piping systems shall meet the requirements of ASME B31.1.

2) Other high pressure piping systems shall meet the requirements of ASME B31.3.

b. Low Pressure (Below 125 psig):

1) Refrigeration piping systems shall meet the requirements of ASME B31.5.

2) Plumbing piping systems shall meet the requirements of BOCA-01.

3) Other low pressure piping systems shall meet the requirements of ASME B31.1.

3.4 PROTECTION OF ADJACENT MATERIALS: Contractor shall sufficiently protect machinery, materials, floor, etc., adjacent to the welding/brazing operations to prevent any damage from these operations.

END OF SECTION

SECTION 15068

PLASTIC PIPE AND FITTINGS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 1527	(1989) Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe, Schedules 40 and 80
ASTM D 1784	(1992) Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
ASTM D 1785	(1991) Standard Specification for Poly (Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D 2104	(1989a) Standard Specification for Polyethylene (PE) Plastic Pipe, Schedule 40
ASTM D 2235	(1988) Standard Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings
ASTM D 2239	(1989) Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR), Based on Controlled Inside Diameter
ASTM D 2241	(1989) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure Rated Pipe (SDR Series)
ASTM D 2447	(1989) Standard Specification for Polyethylene (PE) Plastic Pipe, Schedules 40 and 80 Based on Outside Diameter
ASTM D 2464	(1990) Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D 2466	(1990a; E1) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D 2467	(1990) Standard Specification for Socket-Type Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80

ASTM D 2564	(1993) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings
ASTM D 2609	(1990a) Standard Specification for Plastic Insert Fittings for Polyethylene (PE) Plastic Pipe
ASTM D 2661	(1990a) Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Schedule 40, Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM D 2680	(1990) Standard Specification for Acrylonitrile-Butadene-Styrene (ABS) Composite Sewer Piping and Poly(Vinyl Chloride) (PVC)
ASTM D 2683	(1990) Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
ASTM D 2751	(1989) Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings
ASTM D 2855	(1990) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM F 437	(1989b) Standard Specification for Threaded Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
ASTM F 439	(1990) Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
ASTM F 441	(1989) Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Schedules 40 and 80
ASTM F 442	(1989) Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR)

1.2 GENERAL REQUIREMENTS: Section 15003, "General Mechanical Provisions," applies to work specified in this section.

1.3 SUBMITTALS

The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Manufacturer's Catalog Data shall be submitted for Plastic Pipe and Fittings.

B. Drawings: Installation Drawings for Plastic Piping Systems shall be in accordance with the paragraph entitled, "Installation," of this section.

C. Certificates of Compliance shall be submitted for the following items: Seal of approval of an approved testing laboratory acceptable to public health officials] for Potable Water Systems Materials.

PART 2 - PRODUCTS

2.1 POLYVINYLCHLORIDE (PVC) PIPE: PVC pipe shall be in accordance with ASTM D 1785.

A. Schedule Pipe (PVC) shall be Schedule [40] [80]. Material shall be PVC Class 12454-B in accordance with ASTM D 1784.

B. SDR-PR Nonthreaded Pipe (PVC): Nonthreaded standard dimension ratio/pressure rated (SDR-PR) pipe shall be in accordance with ASTM D 2241. Material shall be PVC Class 12454-B.

C. Fittings (PVC)

1. Socket-Type, Schedule 80 material shall be PVC in accordance with ASTM D 2467.

2. Threaded, Schedule 80 material shall be PVC in accordance with ASTM D 2464.

D. Cement and Lubricant: Solvent cement for pipe and fittings shall be in accordance with ASTM D 2564. Thread lubricant shall be in accordance with the pipe manufacturer's recommendations.

2.2 CHLORINATED POLYVINYLCHLORIDE (CPVC) PIPE: CPVC pipe shall be in accordance with ASTM F 441.

A. Schedule Pipe (CPVC) shall be Schedule [40] [80]. Material shall be CPVC Class 23447-B in accordance with ASTM D 1784.

B. SDR-PR Nonthreaded Pipe (CPVC) shall be in accordance with ASTM F 442. Material shall be CPVC Class 23447-B in accordance with ASTM D 1784

C. Fittings (CPVC), Socket-Type, Schedule 80 material shall be CPVC in accordance with ASTM F 439.

D. Threaded Schedule 80 Material shall be CPVC in accordance with ASTM F 437.

E. Cement and Lubricant: Solvent cement for pipe and fittings shall be in accordance with ASTM D 2564. Thread lubricant shall be in accordance with the pipe manufacturer's recommendations.

2.3 POLYETHYLENE (PE) PIPE

A. Schedule Pipe (PE) Pipe shall be Schedule 40 and shall be in accordance with ASTM D 2104. Material shall be PE 2305.

B. Standard Inside Dimension Ratio-Pressure Rated (SIDR-PR) Pipe shall be in accordance with ASTM D 2239. Material shall be PE 2305.

C. Schedule, Outside-Diameter-Controlled: Schedule pipe that is outside-diameter-controlled shall be in accordance with ASTM D 2447. Pipe shall be Schedule 80. Material shall be PE 2305.

D. Fittings (PE) Schedule 80, Butt Fusion fittings shall be in accordance with ASTM D 3261. Pipe shall be [14333-D] [13233].

E. Insert Fittings: Insert fittings for PE pipe shall be in accordance with ASTM D 2609. Material shall be acrylonitrile-butadiene-styrene (ABS), Type 1. Material shall be PVC class 12454-C.

F. Socket-Type for SDR 11.0 Pipe shall be in accordance with ASTM D 2683. Pipe shall be in accordance with 14333-D.

2.4 ACRYLONITRILE-BUTADIENE-STYRENE (ABS) PIPE

A. Schedule Pipe (ABS): ABS schedule pipe shall be in accordance with ASTM D 1527. Pipe shall be Schedule 40. Pipe shall be ABS 1210.

B. SDR-PR Nonthreaded Pipe (ABS): Nonthreaded SDR-PR pipe shall be in accordance with ASTM D 1527 and ASTM F 442. Pipe shall be ABS 1210.

C. Threaded Pipe shall be in accordance with ASTM D 1527. Pipe shall be ABS 1210.

D. Drain, Waste, and Vent Pipe shall be in accordance with ASTM D 2661.

E. Sewer Pipe shall be in accordance with ASTM D 2751.

F. Composite Sewer Piping shall be in accordance with ASTM D 2680.

G. Fittings (ABS)

1. Schedule 80, Socket-Type fittings shall be in accordance with ASTM D 1527. Fittings shall be Type [I] [II], Grade [1] [2] [3].

2. Schedule 80, Threaded fittings shall be in accordance with ASTM D 1527. Fittings shall be Type [I] [II], Grade [1] [2] [3].

3. Drain, Waste, and Vent Fittings shall be in accordance with ASTM D 2661.

4. Sewer Pipe Fittings shall be in accordance with ASTM D 2751.

H. Cement and Lubricant: Solvent cement for pipe and fittings shall be in accordance with ASTM D 2235. Thread lubricant shall be in accordance with the pipe manufacturer's instructions.

PART 3 - EXECUTION

3.1 PIPE LAYOUT: Installation shall present a neat, orderly appearance. Openings or passageways shall not be blocked. Piping shall be parallel to exterior walls of building. Piping shall be kept free from contact with structure or installed items to prevent noise transmission.

3.2 INSTALLATION: Plastic piping shall be installed in accordance with the manufacturer's installation instructions.

A. Vertical Piping

1. CPVC piping shall be supported at intervals of not more than \~3 feet.~\^900 millimeter.^\

2. All other piping shall be supported at intervals of not more than \~4 feet. ~\ \^1200 millimeter.^\

3. Piping shall be secured at sufficiently close intervals to keep pipe in alignment and to support weight of pipe and contents.

4. Piping shall be secured in position by approved stakes or braces when piping is to stand free, or when no structural element is available for providing stability during construction.

B. Horizontal Piping, Suspended

1. All piping shall be supported at intervals in accordance with the manufacturer's instructions and in no case not more than \~3 feet. ~\ \^900 millimeter.^\

2. Hangers shall be installed at ends of runs or branches and at each change of direction or alignment.

C. Horizontal Piping, Underground:

1. Piping shall be laid on a firm bed for the entire trench length, except where otherwise supported.

2. Partial backfilling and cradling shall be employed to secure piping during backfilling operations.

3. Piping laid on grade shall be firmly braced prior to embedment in concrete.

D. Cutting: Cuts shall be made square with pipe and burrs shall be removed by smoothing edges.

E. Joints: Threaded joints shall be used. Joints shall be tightened by strap wrench to not more than one full turn beyond hand tight, or joints shall be solvent cemented in accordance with ASTM D 2855. Junction with other materials shall be the type of adapter and technique as recommended by the pipe manufacturer.

END OF SECTION

SECTION 15161

CENTRIFUGAL PUMPS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

ANTI-FRICTION BEARING MANUFACTURERS ASSOCIATION, INC. (AFBMA)

AFBMA 11	(1990) Load Ratings and Fatigue Life for Roller Bearings
AFBMA 9	(1990) Load Ratings and Fatigue Life for Ball Bearings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.1	(1989) Cast Iron Pipe Flanges and Flanged Fittings

HYDRAULIC INSTITUTE (HI)

HI-01	(1983; 14th Ed) Standards for Centrifugal, Rotary Reciprocating Pumps

MANUFACTURER'S STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP 51	(1991) Class 150 LW Corrosion Resistant Cast Flanges and Flanged Fittings

1.2 DESIGN REQUIREMENTS

A. Pumps shall be designed using hydraulic criteria based upon actual model developmental test data. Manufacturer shall certify that pumps have been hydraulically tested at the factory.

B. Pumps shall be selected at a point within the maximum efficiency for a given impeller casing combination. Deviations within 3 percent of maximum efficiency are permissible, provided the lesser efficiency is not less than the scheduled efficiency.

C. Pumps having impeller diameters larger than 90 percent of the published maximum diameter of the casing or less than 15 percent larger than the published minimum diameter of the casing will be rejected.

D. Acceptable maximum impeller diameter calculations shall not be based on percentage of impeller diameter range for a given casing. Shop drawings will be approved only if complete performance curves for all impeller sizes for a given casing are included in the submittal.

E. Where parallel-pump operation is indicated, pumps selected shall have characteristics specifically suitable for the service without unstable operation.

F. Pumps shall be suitable for operation at indicated temperature without vapor binding and without cavitation under any system operating condition. The only acceptable means of rectification of cavitation shall be replacement of entire pump assembly.

G. Available Net Positive Suction Head (NPSH) shall exceed required NPSH by not less than 1-1/2 feet.

H. Pumps of the same duty condition, classification, and accessories, or with specified accessory deviation, shall be identical and the product of one manufacturing source.

I. Pumps from more than one manufacturing source shall be provided only when a single manufacturing source is unable to meet all specification requirements.

1.3 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data

1. Design Analysis and Calculations shall show NPSH (net positive suction head) calculations for Centrifugal Pumps.

2. Equipment and Performance Data consisting of pump curves (gallons per minute versus total head in feet per rpm) shall be provided for each type Centrifugal Pump.

3. Equipment Foundation Data shall be submitted for Centrifugal Pumps.

B. Drawings: Installation Drawings for Centrifugal Pumps shall be submitted in accordance with Part 3, "Execution," of this section.

C. Reports: Test Reports for pumps shall be submitted on the following tests:

Hydraulic Tests
Efficiency Tests
Vibration Tests
Output Efficiency
Surface Hardness Tests
Deflection Tests

D. Certificates of Compliance shall be submitted for the following items showing conformance with the referenced standards contained in this section.

Base-Mounted Pumps
Line-Mounted Pumps
Accessories

1.4 GENERAL REQUIREMENTS: Section 15003, "General Mechanical Provisions," applies to work specified in this section. Section 15245, "Vibration Isolation for Air Conditioning Equipment," applies to work specified in this section.

PART 2 - PRODUCTS

2.1 GENERAL PUMP REQUIREMENTS: This specification includes design, construction, installation, and performance features of centrifugal water pumps. Pumps provided shall conform to HI-01 standards for centrifugal pumps, and to requirements specified herein.

A. Classification: Class CES, Radially (vertically) split-case, single-stage, close-coupled, distance piece end-suction, single- or double-volute centrifugal type

B. Casing

1. Pump casings shall be bronze-fitted, seasoned cast iron with a design working pressure of not less than 185 pounds per square inch gage (psig) at 100 degrees F. Casings shall be single or double volute with flanged piping connections conforming to ASME B16.1, Class 125 psi. Direction of shaft rotation shall be conspicuously indicated. Casing shall have tapped openings for air venting, priming, draining, and suction and discharge gages. A brass or bronze umbrella or vent cock shall be furnished for venting except where automatic air vents are indicated. Drain openings in the volute, intake, or other passages capable of retaining trapped water shall be located in the low point of such passages.

2. Casing construction shall be such that packing seals may be substituted in the field for mechanical seals without machining.

3. Packing-box depth shall accommodate six rings of square packing, lantern ring, and throttling bushing.

C. Distance Piece

1. A suction end distance piece shall be provided with each end suction pump as a part of the pump or piping system.

D. Impellers shall be enclosed cast bronze or corrosion-resistant steel, machined and polished. Waterways shall be machine- or hand-finished. Impellers shall meet maximum and minimum diameter requirements.

E. Balancing

1. Pump impeller assemblies shall be statically and dynamically balanced to within 1/2 percent of W times R squared, where W equals load of the impeller and R equals impeller radius. Correction planes needed for additional weight for balancing shall be determined by using a calibrated and certified balancing machine capable of identifying the magnitude and angular position of any unbalance of the impeller.

2. Rotating elements shall be statically balanced as a minimum and, where necessary to conform to the requirements of these specifications, shall be dynamically balanced.

F. Wearing Rings shall be dissimilar bronze composition for nongalling service.Wearing rings shall be provided in every pump case and on all impellers larger than 7 inches in diameter.

G. Shaft

1. Shafts for mechanical-seal service shall be solid or sleeved and all materials shall be AISI Type 304 or 316 corrosion-resistant steel. Motor shafts of close-coupled pumps shall be manufacturer's standard AISI 18-8 corrosion-resistant steel and finish.

2. Surfaces shall have a 16-microinch surface finish where packing is specified or where a pump must be convertible to packing seals from mechanical seals. Pump shafts to be sealed by mechanical seals only shall have a 32-microinch surface finish, or better.

3. End-suction pump shafts shall have an impeller nut that completely encloses shaft end threads and seals tight to the impeller.

4. Shaft construction shall be substantial to prevent seal or bearing failure due to vibration.Total shaft peak-to-peak dynamic deflection measured by vibrometer at pump-seal face shall not exceed 2.0 mils under shutoff-head operating conditions. Flow from 1/4-inch iron pipe size (ips) pipe shall be provided during testing.

5. Shaft shall be equipped with bronze or nylon water slingers at each bearing and shall be sealed at the casing interface with a bronze throttling bushing.

H. Packing Seals

1. Packing shall be soft woven non-asbestos material with not less than 25 percent by weight of tetrafluoroethylene resin. Pump shall be shipped to the site without the packing inserted and shall be packed on site in the presence of the pump or packing manufacturer's representative. At no time during startup or run-in shall the gland drip less water than 80 drops per minute. After a minimum of 40 operating hours and upon permission of the Construction Manager, leakage rate may be reduced to 50 drops per minute or to the rate recommended by packing manufacturer.

2. Gland shall be split-bronze type with AISI 18-8 corrosion-resistant steel eyebolts and pins or studs. Hex-nuts shall be bronze or nongalling corrosion-resistant steel.

3. Stuffing boxes exposed to below atmospheric pressure at any operating condition, including starting, shall be provided with a water seal. Water seal shall consist of nonferrous lantern ring or a seal cage and required connections to the pump case.

I. Mechanical Seals

1. Mechanical seals shall be balanced or unbalanced, as necessary to conform to specified service requirements. Mechanical seals shall be constructed in a manner and of materials particularly suitable for the temperature service range and chemical analysis of water being pumped.

2. Cooling-water characteristics for seal construction purposes are as follows:makeup total dissolved solids of 200 parts per million (ppm) cycled up to five times, containing not more than 600 ppm of hexavalent chromate, and pH not less than 6.0.

3. Seal construction shall not require external source cooling for pumped-fluid service temperatures up to 250 degrees F.

4. Seal pressure rating shall be suitable for maximum system hydraulic conditions. Materials of construction shall include AISI 300 series corrosion-resistant steel, solid tungsten-carbide rotating-seal face, and Buna-N vinylidene-fluoride-hexafluoropropylene, EPT, or tetrafluoroethylene seals. Bypass flushing water supply shall be free of iron rust products and other abrasive materials and shall be directed onto face of seal without dead ending.All piping and accessories shall be provided.

5. Throttling bushing shall have clearances to minimize leakage in case of complete seal failure without restriction of flushing water.

6. Mechanical seals shall not be subjected to hydrostatic test pressures in excess of the manufacturer's recommendations.

7. Mechanical-seal manufacturer's representative shall direct on-site seal installation, testing, adjustment, and placing-into-service operations and shall instruct facility personnel as scheduled by the Construction Manager.

J. Centrifugal Abrasive-Separators: Pump seals shall be flushed with pump discharge water cleansed by centrifugal force in a cyclone abrasive-separator. Separator shall be constructed of AISI Type 316 corrosion-resistant steel. Underflow shall be piped to waste.

K. Bearings and Lubrication

1. Bearings shall be heavy-duty ball or roller type with full provisions for the mechanical and hydraulic radial and thrust loads imposed by any normal service condition. Bearings shall be manufactured from vacuum-degassed or processed-alloy steel. Thrust-bearing endplay shall not exceed 0.005 inch. Thrust bearings shall be secured to the shaft by threaded collar and locknut. Double-row ball or roller bearings shall be self-aligning. Bearings shall have an L-10 rated life of not less than 30,000 hours or an average life of 150,000 hours in accordance with AFBMA 9 or AFBMA 11. Shop drawings shall bear manufacturer's certification of bearing life.

2. Bearings shall be heavy-duty ball or roller type with full provisions for the mechanical and hydraulic radial and thrust loads imposed by any normal service condition. Bearings shall be manufactured from vacuum-degassed or processed-alloy steel. Bearings shall have an L-10 rated life of not less than 30,000 hours or an average life of 150,000 hours in accordance with AFBMA 9 or AFBMA 11. Shop drawings shall bear manufacturer's certification of bearing life.

3. Bearing housings shall be cast iron, self-aligning on metal-to-metal surfaces and shall totally enclose bearings.

L. Flexible Coupling

1. Pump shaft shall be connected to the motor shaft through a flexible coupling. Flexible member shall be a tire shape in shear, or a solid-mass serrated-edge disk shape made of chloroprene materials and retained by fixed flanges. Flexible coupling shall act as a dielectric connector and shall not transmit sound, vibration, or end thrust.

2. All couplings in intermittent on/off service shall have couplings selected on the basis of a 2.0 service factor. Other service factors shall be in accordance with the manufacturer's instructions.

M. Bedplate

1. Pump and driver shall be mounted on a common bedplate, hollow cast iron, multiribbed for maximum rigidity, with adequate number of grout holes and grout air vents, and with drip rim and drain tapping.

2. Contractor shall submit for approval, when specified, a fabricated steel base constructed of a rolled structural-steel perimeter frame, reinforced and cross-braced internally with pipe or rolled structural members, capped with 1/4 inch steel plate, and provided with adequate grout holes, grout air vents, drip rim, and drain tapping. Formed or bent steel bedplates are not acceptable.

N. Motors: Pump motors shall be checked for current direction of rotation only after pumps have been primed and approved by the manufacturer's representative and the Construction Manager. Motors shall be permanently tagged as quiet.

O. Special Requirements

1. Plugged or valved casing drains which may require ips red-brass pipe shall be brought out beyond periphery of casing to facilitate drainage. Volute plugs at flanges shall be assembled with tetrafluoroethylene tape.

2. Pump casing and pump motor shall be mounted on a single pedestal and shall not require a bedplate. Pump casing drain shall be plugged.

3. Pump casing with threaded inlet and outlet connections shall be furnished.

4. Pump casing and impeller wear rings shall be furnished.

5. Pump motor shall be an extended-shaft type with special heavy-duty thrust and radial bearings to accommodate motor and pump thrust loads.Impeller shall be mounted directly on the motor-shaft extension.

6. Pump seals shall be packed type.

7. Pump seals shall be packed type or have the manufacturer's standard mechanical seals for the specified service.

2.2 BASE-MOUNTED CENTRIFUGAL PUMPS

A. Pumps provided shall conform to HI-01 standards for centrifugal pumps and to requirements specified herein.

B. Pump Schedule: Pump capacity design requirements, and characteristics not specified herein shall be as indicated on the pump schedules.

C. Classification: Pump class shall be as scheduled.

D. Pump Selection: Pumps shall be selected at the point of maximum efficiency for a given impeller/casing combination. Deviations within 3 percent of maximum efficiency are permissible, provided that the efficiency is not less than the scheduled efficiency. Pumps having impeller diameters larger than 90 percent of the published maximum diameter of the casing or less than 15 percent larger than the published minimum diameter of the casing will be rejected.

E. Balancing

1. Pump impeller assemblies shall be statically and dynamically balanced to within 0.5 percent of W times R squared, where W equals load of the impeller and R equals impeller radius. Correction planes needed for additional weight for balancing shall be determined by using a calibrated certified balancing machine capable of identifying the magnitude and angular position of any unbalance of the impeller.

2. Rotating elements shall be statically balanced as a minimum and, where necessary to conform to the requirements of these specifications, shall be dynamically balanced.

F. Casing: Pump casing shall be bronze-fitted cast iron with a design working pressure of not less than 125 psig at 200 degrees F. Casing piping connections in 2-inch and larger sizes shall be flanged and shall conform to ASME B16.1. Casing shall have trap-equipped openings for air venting, priming, draining, and suction and discharge gages. Pump shall be convertible to packing service without machining of casing.

G. Wearing Rings shall be provided in every pump case and on all impellers larger than 8-inch diameter.

H. Shaft:

1. Shaft shall be solid, sleeveless, AISI 400 series corrosion-resistant steel, hardened to 425 Brinell in stuffing-box area or sleeved type with AISI 300 series shaft and AISI 400 series corrosion-resistant steel sleeves hardened to 425 Brinell.

2. Shaft vibration at sealing face shall not exceed a 3-mil peak-to-peak deflection when pump is operating against shutoff head.

I. Mechanical Seals shall be the manufacturer's standard for the specified and indicated service. Bypass flushing water supply shall be free of iron rust products and other abrasive materials and shall be directed onto face of seal without dead ending. All piping and accessories necessary to the function shall be provided.

J. Bearings and Lubrication

1. Bearings shall be heavy-duty ball or roller type and shall have an L-10 rated life of not less than 20,000 hours in accordance with AFBMA 9 or AFBMA 11.

2. Bearings shall be grease lubricated unless otherwise specified and shall be provided with grease supply and relief fittings located at bottom of bearing.

K. Flexible Coupling: Pump shaft shall be connected to the motor shaft through an elastomeric flexible member in shear and shall be a tire shape or a solid-mass serrated-edge disk shape retained by fixed flanges. Flexible coupling shall act as a dielectric connector and shall not transmit sound, vibration, or end thrust.

L Bedplate: Pump and driver shall be mounted on a common bedplate which shall be constructed for maximum rigidity, with an adequate number of grout holes and grout air vents and with drip rim and drain tapping.

PART 3 - EXECUTION

3.1 PUMP PROTECTION

A. Before any pump is operated, sumps and piping systems shall be cleaned to remove all particles larger than 1,000 micrometer or larger than one-half of the smallest pump axial or radial clearance, whichever is smaller. Permanent and temporary pipeline strainers shall be in place and shall be cleaned frequently to prevent cavitation. Temporary strainers shall not be removed until after system acceptance, unless otherwise approved.

B. Mechanical-seal flushing water shall be provided with centrifugal separator or 10-micrometer filter element where loose rust may be present at startup.

3.2 VIBROMETER: A calibrated, certified vibrometer shall be provided for pump-vibration checking.Instrument shall be readable to 0.0001-inch deflection. Testing shall be performed by an experienced operator. Contractor shall provide a tabulation of readings and points read, together with instrument data. Vibrometer shall remain the property of the Contractor.

3.3 GROUTING: Shimming, alignment, and grouting of pump, driver, and bedplate shall be in accordance with the most stringent requirements of the manufacturer's instructions and as specified herein. After grouting has cured, bedplate shall be hammer-tested for voids.Poor grouting, as evidenced by voids, shall require resetting of pump assembly.

3.4 VIBRATION ISOLATION: Vibration isolation shall conform to the provisions of Section 15245, "Vibration Isolation for Air Conditioning Equipment."

3.5 ALIGNMENT

A. Pump and driver shall be aligned to manufacturer's maximum permissible tolerances, but in no case shall angularity exceed 0.5 degree nor shall parallel misalignment exceed 0.002 inch. Pump alignment shall be performed under the direction of the manufacturer's representative.

B. Pump shall be dowelled in place with AISI 18-8 corrosion-resistant steel spiral-wrapped pins before being subjected to pressure or piping reaction. After grouting and final alignment, and no sooner than after 40 hours of continuous operation, the driver shall be similarly dowelled in place. Taper pins are not acceptable.

3.6 PUMP ACCEPTANCE

A. Prior to pump final acceptance, dial indicator gages shall be used to demonstrate that pump and motor are aligned as specified and that the pump casing is entirely free of any piping loads.

B. Prior to final acceptance, pump conformance to specifications shall be demonstrated by checking vibration with specified vibrometer while the pump is operating against shutoff head; i.e., with discharge valve closed.

C. Pump shall be operated and demonstrated to be nonoverloading at any operating point and that the flow capacity is as specified.

END OF SECTION

SECTION 15245

VIBRATION ISOLATION FOR AIR CONDITIONING EQUIPMENT

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA 48	(1983) Guide to Evaluation of Human Exposure to Vibration in Buildings
ASA 50	(1984) Mechanical Vibration of Rotating and Reciprocating Machinery - Requirements for Measuring Vibration Severity

AMERICAN SOCIETY OF HEATING, REFRIGERATING, AND AIR CONDITIONING ENGINEERS, INC. (ASHRAE)

ASHRAE-01	(1993) Handbook, HVAC Applications (IP Edition)

NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)

NEBB-01	(1983; 5th Ed) Procedural Standards for Testing-Adjusting-Balancing of Environmental Systems
NEBB-02	(1977) Procedural Standards for Measuring Sound and Vibration

1.2 GENERAL REQUIREMENTS

A. Section 15003, "General Mechanical Provisions," applies to work specified in this section to the extent applicable.

B. Section 15050, "Basic Mechanical Materials and Methods," applies to work specified in this section to the extent applicable.

C. All vibration-control apparatus shall be the product of a single manufacturing source, where possible. Human exposure levels should be considered using ASA 48 and NEBB-02.

D. Scheduled isolation mounting is in inches and is a minimum static deflection.

E. Spans referred to in Part 2, "Vibration-Isolation Systems Application," shall mean longest bay dimension.

F. Exact mounting sizes and number of isolators shall be determined by the isolator manufacturer based on equipment that will be installed. Equipment revolutions per minute (rpm) and spring deflections shall be checked to verify that resonance cannot occur.

1.3 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data:

1. Equipment and Performance Data for Vibration Isolator Systems shall include equipment base design; inertia-block mass relative to support equipment weight; spring loads and free, operating, and solid heights of spring; spring diameters; nonmetallic isolator loading and deflection; disturbing frequency; natural frequency of mounts; deflection of working member; and anticipated amount of physical movement at the reference points.

2. Manufacturer's Catalog Data shall be submitted for the following items:

Mounting
Bases
Isolators
Floor-Mounted Piping
Vertical Piping

B. Drawings

1. Installation Drawings for Vibration Isolator Systems shall include equipment and performance requirements.

2. Outline Drawings for Vibration Isolator Systems shall indicate overall physical features, dimensions, ratings, service requirements, and weights of equipment.

C. Reports: Test Reports shall be submitted for Deflection Tests in accordance with the paragraph entitled, "Tests and Reports," of this section. Reports shall include the following information:

Type of Isolator
Type of Base
Allowable Deflection
Measured Deflection

PART 2 - PRODUCTS

2.1 TYPE OF VIBRATION-ISOLATION PROVISIONS: Design for vibration isolation using NEBB-01, NEBB-02, or ASHRAE-01, Chapter 42, as applicable to the following sections.

A. Materials

1. Rubber shall be natural rubber. Elastomer shall be chloroprene. Shore A durometer measurement of both materials shall range between 40 and 60.

2. Inorganic materials such as precompressed, high-density, fibrous glass encased in a resilient moisture-impervious membrane may be used in lieu of specified natural rubber and elastomers. Where this substitution is made, specified deflections shall be modified by the manufacturing source to accommodate physical characteristics of inorganic materials and to provide equal or better vibration isolation.

3. Weather-exposed metal vibration-isolator parts shall be corrosion protected. Springs shall be chloroprene coated.

B. Mountings shall be:

1. Type A: Composite pad, with 0.25-inch thick elastomer top and bottom layers, molded to contain a pattern with nonslip characteristics in all horizontal directions.Elastomer loading shall not exceed 40 pounds per square inch (psi). Minimum overall thickness shall be 1 inch. Maximum deflections up to 0.25-inch are allowed.

2. Type B: Double rubber-in-shear elastomer-in-shear with molded-in steel reinforcement in top and bottom. Maximum deflections up to 0.50 inch are allowed.

3. Type C: Free-standing laterally stable open-spring type for deflections over 0.50 inch, with built-in bearing and leveling provisions, 0.25-inch thick Type A base elastomer pads, and accessories. Outside diameter of each spring shall be equal to or greater than 0.9 times the operating height of the spring under rated load.

4. Type D: Partially housed type, containing one or more vertically restrained springs with at least 0.50 inch clearance maintained around springs, with adjustable limit stops, 0.25-inch thick Type A base elastomer pads, and accessories.

5. Type E: Pendulum-suspension configuration with free-standing stable spring with resilient horizontal and vertical restraints to allow maximum movements of 0.25 inch in each direction, 0.25-inch thick Type A base elastomer pads.

6. Type F: Combination spring and rubber-in-shear elastomer-in-shear steel framed for hanger-rod mounting.Minimum total static deflection shall be 1 inch.

7. Type G: Air spring with body constructed of reinforced elastomer specifically suitable for application environment. Air spring shall be selected to provide a natural frequency equal to 5 inches of deflection of conventional specified steel springs. Facilities shall be provided for dead-level adjustment and height-control of supported equipment.

C. Bases shall be:

1. Type U: Unit isolators without rails, structural-steel bases, or inertia blocks.

2. Type R: Rails, disconnected mill-rolled structural steel, of sufficient dimension to preclude deflection at midpoint of unsupported span in excess of 1/1,440th of the span between isolators, power transmission, component misalignment, and any overhung weight. Where Type R bases are specified and the equipment proposed requires additional base support, a Type S base shall be used.

3. Type S: Structural-steel bases common to a supported assembly, made from welded-joint mill-rolled structural steel with closed-perimeter configuration, isolators attached to outrigger supports.

4. Height of steel members shall be sufficient to provide stiffness required to maintain equipment manufacturer's recommended alignment and duty efficiency of power-transmission components. Height of steel member shall not result in member deflection at midpoint of unsupported span of more than 1/1,440th of the span between isolators. Minimum height shall be 5 inches.

5. Type CIB: Concrete inertia blocks shall be common to the entire assembly, shall have welded-joint construction, mill-rolled structural-steel perimeters, welded-in No. 4 reinforcing bars 8 inches on center each way near the bottom of the block, outrigger-isolator mounting provisions, anchor bolts, and shall be filled with 3,000 psi cured-strength concrete.

a. Configuration of inertia bases shall be rectangular to accommodate equipment supported.

b. Minimum thickness of inertia base, in addition to providing suitable mass, shall be sufficient to provide stiffness to maintain equipment manufacturer's recommended alignment and duty efficiency of power-transmission components. Minimum thickness shall be sufficient to result in base deflection at midpoint of unsupported span of not more than 1/1,440th of the span between isolators. Minimum thickness, the preceding requirements not withstanding, shall be 8 percent of the longest base dimension.

c. Pumps with flexible couplings shall have inertia bases not less than 8 inches thick.

d. Minimum mass of concrete inertia block shall be equal in weight to supported equipment.

2.2 VIBRATION-ISOLATION SYSTEMS APPLICATION

Vibration isolation design shall be based on the most conservative of NEBB-01, NEBB-02 and ASHRAE-01, Chapter 42, ASA 50.

A. Water Chiller Package: D - U - 3.0*

B. Centrifugal Pump: C - C1B - 3.0*

C. Low-Pressure Suspended Fans: F - U - 1.75* Vibration-isolation provisions apply to ceiling-suspended

D. Low-Pressure AHU: C - U - 1.75* Vibration-isolation provisions apply to floor-mounted Air Moving and Conditioning Association Class A packaged central-station units.

E. Medium- and High-Pressure Vane Axial Fans: C - C1B - 5.0* Vibration-isolation provisions apply to floor-mounted vane axial fans.

F. Air Compressors: C - C1B - 3.5* Vibration-isolation provisions apply to housed unhoused free-standing control air compressors

*TYPE OF MOUNTING, BASE, AND MINIMUM DEFLECTION IN INCHES

2.3 PIPE AND DUCT VIBRATION ISOLATION

A. Type G: Isolators shall be devices with in-series contained steel springs and preformed fibrous-glass or chloroprene-elastomer elements for connecting to building-structure attachments. Devices shall be loaded by supported system during operating conditions to produce a minimum spring and elastomer static deflection of 1 inch and 3/8 inch, respectively.

1. Application: Ducts and pipes inside mechanical rooms.

B. Type H: Isolators shall be devices with contained chloroprene-elastomer elements for connecting to building-structure attachments. Devices shall be loaded by supported system during operating conditions to produce a minimum elastomer static deflection of 3/8 inch.

1. Application: Ducts and pipes inside spaces.

C. Type J: Isolators shall be devices with elastomers mounted on floor-supported columns or directly on the floor. Devices shall be loaded by supported system during operating conditions to produce a minimum elastomer static deflection of 3/8 inch.

1. Applications: Pipes inside mechanical rooms.

D. Floor-Mounted Piping: Type K Isolators shall be devices with springs mounted on floor-supported columns or directly on the floor. Devices shall be loaded by supported system during operating conditions to produce a minimum spring static deflection of 1 inch.

1. Application: Pipes at chiller yards.

E. Vertical Piping:

1. Type L Isolators shall be pipe base-support devices with one or more contained steel springs. Devices shall be loaded by supported system during operating conditions to produce a minimum static deflection of 1 inch. Devices shall be equipped with precompression and vertical-limit features, as well as a minimum 1/4-inch thick elastomer sound pad and isolation washers, for mounting to floor.

2. Type M Isolators shall be elastomer mounted baseplate and riser pipe-guide devices. Elastomer elements shall be contained double acting, and elastomers under rated load shall have a minimum static deflection of 3/8 inch.Isolator shall be sized to accommodate thermal insulation within the stationary guide ring.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment shall be installed in accordance with manufacturer's recommendations.

B. Rails, structural steel bases, and concrete inertia blocks shall be raised not less than 1 inch above the floor and shall be level when equipment supported is under operating load.

C. Vibration-isolation installation and deflection testing after equipment start-up shall be directed by a competent representative of the manufacturer.

3.2 TESTS AND REPORTS Vibration-isolation devices shall be deflection tested. Test reports shall be submitted in accordance with paragraph entitled, "Submittals," substantiating that all equipment has been isolated as specified and that minimum specified deflections have been met. All measurements shall be made in the presence of the Construction Manager.

END OF SECTION

SECTION 15260

PIPING INSULATION

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B 209	(1993) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM C 1136	(1992) Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
ASTM C 195	(1990) Mineral Fiber Thermal Insulating Cement
ASTM C 449	(1988) Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
ASTM C 533	(1985; R 1990) Calcium Silicate Block and Pipe Thermal Insulation
ASTM C 534	(1988) Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
ASTM C 552	(1991) Standard Specification for Cellular Glass Thermal Insulation
ASTM C 592	(1980) Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)
ASTM C 795	(1989) Standard Specification for Wicking-Type Thermal Insulation for Use Over Austenitic Stainless Steel
ASTM C 916	(1985; R 1990) Standard Specification for Adhesives for Duct Thermal Insulation
ASTM C 920	(1987) Standard Specification for Elastomeric Joint Sealants
ASTM C 921	(1989) Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation
ASTM D 1927	(1981; R 1988) Rigid Poly (Vinyl Chloride) Plastic Sheet
ASTM D 579	(1990) Standard Specification for Greige Woven Glass Fabrics

ASTM E 84	(1991a) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E 96	(1990) Standard Test Methods for Water Vapor Transmission of Materials

SOCIETY OF AUTOMOTIVE ENGINEERS, INC. (SAE)

SAE AMS 3779	(1990) Tape Adhesive, Pressure Sensitive Thermal Radiation Resistant
SAE AMS 3779/2	(1990) Tape Adhesive, Pressure Sensitive Thermal Radiation Resistant, Aluminum Foil/Glass Cloth

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 220	(1985) Standard Types of Building Construction
NFPA 255	(1990) Standard Method of Test of Surface Burning Characteristics of Building Materials

1.2 SYSTEM DESCRIPTION: Section 15003, "General Mechanical Provisions," applies to work specified in this section.

1.3 PERFORMANCE REQUIREMENTS

A. Thermal-insulation system materials shall be noncombustible, as defined by NFPA 220. Adhesives, coatings, sealants, facings, jackets, and thermal-insulation materials, except cellular elastomers, shall have a flame-spread classification (FSC) of not more than 25, and a smoke-developed classification (SDC) of not more than 50. These maximum values shall be determined in accordance with [ASTM E 84] [NFPA 255]. Adhesives, coatings, and sealants shall be nonflammable in their wet state.

B. Adhesives, coatings, and sealants shall have published or certified temperature ratings suitable for the entire range of working temperatures normal for the surfaces to which they are to be applied.

1.4 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Manufacturer's Catalog Data shall be submitted for the following items:

Adhesives
Coatings
Insulating Cement
Insulating Materials
Jacketing
Tape Materials

B. Drawings: Installation Drawings for Pipe Insulation shall be in accordance with the adhesive manufacturer's written instructions for installation.

PART 2 - PRODUCTS

2.1 MATERIALS: Materials shall be compatible and shall not contribute to corrosion, soften, or otherwise attack surfaces to which applied in either the wet or dry state. Materials to be used on stainless steel surfaces shall meet ASTM C 795 requirements. Materials shall be asbestos free and conform to the following.

A. Adhesives

1. Cloth Adhesives: Adhesives for adhering, sizing, and finishing lagging cloth, canvas, and open-weave glass cloth shall be a pigmented polyvinyl acetate emulsion and shall conform to the requirements of ASTM C 916, Class 1, Grade [A] [B].

2. Vapor-Barrier Material Adhesives: Adhesives for attaching laps of vapor-barrier materials and presized glass cloth and for attaching insulation to itself, to metal, and to various other substrates, shall be solvent-base, synthetic-rubber type and shall conform to the requirements of ASTM C 916, Class 2, Grade [A] [B], for attaching fibrous-glass insulation to metal surfaces. Solvent shall be nonflammable.

3. Cellular Elastomer Insulation Adhesive

Adhesive for cellular elastomer insulation shall be a solvent cutback chloroprene elastomer conforming to ASTM C 916, [Type [II] [III], [Class 1]], and shall be of a type approved by the manufacturer of the cellular elastomer for the intended use.

B. Coatings

1. Outdoor Vapor-Barrier Finishing: Coatings for outdoor vapor-barrier finishing of insulation surfaces such as fittings and elbows shall be a nonasphaltic, hydrocarbon polymer, solvent-base mastic containing a blend of nonflammable solvents. Coatings shall conform to the requirements of ASTM C 1136 and ASTM C 921.

2. Indoor Vapor-Barrier Finishing: Coatings for indoor vapor-barrier finishing of insulation surfaces shall be a pigmented resin and solvent compound and shall conform to ASTM C 1136, Type II.

3. Outdoor and Indoor Nonvapor-Barrier Finishing: Coatings for outdoor and indoor nonvapor-barrier finishing of insulation surfaces shall be pigmented polymer-emulsion type recommended by the insulation material manufacturer for the surface to be coated and shall be applied to specified dry-film thickness.

4. Cellular-Elastomer Insulation Coating: Finish coating for cellular-elastomer insulation shall be a polyvinylchloride lacquer approved by the manufacturer of the cellular elastomer.

5. Coating Color shall [be white] [conform to the color code specified] [blend with background of surrounding area] [be as specified by the Contracting Officer.]

C. Insulating Cement

1. General Purpose Insulating Cement: General purpose insulating cement shall be [diatomaceous silica] [mineral fiber] and shall conform to ASTM C 195. Composite shall be rated for 1800 degrees F service and shall have a thermal-conductivity maximum of [0.85] [.123] Btu by inch per hour per square foot for each degree F temperature differential at 200 degrees F mean temperature for 1 inch thickness.

2. Finishing Insulating Cement shall be mineral-fiber, hydraulic-setting type conforming to ASTM C 449.

D. Calking used with specified insulation materials shall be an elastomeric joint sealant in accordance with ASTM C 920, Type S, Grade NS, Class 25, Use A.

E. Corner Angles: Corner angle piping insulation shall be nominal 0.016 inch aluminum 1 by 1 inch with factory applied kraft backing.Aluminum shall be in accordance with ASTM B 209, Alloy 3003.

F. Insulation Materials: Insulation conductances shall be maximum values, as tested at any point, not an average. Insulation conductance found by test to exceed the specified maximum shall either be replaced or augmented by an additional thickness to bring it to the required maximum conductance and a complete finishing system.

1. Mineral Fiber shall conform to ASTM C 592, shall be suitable for surface temperatures up to 370 degrees F, and shall be of not less than 4-pound per cubic foot density. Thermal conductivity shall be not greater than 0.26 Btu per hour per square foot square per degree F at 150 degrees F mean.

2. Pipe barrel insulation shall be Form D, sleeving, pipe, and the tube covering, Type III, molded, Class 12, for use at temperatures up to and including 450 degrees F.

3. Pipe Fittings: Pipe fitting insulation shall be Form E, molded pipe fitting covering, Class 16, for use at temperatures up to and including 450 degrees F.

4. Flexible Blankets shall be Form B, blankets and felts, flexible, Class 6, resilient for use at temperatures up to and including 350 degrees F, minimum 1 pound per cubic foot density. Thermal conductivity shall be not greater than 0.27 Btu per hour per square foot per degree F at 75 degrees F mean.

5. Cellular Elastomer shall conform to ASTM C 534, except that the water-vapor permeability shall not exceed 0.30 perms per foot per inch per hour per square foot mercury pressure difference for 1-inch thickness.

6. Cellular Glass shall conform to ASTM C 552, Type II, pipe covering. Substitutions for this material shall not be permitted.

7. Calcium Silicate shall conform to ASTM C 533.Thermal conductivity shall be not greater than 0.37 Btu-inch per hour per square foot per degree F at 200 degrees F mean.

G. Jacketing

1. Aluminum Jackets: Aluminum sheet shall be in accordance with ASTM B 209 and shall be 0.016 inch thick with factory-applied vapor barrier on the insulation side. Aluminum shall be made from smooth, polished, Temper [H14] [H16], Alloy 3003. Straps shall be AISI 300 series corrosion-resistant steel, 15 mils thick, 1/2 inch wide, for pipe under 12-inch diameter and 3/4-inch wide for pipe over 12-inch diameter.

a. Elbow jackets shall be 0.016-inch thick, deep-drawn, die-shaped, two-piece components for long-radius, butt-weld elbows manufactured from the same materials as specified for jackets, with factory-attached vapor-seals on underside of the aluminum. Preinsulated, voidless, jacketed components conforming to these specifications shall be used. Preinsulated fittings shall have a 2-inch overlay beyond route for weld bead.

b. Vapor barrier shall be [30-60-30 laminated-asphalt paper] [60-pound per 100 square foot kraft paper] with 10-pound per 100 square foot polyethylene coating.

c. Pipe jackets shall have not less than 2-inch longitudinal and circumferential lap.

d. Sealant for longitudinal and butt joints of aluminum jacketing shall be an aluminum-pigmented, butyl, polymer sealant with high-butyl solids.

2. Glass Cloth Jackets:

a. Glass cloth shall be plain-weave glass cloth conforming to ASTM D 579, Style 141 and shall weigh not less than 7.23 ounces per square yard before sizing. Cloth shall be factory applied wherever possible.

b. Glass reinforcing cloth shall be a leno weave, 26-end and 12-pick thread conservation, with a warp and fill tensile strength of 45 and 30 pounds per inch of width, respectively, and with a weight of not less than 1.5 ounces per square yard. At the Contractor's option, Style 191 leno-weave glass cloth conforming to ASTM D 579 may be provided.]

3. PVC Jackets

a. Polyvinylchloride (PVC) shall be a 0.010-inch thick, factory-premolded, [one-piece fitting] [pipe-barrel sheeting vapor-barrier jacketing]. Material shall be self-extinguishing, and shall conform to ASTM D 1927, Composition A polyvinylchloride, Type II, high-impact strength, moderate chemical resistance. Permeability rating shall be 0.01 grain per hour per square foot per inch of mercury pressure difference, determined in accordance with ASTM E 96.Vapor-barrier joint adhesive shall be the manufacturer's standard solvent-weld type.

b. Vapor barrier shall conform to ASTM C 1136, Type I, low-vapor transmission, high-puncture resistance for use on insulation for piping, ducts, and equipment.

4. 3-Ply Laminate

a. Jacketing shall be a 3-ply laminate of 35-pound per 100 square foot white-bleached kraft, bonded to not less than 0.0007-inch thick aluminum foil and reinforced with glass fiber.

b. Water-vapor permeance rating of the composite shall be 0.02 perm or grain per hour per square foot, per inch of mercury pressure differential, determined in accordance with ASTM E 96.

H. Tape: Glass lagging shall be a knitted elastic cloth specifically suitable for continuous spiral wrapping of insulated pipe bends and fittings and shall produce a smooth, tight, wrinkle-free surface. Tape shall conform to requirements of SAE AMS 3779, SAE AMS 3779/2, ASTM D 579, and ASTM C 921, and shall weigh not less than 10 ounces per square yard.

2.2 PIPING SYSTEMS: Insulation thickness and pipe sizes are in inches. Pipe size is inclusive dimensionally, and includes pipe nominal pipe size (NPS) and tubing outside diameter.

A. Dual-Temperature (Hot- and Chilled-) Water Piping: Insulation shall be mineral fiber with vapor barrier jacket, Type T-1. Thickness shall be not less than that given in the following list. Aboveground pipes, valve bodies, fittings, unions, and flanges shall be insulated.

PIPE SIZE (INCH)	INSULATION THICKNESS (INCH)
Up to 1-1/4	1
1-1/4 to 3	1-1/2
3 and larger	2

B. Hot-Water, Steam, and Condensate-Return Piping: Insulation shall be mineral fiber with glass cloth jacket, Type T-2. Thickness shall be not less than that given in the following list. Aboveground pipes, valve bodies, fittings, unions, flanges, and miscellaneous surfaces shall be insulated.

PIPE SIZE (INCH)	INSULATION THICKNESS (INCH)
Up to 4	1
4 to 10	1-1/2
10 and larger	2

C. Cold-Water and Condensate-Drain Piping: Aboveground pipes, valve bodies, fittings, unions, flanges, and miscellaneous surfaces shall be insulated

1. [Insulation shall be 3/8-inch mineral fiber with glass cloth jacket, Type T-2.]

2. [Insulation shall be cellular-elastomer conforming to ASTM C 534. Water-vapor permeability shall not exceed 0.1 grain per square foot per hour per inch mercury pressure-differential for 1-inch thickness.]

3. [Cold-water piping insulation shall be flexible unicellular-elastomeric thermal insulation, Type T-3.Pipe insulation thickness shall be [3/8] [1/2] inch per calculation. Expanded, closed-cell pipe insulation shall be used only aboveground, not for underground piping.]

D. Refrigerant Suction Piping: Insulation shall be cellular-elastomer, Type T-3.Thickness shall be nominal 3/4 inch. Surfaces, including valve, fittings, unions, and flanges, shall be insulated.

E. Cooling-Tower Circulating Water Piping: Insulation shall be cellular-elastomer, Type T-3.Thickness shall be not less than that given in the following list. Aboveground pipes, valve bodies, fittings, unions, flanges, and miscellaneous surfaces shall be insulated.

PIPE SIZE (INCH)	THICKNESS EXPOSED TO WEATHER (INCH)
Up to 2	1/2
2 to 6	3/4
6 and larger	1

1. Thickness inside buildings shall be 3/8 inch for all pipe sizes.

2. Insulation shall be mineral fiber with aluminum jacket, Type T-6. Thickness shall be not less than that indicated. Aboveground pipes, valve bodies, fittings, unions, flanges, and miscellaneous surfaces shall be insulated.

F. Steam and Condensate Piping, 350 psig: Insulation shall be calcium silicate with glass cloth jacket, Type T-5. Thickness shall be not less than indicated in following list which is based on an 80 degrees F ambient temperature in still air with an insulation "K" factor of 0.37 at 200 degrees F mean temperature:

PIPE SIZE (INCH)	MAXIMUM SURFACE TEMPERATURE (DEGREE F)
Up to 1-1/2	112
1-1/2 to 4	110
4 TO 8	107
8 to 12	104

G. Hot Water Heating Convertor: Insulation shall be calcium silicate with glass cloth jacket, Type T-7. Thickness shall be 1-1/2 inches.

H. Chilled-Water and Dual-Temperature Pumps: Insulation shall be cellular elastomer, Type T-9.Thickness shall be 1 inch. Surfaces subject to condensation shall be covered, and a vapor-barrier coating shall be supplied.

PART 3 - EXECUTION

3.1 INSTALLATION OF INSULATION SYSTEMS

A. Contours on exposed work shall be smooth and continuous. Cemented laps, flaps, bands, and tapes shall be smoothly and securely pasted down. Adhesives shall be applied on a full-coverage basis.

B. Insulation shall be applied only to system or component surfaces that have been tested and approved.

C. Joints shall be tight with insulation lengths tightly butted against each other. Where lengths are cut, cuts shall be smooth and square and without breakage of end surfaces. Where insulation terminates, ends shall be neatly tapered and effectively sealed, or finished as specified. Longitudinal seams of exposed insulation shall be directed away from normal view.

D. Materials shall be applied in conformance with the recommendations of the manufacturer.

E. Surfaces shall be clean and free of oil and grease before insulation adhesives or mastics are applied. Solvent cleaning required to bring metal surfaces to such condition shall be provided.

3.2 SYSTEM TYPES

A. Type T-1, Mineral Fiber with Vapor-Barrier Jacket

1. Piping shall be covered with mineral-fiber pipe insulation with factory-and field-attached vapor-barrier jacket. Vapor seal shall be maintained. Jackets, jacket laps,

flaps, and bands shall be securely cemented in place with vapor-barrier adhesive. Jacket overlap shall be not less than 1-1/2 inches. Jacketing bands for butt joints shall be 3 inches wide.

2. Exposed-to-view fittings and valve bodies shall be covered with preformed mineral-fiber pipe-fitting insulation of the same thickness as the pipe-barrel insulation. Fitting insulation shall be temporarily secured in place with light cord ties. A 60-mil coating of white indoor vapor-barrier coating shall be applied and, while still wet, wrapped with glass lagging tape with 50 percent overlap, and shall be smoothly blended into the adjacent jacketing. Additional coating shall be applied as needed and rubber-gloved to smooth fillet or contour coating, then allowed to fully cure before the finish coating is applied. On-the-job fabricated insulation for concealed fittings and special configurations shall be built up from mineral fiber and a special mastic consisting of a mixture of insulating cement and lagging adhesive diluted with 3 parts water. Where standard vapor-barrier jacketing cannot be used, the surfaces shall be made vapor tight by using coating and glass lagging cloth or tape as previously specified.

3. In lieu of materials and methods previously specified, fittings may be wrapped with a twine-secured, mineral-wool blanket to the required thickness and covered with premolded polyvinylchloride jackets. Seams shall be made vapor tight with a double bead of manufacturer's standard vapor-barrier adhesive applied in accordance with the manufacturer's instructions. All jacket ends shall be held in place with AISI 300 series corrosion-resistant steel straps, 15 mils thick by 1/2 inch wide.

4. Pipe insulation shall be set into an outdoor vapor-barrier coating for a minimum of 6 inches at maximum 12-foot spacing and the ends of the insulation sealed to the jacketing with the same material to provide an effective vapor-barrier stop.

5. Staples shall not be used in applying insulation. Vapor-barrier materials shall be continuous over all surfaces, including areas inside pipe sleeves, hangers, and other concealments.

6. Piping insulation at hangers shall consist of 13-pounds per cubic foot density, fibrous-glass inserts or expanded, rigid, closed-cell, polyvinylchloride. Junctions shall be sealed with vapor-barrier jacket where required, glass-cloth mesh tape, and vapor-barrier coating.

7. White-bleached kraft paper side of the jacketing shall be on the side exposed to view. Exposed-to-view insulation shall be finished with not less than a 6-mil dry-film thickness of nonvapor-barrier coating suitable for painting.

B. Type T-2, Mineral Fiber with Glass Cloth Jacket

1. Piping shall be covered with a mineral-fiber, pipe insulation with factory-attached, presized, white, glass cloth. Jackets, jacket laps, flaps, and bands shall be securely cemented in place with vapor-barrier adhesive. Jacket overlap shall be not less than 1-1/2 inches. Jacketing bands for butt joints shall be 3 inches millimeter wide.

2. Exposed-to-view fittings shall be covered with preformed mineral-fiber fitting insulation of the same thickness as the pipe insulation and temporarily secured in place with light cord ties. Impregnated glass lagging tape shall be installed with indoor vapor-barrier on 50 percent overlap basis and the tape shall be blended smoothly into the adjacent jacketing. Additional coating shall be applied as needed, and rubber gloved to a smooth contour. Ends of insulation shall be taped to the pipe at valves 2 inches and smaller. On-the-job fabricated

insulation for concealed fittings and special configurations shall be built up from mineral fiber and a mixture of insulating cement and lagging adhesive, diluted with 3 parts water. Surfaces shall be finished with glass cloth or tape lagging.

3. [Valves 2-1/2 inches and larger and all flanges shall be covered with preformed insulation of the same thickness as the adjacent insulation.]

4. [Exposed-to-view insulation shall be finished with a minimum [6]-mil dry-film thickness of nonvapor-barrier coating suitable for painting.]

5. [In lieu of materials and methods specified above, fittings may be wrapped with a twine-secured, mineral-wool blanket to the required thickness and covered with premolded polyvinylchloride jackets. All jacket ends shall be held in place with ANSI 300 series corrosion-resistant steel straps, 15 mils thick by 1/2 inch wide. Fitting insulation shall be thermally equivalent to pipe-barrel insulation to preclude surface temperatures detrimental to polyvinylchloride.]

C. Type T-3, Cellular Elastomer

1. Piping-system surfaces shall be covered with flexible cellular-elastomer sheet or preformed insulation. Vapor seal shall be maintained. Insulation shall be cemented into continuous material with a solvent cutback chloroprene adhesive recommended by the manufacturer for the specific purpose. Adhesive shall be applied to both of the surfaces on a 100-percent coverage basis to a minimum thickness of 10 mils wet or approximately 150 square feet per gallon of undiluted adhesive.

2. Insulation on cold water piping shall be sealed to the pipe for a minimum of 6 inches at maximum intervals of 12 feet to form an effective vapor barrier. At piping supports, insulation shall be continuous through using outside-carrying type clevis hangers with insulation shield. [Cork] [Wood dowel] load-bearing inserts shall be installed between the pipe and insulation shields to prevent insulation compression.

3. Hot-water, cold-water, and condensate drain pipes shall be insulated to the extent shown with nominal [3/8] [1/2]-inch thick, fire retardant (FR), cellular elastomer, preformed pipe insulation. Joints shall be sealed with adhesive.

4. At pipe hangers or supports where the insulation rests on the pipe hanger strap, the insulation shall be cut with a brass cork borer and a No. 3 superior grade cork inserted. Seams shall be sealed with approved adhesive. Sweat fitting shall be insulated with miter-cut pieces of cellular elastomer insulation of the same nominal pipe size and thickness as the insulation on the adjacent piping or tubing. Miter-cut pieces shall be joined with approved adhesive. Covers shall be slit and snapped over the fitting, and joints shall be sealed with approved adhesive.

5. Screwed fittings shall be insulated with sleeve-type covers formed from miter-cut pieces of cellular elastomer thermal insulation having an inside diameter large enough to overlap adjacent pipe insulation. Pipe insulation shall be butted against fittings. Overlap shall be not less than 1 inch. Adhesive shall be used to join cover pieces and cement the cover to the pipe insulation.

6. Surfaces exposed to view or ultraviolet light shall be finished with a 2-mil minimum dry-film thickness application of a polyvinylchloride lacquer recommended by the manufacturer, and applied in not less than two coats.

D. Type T-4, Cellular Glass with Vapor-Barrier Jacket

1. Piping shall be covered with cellular glass insulation and factory- and field-attached vapor-barrier jacket. Vapor seal shall be maintained. Jackets, jacket laps, flaps, and bands shall be securely cemented in place with vapor-barrier adhesive. Jacket overlap shall be not less than 1-1/2 inches. Jacket bands for butt joints shall be not less than 3 inches wide. Insulation shall be continuous through hangers. Insulation shall be bedded in an outdoor vapor-barrier coating applied to all piping surfaces.

2. Flanges, unions, valves, anchors, and fittings shall be insulated with factory premolded or prefabricated or field fabricated segments of insulation of the same material and thickness as the adjoining pipe insulation. When segments of insulation are used, elbows shall be provided with not less than three segments. For other fittings and valves, segments shall be cut to the required curvature or nesting size.

3. Segments of the insulation shall be secured in place with twine or copper wire. After the insulation segments are firmly in place, a vapor-barrier coating shall be applied over the insulation in two coats with glass tape imbedded between coats. First coat shall be tinted, the second shall be white to ensure application two coats. Coating shall be applied to a total dry-film thickness of 1/16 inch minimum. Glass tape seams shall overlap not less than 1 inch and the tape end not less than 4 inches.

4. In lieu of materials and methods specified above, fittings may be wrapped with 3/8-inch thick, vapor-barrier, adhesive-coated strips of cellular elastomer insulation. Insulation shall be under tension, compressed to 25 percent of original thickness, and wrapped until overall thickness is equal to adjacent insulation. Cellular elastomer shall be secured in place with twine and sealed with vapor-barrier coating applied to produce not less than 1/16 inch dry-film thickness. Fittings shall then be covered with premolded polyvinylchloride jackets. Seams shall be made vapor-tight with a double bead of manufacturer's standard vapor-barrier adhesive applied in accordance with the manufacturer's instructions. Jacket ends shall be held in place with AISI 300 series corrosion-resistant steel straps, 15 mils thick by 1/2-inch millimeter wide.

5. Anchors secured directly to piping shall be insulated, to prevent condensation, for not less than 6 inches from the surface of the pipe insulation.

6. White-bleached kraft paper side of jacketing shall be on the side exposed to view. Exposed-to-view insulation shall be finished with not less than a 6-mil dry-film thickness of nonvapor-barrier coating suitable for painting.

E. Type T-5, Calcium Silicate with Glass Cloth Jacket (Piping): Piping shall be covered with a calcium-silicate pipe insulation with factory attached and presized, white, glass cloth. Jackets shall be field applied when required. Jackets, jacket laps, flaps, and bands shall be securely cemented in place with vapor-barrier adhesive. Jacket overlap shall be not less than 1-1/2 inches. Jacketing bands for butt joints shall be 4-inches wide. Fittings shall be fabricated from segmented pipe barrel sections bedded in general purpose insulating cement and wired in place. Voids shall be filled with general purpose insulating cement with not less than 1/4-inch thick, final coating. Glass lagging tape shall be impregnated with lagging adhesive, wrapped with a 50-percent overlap, and be blended smoothly into adjacent jacketing. Additional adhesive shall be applied as needed and rubber-gloved to a smooth contour.

F. Type T-6, Mineral Fiber with Aluminum Jacket

1. Piping shall be covered with mineral-fiber pipe insulation with factory-attached or field-applied aluminum jacketing.

2. Fittings and valve bodies shall be covered with preformed mineral-fiber pipe-fitting insulation of the same thickness as the pipe-barrel insulation. Fitting insulation shall be secured temporarily in place with light cord ties. A 60-mil coating of vapor-barrier mastic shall be applied, and while still tacky, wrapped with glass lagging tape.

3. Additional mastic shall be applied as needed and rubber-gloved to smooth fillets or contours. On-the-job fabricated insulation for special configurations shall be built up from mineral fiber and a mixture of insulating cement and lagging adhesive diluted with 3 parts water. Only where standard aluminum jacketing cannot be used, the surfaces shall be made vapor-tight by using mastic and glass lagging cloth or tape as specified above with an added finish coat of mastic.

4. Pipe insulation shall be set into outdoor vapor-barrier coating for a minimum of 6 inches at maximum 12-foot spacing. Ends of the insulation shall be sealed to the jacketing with the same material to provide effective vapor barrier stops.

5. Vapor barrier shall be continuous over all surfaces, including areas inside pipe sleeves, hangers, and other concealment.

6. Piping insulation shall be applied to both sides of pipe hangers.

7. Junctions shall be insulated with a special mastic mixture, glass cloth mesh tape, and mastic as previously specified.

8. Jacket laps, flaps, and bands shall be securely cemented in place with aluminum jacket sealant. Jacketing bands for butt joints shall be 6 inches wide.

9. Joints, wherever possible, shall be lapped against the weather so that the water will run off the lower edge. Laps shall be in accordance with the pipe drainage pitch. Longitudinal laps on horizontal lines shall be located 45 degrees below the horizontal centerline and alternately staggered 1 inch. Jacketing material shall be lapped a minimum of 2 inches, circumferentially sealed with mastic, and strapped to provide a waterproof covering throughout. Straps shall be located 8 inches on center and shall be pulled up tight to hold jacketing securely in place. Screws shall be used in addition to straps when necessary to obtain a waterproof covering. Extra straps shall be placed on each side of supporting devices and at openings. Where flanging access occurs, a chamfer sheet shall be strapped to the pipe at jacketing.

10. Exposed longitudinal edges of aluminum jacketing shall be stiffened by bending a 1-inch hem on one edge.

11. Expansion joints shall provide for maximum and minimum dimensional fluctuations.

12. To prevent corrosion, the aluminum jacketing shall not come in direct contact with other types of metal.

13. At openings in jacket, an outdoor vapor-barrier coating shall be applied for 2 inches in all directions. Jacketing shall be applied while waterproofing is tacky.

14. Screws shall be used at each corner of each sheet, at fitting jackets, and as necessary for the service. Number 7, 3/8-inch long, binding-head aluminum sheet metal screws shall be placed through the mastic seal.

G. Type T-7, Calcium Silicate with Glass Cloth Jacket (Surfaces)

1. Surfaces shall be covered with insulation block bedded in an insulating cement and covered with glass cloth jacketing.

2. Surfaces shall be cleaned with a chlorinated solvent. General purpose insulating cement shall be mixed with 3 parts water to 1 part nonvapor-barrier adhesive to bring to application consistency. Block shall be set into bedding and joints and spaces shall be filled with a bedding mix and wrapped with galvanized chicken wire mesh well laced into an envelope. A 3/8-inch thick coating of bedding mix jacket shall be troweled on with nonvapor-barrier adhesive and glass cloth. Surfaces shall be finished with not less than a 6-mil dry-film thickness of nonvapor-barrier coating.

3. [At the Contractor's option, aluminum sheet jacketing may be used in lieu of glass cloth.]

H. Type T-9, Cellular Elastomer

1. Pump surfaces shall be solvent cleaned. Not less than 1 inch of general purpose insulating cement shall be applied, mixed with nonvapor-barrier adhesive diluted with 3 parts water, to achieve smooth surface and configuration contours. After all water has been removed, surfaces shall be covered with 1/2-inch thick cellular elastomer insulation attached and joined into a continuous sheet with an outdoor vapor-barrier coating recommended by the insulation manufacturer for the specific purpose. Coating shall be applied to both of the surfaces on a 100-percent coverage basis with a minimum thickness of 10 mils wet, or approximately 150 square feet per gallon of undiluted coating. Coating shall be blended into the adjacent flange insulation and the joint covered with a band of cellular elastomer equal to the flange assembly width. Same coating shall be used to seal insulation to the casing at penetrations and terminations. Pumps shall be insulated in a manner that will permit insulation to be removed to repair or replace pumps.

2. Insulation shall be finished with a 2-mil minimum dry-film application of a polyvinylchloride lacquer coating recommended by the manufacturer and applied in not less than two coats.

I. Type T-10, Mineral-Fiber Fill: Voids surrounding pipe shall be packed with mineral-fiber fill.

J. Type T-17, Calcium Silicate Weatherproof Jacket: Piping system surfaces shall be covered with calcium silicate insulation. Fittings and valve bodies shall be covered with preformed insulation of the same material and thickness as the adjoining pipe insulation.

END OF SECTION

SECTION 15290

DUCT INSULATION

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 527	(1990) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality
ASTM C 1071	(1991) Standard Specification for Thermal and Acoustical Insulation (Glass Fiber, Duct Lining Material)
ASTM C 1136	(1992) Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
ASTM C 534	(1988) Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
ASTM C 553	(1992) Standard Specification for Mineral Fiber Blanket and Felt Insulation (Industrial Type)
ASTM C 592	(1980) Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)
ASTM C 795	(1989) Standard Specification for Wicking-Type Thermal Insulation for Use Over Austenitic Stainless Steel
ASTM C 916	(1985; R 1990) Standard Specification for Adhesives for Duct Thermal Insulation
ASTM D 579	(1990) Standard Specification for Greige Woven Glass Fabrics
ASTM E 84	(1991a) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E 96	(1990) Standard Test Methods for Water Vapor Transmission of Materials

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 220	(1985) Standard Types of Building Construction
NFPA 255	(1990) Standard Method of Test of Surface Burning Characteristics of Building Materials

NFPA 90A	(1993) Standard for the Installation of Air Conditioning and Ventilating Systems

1.2 SYSTEM DESCRIPTION: Section 15003, "General Mechanical Provisions," Section 15895, "Low Pressure Ductwork," and Section 15896, "Medium/High Pressure Ductwork," apply to work specified in this section.

1.3 PERFORMANCE REQUIREMENTS

A. Thermal-insulation system materials shall be noncombustible, as defined by NFPA 220.Adhesives, coatings, sealants, facings, jackets, and thermal-insulation materials, except cellular elastomers, shall have a flame-spread classification (FSC) of 25 and a smoke-developed classification (SDC) of 50 .Flame-contributed classification (FCC) shall be as specified for the application.These maximum values shall be determined in accordance with ASTM E 84 NFPA 255. Adhesives, coatings, and sealants shall be nonflammable in their wet state.

B. Adhesives, coatings, and sealants shall have published or certified temperature ratings suitable for the entire range of working temperatures normal for the surfaces to which they are to be applied.

1.4 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Manufacturer's Catalog Data shall be submitted for the following items:

Adhesives
Coatings
Thermal-Insulation Materials
Jacketing Materials

B. Drawings: Installation Drawings for Duct Insulation Systems shall be in accordance with the adhesive manufacturer's recommended instructions for application.

C. Samples: Contractor shall submit the following samples:

Adhesives
Coatings
Thermal-Insulation Materials
Jacketing Materials

PART 2 - PRODUCTS

2.1 MATERIALS: Materials shall be compatible and shall not contribute to corrosion, soften, or otherwise attack surfaces to which applied in either the wet or dry state. Materials to be used on stainless steel surfaces shall meet ASTM C 795 requirements. Materials shall be asbestos free and conform to the following.

A. Adhesives

1. Cloth: Adhesives for adhering, sizing, and finishing open-weave glass cloth shall be pigmented polyvinyl acetate emulsion and shall conform to the requirements of ASTM C 916, Class 1, Grade A B.

2. Adhesive Vapor Barrier: Adhesives for attaching laps of vapor-barrier materials and presized glass cloth and for attaching insulation to itself, to metal, and to various other substrates, shall be the solvent-base synthetic-rubber type and shall conform to the requirements of ASTM C 916, Class 2, Grade A B, for attaching fibrous-glass insulation to metal surfaces.Solvents shall be nonflammable.

3. Cellular Elastomer: Adhesive for cellular elastomer insulation shall be a solvent cutback chloroprene elastomer conforming to ASTM C 916, Type II III Class 1 and shall be a type approved by the manufacturer of the cellular elastomer for the intended use.

B. Coatings

1. Indoor Vapor-Barrier Finishing: Coatings for indoor vapor-barrier finishing of insulation surfaces shall be pigmented resin and solvent compound and shall conform to ASTM C 1136.

2. Indoor Nonvapor-Barrier Finishing: Coatings for indoor nonvapor-barrier finishing of insulation surfaces shall be pigmented polymer emulsion recommended by the insulation-material manufacturer for the surface to be coated and shall be applied to the specified dry-film thickness.

3. Cellular Elastomer Insulation: Finish coating for cellular elastomer insulation shall be a polyvinylchloride lacquer approved by the manufacturer of the cellular elastomer for the intended use.

select one of these

4. Coating Color shall be white. Conform to color code specified. Blend with background of surrounding area. Coating colors will be selected by the Contracting Officer.

C. Insulation: Insulation conductances shall be maximum values, as tested at any point, not an average. Insulation conductance found by test to exceed the stipulated maximum shall either be replaced or augmented by an additional thickness to bring it to the required maximum conductance. Insulation materials requirements for exterior applications are acceptable for interior applications.

1. Mineral fiber shall conform to ASTM C 592, shall be suitable for surface temperatures up to 370 degrees F, and shall be not less than 4-pound per cubic foot density, unless otherwise specified. Thermal conductivity shall be not greater than 0.26 Btu inch per hour per square foot per degree F at 150 degrees F, unless otherwise specified.

2. Rigid Boards shall be Form A, blocks and boards, Class 1, for use at temperatures up to 400 degrees F, nonloadbearing, minimum 3-pound per cubic foot density. Thermal conductivity shall be not greater than 0.24 Btu inch per square foot per hour per degree F at 75 degrees F.

3. Flexible blankets shall be Type 1, Class B, blankets and felts, flexible, resilient for use at temperatures up to 400 degrees F, minimum 1-pound per cubic foot density.Thermal conductivity shall be not greater than 0.27 Btu by inch per square foot per hour per degree F at 75 degrees F. Insulation shall conform to ASTM C 553.

4. Cellular elastomer shall conform to ASTM C 534, except that the water-vapor permeability shall not exceed 0.30 perm-inch per hour per inch mercury pressure-differential for 1 inch thickness.

D. Jacketing

1. Composite Jacketing shall be a 3-ply laminate of 35-pound per cubic foot white-bleached kraft bonded to not less than 1-mil thick aluminum foil and reinforced with glass fiber. Fire-resistance classification shall be as follows:

	FOIL EXPOSED	KRAFT EXPOSED
FSC	5	25
FCC	0	10
SDC	0	15

Water-vapor permeance rating of the composite shall be 0.02 perm or grain per hour per square foot per inch of mercury per second per square meter pressure-differential determined in accordance with ASTM E 96.

2. Sheetmetal Jacketing shall be minimum 26-gage (0.0217 inch) galvanized steel in conformance with ASTM A 527/A 527M aluminum in conformance with ASTM B 209, having lock-forming corner bead and joint capability.

3. Glass cloth shall be plain weave conforming to ASTM D 579, Style 141, and shall weigh not less than 7.23 ounces per square yard before sizing. Cloth shall be factory-applied wherever possible. Glass reinforcing cloth shall be a leno weave, 26-end and 12-pick thread conservation, with a warp-and-fill tensile strength in pounds per inch of width of 45 and 30, respectively, and with a weight not less than 1.5 ounces per square yar. Style 191 leno-weave glass cloth conforming to ASTM D 579 may be provided.

4. Vapor Barrier Material shall conform to ASTM C 1136, Type I, low vapor transmission, high puncture resistance for use on insulation for piping, ducts, and equipment, and as indicated.

PART 3 - EXECUTION

3.1 INSTALLATION OF INSULATION SYSTEMS:

A. Contours on exposed work shall be smooth and continuous. Cemented laps, flaps, bands, and tapes shall be smoothly and securely pasted down. Adhesives shall be applied on a 100-percent coverage basis. Departure from these requirements shall be a basis for rejection.

B. Joints shall be tight, with insulation lengths tightly butted against each other. Where lengths are cut, cuts shall be smooth and square and without breakage of end surfaces. Where insulation terminates, ends shall be neatly tapered and effectively sealed or finished. Longitudinal seams of exposed insulation shall be directed away from normal view.

C. Surfaces shall be clean and free of all oil and grease before insulation adhesives or mastics are applied. Solvent cleaning required to bring metal surfaces to such condition shall be provided.

3.2 SYSTEM TYPES

A. Type T-11, Flexible Mineral Fiber with Jacket: Sheet metal ducts shall be covered with mineral-fiber duct insulation with factory-attached vapor-barrier jacket. Vapor seal shall be maintained. Jacket overlap shall be not less than 2 inches. Insulation shall be adhered to sheet metal surfaces with vapor-barrier adhesive.

1. Insulation on all rectangular ducting with side- or bottom-surface dimensions over 30 inches shall, in addition to being adhered with adhesive, be impaled on pins secured to the duct surface and then locked by means of flush pin caps. Pins shall be clipped flush with face of cap.Pins shall be 12 inches on center placed not more than 2 inches from duct edges, and there shall be not less than two rows of pins per surface. Pins shall be sealed with outdoor vapor-barrier coating and vapor-barrier duct tape.

2. When insulation is in place, total thickness shall be reduced by not more than 0.5 inch, and no condensation shall appear on any surface.

3. Jackets, jacket flaps, and bands shall be securely cemented in place with vapor-barrier adhesive. Jacketing bands for butt joints shall be not less than 4 inches wide. In lieu of jacketing bands, pressure-sensitive vapor-barrier tape not less than 3 inches wide shall be used to seal horizontal and transverse seams.

4. Duct insulation shall be rigid-board 3-pound per cubic foot density where penetrations through sleeves or prepared openings occur. Duct insulation at fire dampers shall be provided.

5. Duct insulation terminating at insulated or uninsulated sheet metal and equipment surfaces, supports, damper fittings, walls, and similar penetration and construction points shall be sealed with outdoor vapor-barrier coating and, where lengths exceeding 24 inches are involved, flashed with glass-cloth tape and sheet metal trimming. Glass-cloth tape shall be in two layers with not less than 3 inches of overlap imbedded in not less than 1/16 inch dry-film thickness of outdoor vapor-barrier coating.

B. Type T-13, Rigid Mineral Fiber with Jacket: Sheet metal ducts shall be covered with insulation with factory-applied vapor barrier and finished with field-applied glass-cloth jacket. Vapor seal shall be maintained. Jacket overlap shall be not less than 2 inches.

1. Insulation shall be adhered to sheet metal surfaces with vapor-barrier adhesive.

2. Insulation on sheet metal with side- or bottom-surface dimensions over 30 inches, in addition to being adhered with adhesive, shall be impaled on pins secured to the duct surface and then locked by means of flush pin caps clipped flush with face of cap. Pins shall be 12 inches on center placed not more than 2 inches from duct edges, and there shall be not less than two rows of pins per surface. Pins shall be sealed with outdoor vapor-barrier coating and vapor-barrier duct tape. Pinned area and other surfaces shall be level with adjoining insulated surface. Edges shall be square and straight without scallops; where necessary, areas shall be leveled with a mixture of finish insulating cement and nonvapor-barrier adhesive diluted with three parts water.

3. Vapor-barrier jackets, jacket flaps, and bands shall be securely cemented in place with vapor-barrier adhesive. Jacketing bands for butt joints shall be not less than 4 inches wide.

4. Duct insulation at fire dampers shall be provided.

5. Insulation shall be brought tightly against raised-flange standing seams and sealed with vapor-barrier coating.A 3-inch wide strip of the insulation of adequate thickness to give 0.5 inch covering over flange shall be provided.Strip shall be routed out to accommodate the still-exposed portion of the seam or flange and shall be cemented in place over the seam or flange by use of vapor-barrier coating material.

6. Duct insulation terminating at insulated and uninsulated sheet-metal and equipment surfaces, supports, damper fittings, access doors, walls, and similar penetration and construction points shall be sealed with outdoor vapor-barrier coating. Where lengths exceeding 24 inches are involved, insulation shall be flashed with glass-cloth tape and sheet-metal trimming. Glass-cloth tape shall provide not less than 3-inch overlap, shall be in two layers, and shall be embedded in not less than 1/16 inch dry-film thickness of outdoor vapor-barrier coating. Sheet metal trimming shall be installed after glass-cloth jacket is in place.

7. Glass-cloth jacketing shall be applied over the insulation outer corner sheet-metal angles and securely cemented in place with nonvapor-barrier adhesive. Corner angles shall be not less than 30-gage galvanized sheet metal with leg dimensions equal to thickness of insulation. Glass cloth embedded in the adhesive shall be pulled tight and wrinkle-free and shall lap seams not less than 4 inches. The entire outer surface shall be given a flood coat of nonvapor-barrier adhesive while the first coat is still wet.

8. Insulation shall be finished with not less than 6 mils dry-film thickness of nonvapor-barrier coating suitable for painting.

C. Type T-14, Rigid Mineral Fiber with Jacket, Modified: Installation methods and materials are the same, except when no vapor-barrier jacketing and no vapor-barrier integrity is required. Pinned areas and other areas shall be leveled with a mixture of finish insulating cement and nonvapor-barrier adhesive diluted with 3 parts water.

D. Type T-15, Rigid Mineral Fiber: This insulation system consists of 1-inch thick mineral fiber, without jacket, placed between concealed hot and cold ducts to prevent cold-duct heat gain.

E. Type T-16, Plenums: Installation methods and materials are the same, except as follows:

1. No glass-cloth jacket is required.

2. Plenum surfaces shall be made airtight.

3. Mineral-fiber insulation with a vapor-barrier jacket not less than 1 inch thick shall be applied to walls and ceilings where the opposite side is exposed to nonconditioned spaces. Ceilings that separate plenum space from connected occupied space need no vapor-barrier jacket. Insulation with vapor-barrier jacket, as required, shall be applied before installation of piping, ducting, electrical conduit, ceiling suspension system, and other equipment. All air-leakage paths and vapor-barrier penetrations shall be sealed with vapor-barrier jacket mastic.

F. Type T-18, Cellular Elastomer: Surfaces shall be covered with 0.5 inch cellular-elastomer sheet insulation. Vapor seal shall be maintained. Insulation shall be cemented into continuous material with a solvent cut-back chloroprene adhesive recommended by the manufacturer for the specific purpose. Adhesive shall be applied to both of the surfaces to be joined to a minimum thickness of 10 mils wet or 150 square feet per gallon of undiluted adhesive.

1. Duct stiffeners shall be covered with cellular elastomer insulation strips.

2. Surfaces exposed to weather, to view, or to ultraviolet light shall be finished with a 2-mil minimum dry-film thickness of a polyvinylchloride lacquer recommended by the manufacturer and applied in not less than two coats.

G. Acoustic Duct-Lining shall be provided where indicated. Duct sizes indicated shall be interpreted to mean clear air space.

1. Acoustic duct-lining shall be fibrous glass conforming to ASTM C 1071. Material shall be 1-inch thick unless otherwise indicated, and the density of the insulation, including surface coating or facing, shall be not less than 1.5 pounds per cubic foot nor greater than 3.5 pounds per cubic foot. Liner composition shall be uniform density, graduated density, or dual density and deeply impregnated with chloroprene on the surface exposed to airstream. Acoustic liner shall conform to the fire-hazard requirements of NFPA 90A. The airstream side of the liner shall be capable of withstanding air velocities of 4,000 feet per minute without delamination or erosion. Sound-absorption coefficient shall be not less than indicated below.

Octave band	2ND	3RD	4TH	5TH	6TH	7TH
Midfrequency (kilohertz)	.125	.250.	500	1	2	4
Sound-absorption coefficient	0.250	.480	.670	.880	.890	.83

a. Lining shall be applied in cut-to-size pieces attached to the interior of the duct with fire-resistant adhesive conforming to ASTM C 916, Class 2, for attaching fibrous-glass insulation to metal surfaces. Top and bottom pieces shall lap the side pieces and, in addition, shall be secured with pins and speed washers or cup-head pins 12 inches on center, maximum and within 2 inches of each edge. Pins and washers shall be flush with the surface of the duct-liner, and breaks and punctures of the duct-liner coating shall be sealed with fire-resistant adhesive conforming to ASTM C 916, Class 1. Exposed edges of the coated liner at the duct ends and at other joints where the lining will be subject to erosion shall be coated with a heavy brush-coat of fire-resistant adhesive and where necessary with metal nosing to prevent delamination of the glass fibers. Duct liner may also be applied to flat sheet metal with fire-resistant adhesive, ASTM C 916, Class 2, prior to forming duct through the sheet metal brake. The lining at the top and bottom surfaces of the duct shall be additionally secured by pins or adhered clips as specified for cut-to-size pieces.

b. Preformed round duct liner designed for insertion in round ducts shall be used in the sizes commercially available.Duct-liner sections shall be furnished with not less than 2 inch wide ship-lap joints.Joints shall be in accordance with the manufacturer's instructions. Fire-resistant adhesive shall be used to field-coat joints, when recommended by the manufacturer of the liner, to prevent delamination or erosion at the joints. Tubular sections of the duct liner shall fit the metal duct snugly and without gaps between duct-liner sections. Requirements specified previously for acoustic duct-lining shall apply to preformed round duct liner.

END OF SECTION

SECTION 15320

FIRE PUMPS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ANSI/ASME B16.3	(1992) Malleable Iron Threaded Fittings
ASME/ANSI B16.5	(1988; Errata 1988) Pipe Flanges and Flanged Fittings
ASME/ANSI B16.26	(1988) Cast Copper Alloy Fittings for Flared Copper Tubes
ASME/ANSI B16.39	(1986) Malleable Iron Threaded Pipe Unions Classes 150, 250, and 300

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 53	(1993; Rev. A) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM A 193	(1993; Rev. A) Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
ASTM B 42	(1993) Seamless Copper Pipe, Standard Sizes
ASTM B 88	(1993; Rev. A) Seamless Copper Water Tube

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C111/A21.11	(1990; Erratum 1991) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C500	(1993) Metal-Seated Gate Valves for Water Supply Service
AWWA C651	(1992) Disinfecting Water Mains

FACTORY MUTUAL ENGINEERING AND RESEARCH CORPORATION (FM)

FM P7825	(1994) Approval Guide

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY, INC. (MSS)

MSS SP-58	(1993) Pipe Hangers and Supports - Materials, Design and Manufacture
MSS SP-69	(1991) Pipe Hangers and Supports - Selection and Application

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 20	(1993) Installation of Centrifugal Fire Pumps
NFPA 24	(1992) Installation of Private Fire Service Mains and Their Appurtenances
NFPA 70	(1993) National Electrical Code

UNDERWRITERS LABORATORIES INC. (UL)

UL FPED	(1994) Fire Protection Equipment Directory
UL 262	(1994) Gate Valves for Fire-Protection Service

1.2 FIRE PUMP SYSTEM: Provide fire pumps and associated equipment complete and ready for operation.Equipment, materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with NFPA 20 and NFPA 70, except as modified herein. Devices and equipment for fire protection service shall be UL FPED listed or FM P7825 approved.In the NFPA 20, the advisory provisions shall be considered to be mandatory, as though the word "shall" had been substituted for "should" wherever it appears; reference to the "authority having jurisdiction" shall be interpreted to mean the Fire Protection Engineer.

1.3 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification. The Fire Protection Engineer will review and approve all submittals in this section.

A. Manufacturer's Catalog Data: Submit for the following:

Fire pumps
Driver including electric motor
Controller, including electric motor
Pipe
Fittings
Valves, including gate, check, globe, and relief
Hose valve manifold test header
Pipe hangers and supports
Flow meter

B. Submit manufacturer's certified test characteristic curves for each pump, including pump discharge curves.

C. Drawings:

1. Prepare working drawings on sheets not smaller than A1 24 by 36 inches; include data for the proper installation of each system.

Piping layout and sensing piping arrangement
Pump room

2. Show detail plan view of the pump room including elevations and sections showing the fire pumps, associated equipment, and piping. Show piping schematic of pumps, devices, valves, pipe, and fittings. Show point to point electrical wiring diagrams. Show piping layout and sensing piping arrangement. Include:

Pumps, drivers, and controllers
Hose valve manifold test header
Circuit diagrams for pumps
Wiring diagrams of each controller

C. Statements

1. Qualifications of Installer: Prior to installation, submit data for approval showing that the Contractor has successfully installed fire pumps and associated equipment of the same type and design as specified herein, or that he has a firm contractual agreement with a subcontractor having such required experience. The data shall include the names and locations of at least two installations where the Contractor, or the subcontractor referred to above, has installed such systems. Indicate the type and design of each system and certify that each system has performed satisfactorily in the manner intended for a period of not less than 18 months.

2. Preliminary Test Certification: When preliminary tests have been completed and corrections made, submit a signed and dated certificate with a request for a formal inspection and tests.

D. Records: Submit text of proposed posted operating instructions for fire pump components

E. Operation and Maintenance Manuals: Submit in accordance with Section 01730, "Operation and Maintenance Manuals."

Fire pumps
Driver
Controller
Flow meter

1.4 ELECTRICAL MOTORS, CONTROLLERS, CONTACTORS, AND DISCONNECTS: Furnish motors, controllers, contactors, and disconnects with their respective pieces of equipment. Motors, controllers, contactors, and disconnects shall be provided as specified herein and shall have electrical connections provided under section titled "Interior Wiring Systems." Controllers and contactors shall have a maximum of 120-volt control circuits, and auxiliary contacts for use with the controls furnished. When motors and equipment furnished are larger than sizes indicated, the cost of providing additional electrical service and related work shall be included under this section.

1.5 ELECTRICAL WORK: Provide electrical work associated with this section under Section 16402, "Interior Wiring Systems," except for control and fire alarm wiring. Provide control and fire alarm wiring , including connections to fire alarm systems, under this section in accordance with NFPA 70. Provide wiring in rigid metal conduit or intermediate metal conduit, except electrical metallic tubing conduit may be provided in dry locations not enclosed in concrete or where not subject to mechanical damage.

1.6 SEQUENCE OF OPERATION: The lead pump shall start automatically whenever the pressure in the main system is reduced to [_____] psig), or manually when the starter is operated. Pump shall continue to run until shut down manually. Pumps shall automatically shut down after a running time of [_____] minutes unless manually shutdown. If after [_____] seconds, the lead pump cannot maintain a pressure of at least [_____] psig on the system, the lag pump shall start. Failure of the lead pump to start shall not prevent the lag pump from starting.

1.7 POSTED OPERATING INSTRUCTIONS:Provide for pumps, drivers, controllers, and flow meters.

PART 2 - PRODUCTS

2.1 SYSTEM COMPONENTS

A. Fire Pumps: Provide electric motor driven fire pumps. Pumps shall be automatic start and automatic stop. Each pump capacity at rated head shall be not less than that indicated Each pump shall furnish not less than 150 percent of rated capacity at not less than 65 percent of total rated head. Pumps shall be of the centrifugal horizontal split case with automatic air release. Maximum pump and motor speed shall be 1800 rpm.

B. Alarm: Provide an audible and visible alarm with electrical power supplied as indicated, with alarm located at*to be determined*. Alarm signal shall be activated upon the following conditions:electric motor controller has operated into a pump running condition, loss of electrical power to electric motor starter, and phase reversal on line side of motor starter Exterior alarm devices shall be weatherproof type. Provide alarm silencing switch and red signal lamp, with signal lamp arranged to come on when switch is placed in OFF position.

C. Pressure Maintenance Pump: Provide pump with controller to maintain a pressure of [_____] psig on the system. Provide pump of the electrically driven, horizontal shaft, centrifugal type with a rated discharge as indicated. Pump shutoff pressure shall not exceed the design working pressure of the system. Pump shall draft from the suction supply side of the suction pipe gate valve of the pump and shall discharge into the system on the downstream side of the pump discharge gate valve. Provide approved indicating gate valves of the outside screw and yoke type in the maintenance pump suction and discharge piping. Provide pressure gage and an approved check valve in the maintenance pump discharge outlet. Pump shall start when the pressure drops to [_____] psig and to stop when the pressure reaches [_____] psig. Provide steel expansion tank as indicated, and constructed in accordance with ASME Code for 125 psig working pressure; provide tank with polypropylene lined diaphragm to keep air charge separated from water.

D. Electric Motor Driver: Provide electrical motors, controllers, contactors, and disconnects as specified herein. Power supply to each motor and controller shall be as indicated.

E. Motors: Motor power shall be not less than pump power requirements at all points on the pump operating curve.

F. Controllers shall be approved for fire pump service and arranged for automatic and manual pushbutton pump starting and automatic and manual pushbutton pump shutdown. Controller shall be completely terminally wired, ready for field connections, and mounted in a moisture resistant enclosure arranged so that controller current carrying parts will not be less than 12 inches above the floor. Provide controllers with sequential starting timers as required by NFPA 20. Controller shall be of the across the line starting type. Provide an approved power transfer switch to transfer emergency power to the fire pump; the transfer switch shall transfer power from an emergency generator. Provide an approved limit service controller. Provide an approved full service controller.

G. Flow Meter: Provide UL listed or FM approved flow meter for fire pump installation with direct flow readout device. Meter shall be of the venturi type.

2.2 ABOVEGROUND WATER PIPING SYSTEMS

A. Sizes 2.5 Inches and Larger

1. Steel Pipe: ASTM A 53, Weight Class STD (Standard); black steel pipe.

2. Steel Pipe Flanges: Provide ASME/ANSI B16.5, Class 150 flanges at valves, connections to equipment, and where indicated. Extend bolts no less than two full threads beyond the nut with the bolts tightened to the required torque.

a. Gaskets: AWWA C111/A21.11, provide one piece factory cut cloth inserted red rubber gaskets.

b. Bolts: Provide ASTM A 193/A 193M, Grade B7 bolts.

c. Nuts: ASTM A 194/A 194M, Grade 7.

d. Washers: Provide steel flat circular washers under bolt heads and nuts.

B. Piping Sizes 2 Inches and Smaller

1. Steel Pipe: ASTM A 53, Weight Class XS (Extra Strong); zinc-coated steel pipe with threaded end connections.

a. Threaded Fittings: ANSI/ASME B16.3, Class 150, zinc-coated.

b. Unions: ASME/ANSI B16.39, Class 150, zinc-coated.

2. Copper Tubing: ASTM B 88M (ASTM B 88), Type L, soft annealed.

a. Fittings: ASME/ANSI B16.26 flared joint fittings.

b. Pipe Nipples: ASTM B 42 copper pipe with threaded end connections.

C. Pipe Hangers and Supports: MSS SP-58 and MSS SP-69. Provide adjustable type. Finish of rods, nuts, bolts, washers, hangers, and supports shall be zinc plated after fabrication.

D. Valves: Provide valves of types listed or approved for fire protection service with flanged or threaded end connections.

1. Gate Valves: Provide outside screw and yoke type which open by counterclockwise rotation.

2. Check Valves: Provide flanged clear opening swing check type valve with flanged inspection and access cover plate for sizes 4 inches and larger.

E. Pipe Sleeves: Provide where piping passes entirely through walls, ceilings, roofs, and floors. Secure sleeves in position and location during construction. Provide sleeves of sufficient length to pass through entire thickness of walls, ceilings, and floors. Provide one inch minimum clearance between exterior of piping or pipe insulation, and interior of sleeve or core-drilled hole. Firmly pack space with mineral wool insulation. Seal space at both ends of the sleeve or core-drilled hole with plastic waterproof cement which will dry to a firm but pliable mass, or provide a mechanically adjustable segmented elastomeric seal. In fire walls and fire floors, seal both ends of pipe sleeves or core-drilled hole with UL listed fill, void, or cavity material.

1. Sleeves in Masonry and Concrete Walls, Ceilings, Roofs, and Floors: Provide hot-dip galvanized steel, ductile-iron, or cast-iron pipe sleeves. Core drilling of masonry and concrete may be provided in lieu of pipe sleeves provided that cavities in the core-drilled hole be completely grouted smooth.

2. Sleeves in Other Than Masonry and Concrete Walls, Ceilings, Roofs, and Floors: Provide 26 gage galvanized steel sheet.

F. Escutcheon Plates: Provide split-hinge metal plates for piping entering floors, walls, and ceilings in exposed areas. Provide polished stainless steel or chromium-plated finish on copper alloy plates in finished spaces. Provide paint finish on plates in unfinished spaces.

2.3 BURIED WATER PIPING SYSTEMS

A. Pipe and Fittings: Provide outside-coated, cement mortar-lined, ductile-iron pipe and fittings conforming to NFPA 24 for piping under the building and less than 5 feet outside of the building walls. Anchor the joints in accordance with NFPA 24; provide concrete thrust block at the elbow where the pipe turns up toward the floor, and restrain the pipe riser with steel rods from the elbow to the flange above the floor. Minimum pipe size shall be 6 inches. Minimum depth of cover shall be 3 feet. Piping more than 5 feet outside of the building walls shall be provided under Section 02661 "Exterior Water Distribution System".

B. Valves: Provide as required by NFPA 24.Gate valves shall conform to AWWA C500 or UL 262 with cast-iron body and bronze trim and shall open by counterclockwise rotation.

PART 3 - EXECUTION

3.1 INSTALLATION: Equipment, materials, installation, workmanship, fabrication, assembly,erection, examination, inspection, and testing shall be in accordance with NFPA 20, except as modified herein. Install piping straight and true to bear evenly on supports.

A. Cleaning of Piping: Keep the interior and ends of piping thoroughly cleaned of water and foreign matter. Keep piping systems clean during installation by means of plugs or other approved methods. When work is not in progress, securely close open ends of piping and fittings so that water and foreign matter will not enter the pipes or fittings. Inspect piping before placing into position.

3.2 PIPE AND FITTINGS: Test, inspect, and approve piping before burying, covering, or concealing. Provide fittings for changes in direction of piping and for all connections. Make changes in piping sizes through tapered reducing pipe fittings; do not use bushings.

A. Threaded Connections: Jointing compound for pipe threads shall be Teflon pipe thread paste; apply only on male threads. Provide exposed ferrous pipe threads with one coat of zinc molybdate primer applied to a minimum dry film thickness of one mil.

B. Pipe Hangers and Supports: Provide additional hangers and supports for concentrated loads in piping between hangers and supports, such as for valves.

1. Vertical Piping: Support metal piping at each floor, but at not more than 10 foot intervals.

2. Horizontal Piping: Support piping as follows:

MAXIMUM SPACING (FEET)

Nominal Pipe Size (inches)	One and under	1.25	1.5	2	2.5	3	3.5	4	5	6
Copper Tube	6	7	8	8						
Steel Pipe	7	8	9	10	11	12	13	14	16	17

3.3 NAMEPLATES: Provide laminated plastic nameplates for equipment, gages, thermometers, and valves. Nameplates shall be melamine plastic, 0.125 inch thick, black with white center core. Surface shall be a matte finish. Corners shall be square. Accurately align lettering and engrave into the white core. Minimum size of nameplates shall be one by 2.5 inches. Lettering shall be minimum of 0.25 inch high normal block style. Key the nameplates to a chart and schedule for each system. Frame charts and schedules under glass and place where directed near each system. Furnish two copies of each chart and schedule. Each inscription shall identify its function. Equipment nameplates shall show the following information:

Manufacturer, type, and model number;
Contract number and accepted date;
Capacity or size;
System in which installed; and
System which it controls.

3.4 DISINFECTION: Disinfect the new water piping and existing water piping affected by Contractor's operations in accordance with AWWA C651. Fill piping systems with solution containing minimum of 50 parts per million (ppm) of available chlorine and allow solution to stand for minimum of 24 hours. Flush the solution from the systems with domestic water until maximum residual chlorine content is within the range of 0.2 to 0.5 ppm, or the residual chlorine content of domestic water supply. Obtain at least two consecutive satisfactory bacteriological samples from new water piping, analyze by a certified laboratory, and submit the results prior to the new water piping being placed into service. Disinfection of systems supplied by nonpotable water is not required.

3.5 INSTRUCTING OPERATING PERSONNEL: Upon completion of the work and at a time designated by the Contracting Officer, provide for a period of not less than one 8 hour working day the services of experienced technicians regularly employed by the manufacturer of the pumps and the drivers to instruct Government operating personnel in the proper operation and maintenance of the equipment.

3.6 FLUSHING: Flush all new pump suction and discharge piping at 150 percent of rated pump capacity. Where the pump installation involves more than one pump, the flushing volume shall be the total quantity of water flowing when all pumps are discharging at 150 percent of their rated capacities. The new pumps may be used to attain the required flushing volume. Continue flushing operations until water is clear, but for not less than 10 minutes. Submit a signed and dated flushing certificate with a request for field testing.

3.7 FIELD INSPECTIONS AND TESTS

A. Inspections: Prior to initial operation, inspect equipment and piping systems for compliance with drawings, specifications, and manufacturer's submittals.

B. Preliminary Tests: Hydrostatically test each piping system at 200 psig for a period of 2 hours. Perform tests on pumps, drivers, and equipment, including visual equipment checks to ensure compliance with approved detail drawings; pump start-run to ensure proper operation and to detect leakage of piping, valves, and fittings; sequence of operation check; verification that required pump accessories have been provided; test of pump alarm devices; and additional inspections and tests necessary to ensure that the entire pump installation is correct, complete, and ready for operation.

C. Formal Inspection and Tests: The Fire Protection Engineer will witness formal tests and approve all systems before they are accepted. Submit the request for formal inspection at least 15 days prior to the date the inspection is to take place. An experienced technician regularly employed by the pump installer shall be present during the inspection. Tests shall include 100 and 150 percent capacity flows and pressures, and no-flow pressures for compliance with manufacturer's characteristic curves. At this inspection repeat the required tests as directed. Correct defects in the work provided by the Contractor, and make additional tests until the Contractor has demonstrated that the system complies with the contract requirements. Manufacturer's certified shop test characteristic curves for each pump being tested must be furnished by the Contractor at the time of the pump acceptance test. Furnish appliances, equipment, water, electricity, instruments, connecting devices, and personnel for the tests.

3.8 SCHEDULE

Product	Unit of Measurement Rated Head Pressure
Fire Pumps Horizontal Split Case	125 psig

END OF SECTION

SECTION 15400

PLUMBING SYSTEMS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A112.36.2M	(1991) Cleanouts
ANSI B16.18	(1984; R 1994) Cast Copper Alloy Solder Joint Pressure Fittings
ANSI B16.24	(1991; Errata 1991) Cast Copper Alloy Pipe Flanges and Flanged Fittings Class 150, 300, 400, 600, 900, 1500, and 2500
ANSI Z21.22	(1986; Addenda 1990) Relief Valves and Automatic Gas Shutoff Devices for Hot Water Supply Systems
ANSI Z124.2	(1987; Addenda 1990) Plastic Shower Receptors and Shower Stalls
ANSI Z358.1	(1990) Emergency Eyewash and Shower Equipment

AIR-CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 1010	(1984) Drinking-Fountains, and Self-Contained, Mechanically-Refrigerated Drinking-Water Coolers

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A112.6.1M	(1988) Supports for the Off-the-Floor Plumbing Fixtures for Public Use
ASME A112.18.1M	(1994) Plumbing Fixture Fittings
ASME/ANSI A112.19.1M	(1987) Enameled Cast Iron Plumbing Fixtures
ASME A112.19.2M	(1990) Vitreous China Plumbing Fixtures
ASME/ANSI A112.19.3M	(1987) Stainless Steel Plumbing Fixtures (Designed for Residential Use)
ASME A112.19.5	(1979; R 1990) Trim for Water-Closet Bowls, Tanks, and Urinals
ASME A112.21.1M	(1991) Floor Drains
ASME/ANSI B16.1(1989)	Cast Iron Pipe Flanges and Flanged Fittings
ANSI/ASME B16.3	(1992) Malleable Iron Threaded Fittings

ASME/ANSI B16.22	(1989) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME/ANSI B16.26	(1988) Cast Copper Alloy Fittings for Flared Copper Tubes
ANSI/ASME B16.29	(1986) Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings - DWV

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1003	(1993) Water Pressure Reducing Valves for Domestic Water Supply Systems
ASSE 1014	(1989) Hand-Held Showers
ASSE 1019	(1993) Vacuum Breaker Wall Hydrants, Freeze Resistant Automatic Draining

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 53	(1993; Rev. A) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM A 74	(1994) Cast Iron Soil Pipe and Fittings
ASTM B 32	(1994) Solder Metal
ASTM B 42	(1993) Seamless Copper Pipe, Standard Sizes
ASTM B 88	(1993; Rev. A) Seamless Copper Water Tube
ASTM C 564	(1993) Rubber Gaskets for Cast Iron Soil Pipe and Fittings

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C105/A21.5	(1993) Polyethylene Encasement for Ductile - Iron Pipe Systems
AWWA C651	(1992) Disinfecting Water Mains

CAST IRON SOIL PIPE INSTITUTE (CISPI)

CISPI HSN	(1985) Neoprene Rubber Gaskets for Hub and Spigot Cast Iron Soil Pipe and Fittings
CISPI 301	(1990) Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
CISPI 310	(1990) Couplings Joint for Use in Connection with Hubless Cast Iron Soil Pipe and Fitting

FOUNDATION FOR CROSS-CONNECTION CONTROL AND HYDRAULIC RESEARCH (FCCCHR)

FCCCHR-USC	(1992) List of Approved Backflow Prevention Assemblies

MILITARY SPECIFICATIONS (MIL)

MIL-R-6855	(Rev. E; Supp. 1) Rubber, Synthetic, Sheets, Strips, Molded or Extruded Shapes

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY, INC. (MSS)

MSS SP-58	(1993) Pipe Hangers and Supports - Materials, Design and Manufacture
MSS SP-69	(1991) Pipe Hangers and Supports - Selection and Application
MSS SP-70	(1990) Cast Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(1990) Cast Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-80	(1987) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(1994) Cast Iron Globe & Angle Valves Flanged and Threaded Ends

PLUMBING AND DRAINAGE INSTITUTE (PDI)

PDI WH201	(1983) Water Hammer Arrestors

UNDERWRITERS LABORATORIES INC. (UL)

UL 174	(1989; R 1994) Household Electric Storage Tank Water Heaters
UL 430	(1986; R 1992) Waste Disposers

1.2 RELATED REQUIREMENTS: Section 15011, "Mechanical General Requirements," applies to this section with the additions and modifications specified herein.

1.3 SYSTEM DESCRIPTION: Provide new plumbing systems, complete and ready for operation. Plumbing systems including manufacturer's products shall be in accordance with the required and advisory provisions of the Uniform Plumbing Code (UPC). Plumbing systems include piping less than 5 feet outside of building walls including connections to exterior distribution systems].

1.4 SUBMITTALS: Submit the following in accordance with Section 01300, "Submittals."

A. Manufacturer's Catalog Data

Pipe and fittings
Valves
Plumbing fixtures

Water heaters
Pipe hangers and supports
Pressure gages
Strainers
Drains
Water hammer arresters
Backflow preventers
Electric water coolers
Thermometers

B. Operation and Maintenance Manuals

Water heaters
Electric water coolers

Submit operation and maintenance data in accordance with Section 01730, "Operation and Maintenance Data."

1.5 QUALITY ASSURANCE Plumbing systems including fixtures, equipment, materials, installation, and workmanship shall be in accordance with the Plumbing Code except as modified herein. In the Plumbing Code referred to herein, the advisory provisions shall be considered to be mandatory, as though the word "shall" had been substituted for the word "should" wherever it appears; reference to the "authority having jurisdiction," the Administrative Authority, the Plumbing Official, and the Design Engineer shall be interpreted to mean the Construction Manager. Capacity of equipment shall be not less than that indicated.

PART 2 - PRODUCTS

2.1 DRAIN, WASTE, AND VENT (DWV) PIPE AND FITTINGS Fittings shall be long radius fittings, except fittings in vent piping may be short radius fittings. Minimum size piping shall be 2 inches for buried piping and 1.5 inches for aboveground piping.

A. Buried Piping: Provide piping up to but not more than 6 inches aboveground or floor slab on grade.

1. Cast-Iron Hub and Spigot Pipe and Fittings: ASTM A 74 with ASTM C 564 or CISPI HSN rubber compression gasket joints.

B. Aboveground Piping

1. Cast-Iron Hubless Pipe and Fittings: CISPI 301 with CISPI 310 couplings.

2. Cast-Iron Hub and Spigot Pipe and Fittings: ASTM A 74 with ASTM C 564 or CISPI HSN rubber compression gasket joints.

C. Cleanouts: ANSI A112.36.2M; provide threaded bronze or thermoplastic or PVC plastic cleanout plugs.

1. Floor Cleanouts: Provide cast-iron or ductile-iron floor cleanout with [anchor] flange, adjustable height polished bronze, nickel bronze, stainless steel, or chromium-plated copper alloy rim and scoriated floor plate with "CO" cast in the plate, and countersunk screws for installing floor plate flush with finished floor.

2. Wall Cleanouts: Provide polished stainless steel or chromium-plated copper alloy cover plate and secure to cleanout plug with countersunk stainless steel screw.

3. Cleanouts Exterior to Buildings: Provide cast-iron cleanouts and countersunk plugs. Provide 24 by 24 by 4 inch thick concrete slab with top one inch above grade with cleanout located in center of slab.

D. Drains: ASME A112.21.1M; provide cast-iron or ductile-iron drains and clamping rings for use with membrane waterproofing. Provide P-traps for each floor drain.

1. Flush Strainer Floor Drains: Provide with double drainage flange, perforated or slotted cast bronze or nickel bronze, polished stainless steel, or chromium-plated copper alloy strainer, and adjustable collar. Drains of sizes 2, 3, and 4 inches shall have strainers with minimum free drainage area of 5, 11, and 18 square inches, respectively.

2. Shower Floor Drains: Provide as specified for flush strainer floor drains, except that finish shall be polished stainless steel or chromium-plated copper alloy and PVC drains may be provided for fiberglass shower stalls] where fire separation requirements are not violated.

E. Floor Sinks (Drains): Provide cast-iron body with white acid-resisting porcelain enameled or epoxy interior, double drainage flange, nickel bronze rim and slotted grate, removable stainless steel or aluminum slotted buckets, and P-trap.

2.2 DOMESTIC WATER PIPING

A. Buried Piping and Aboveground Piping shall be copper tubing conforming to ASTM B 88, Type L or M for aboveground piping, Type K for buried piping, with ANSI B16.18 or ASME/ANSI B16.22 solder joint fittings; or with ASME/ANSI B16.26 flared joint fittings. Provide ASTM B 42 copper pipe nipples with threaded end connections. Provide ASTM B 32, 95-5 tin-antimony solder, or provide Plumbing Code approved lead-free solder. Provide copper tubing for pipe sizes 4 inches or smaller.

B. Water Valves: Provide valves suitable for minimum of 125 psig and minimum of 180 degrees F hot water. Valves shall have flanged end connections, except sizes smaller than 2.5 inches may have threaded end connections with a union on all but one side of the valve, or solder end connections for connections between bronze valves and copper tubing. Ball valves may be provided in lieu of gate valves. Provide blue finish and red finish on handwheels for valves in cold domestic water piping and hot domestic water piping, respectively.

1. Gate Valves: MSS SP-80, Class 125, except sizes 2.5 inches and larger shall conform to MSS SP-70, Class 125.

2. Globe and Angle Valves: MSS SP-80, Class 125, except sizes 2.5 inches and larger shall conform to MSS SP-85, Class 125.

3. Check Valves: MSS SP-80, Class 125, swing check, except sizes 2.5 inches and larger shall conform to MSS SP-71, Class 125, swing check, cast-iron or bronze body.

4. Ball Valves: Full port design, copper alloy, except sizes 2.5 inches and larger shall be ductile-iron body or cast-iron body. Valves shall have two-position lever handles.

5. Hose Bibbs: Provide angle type copper alloy hose bibb with lockshield and removable handwheel or tee-handle. Inlet shall have internal threads.Outlet shall have vacuum breaker with 0.75 inch external hose threads.

6. Nonfreeze Wall Hydrant: ASSE 1019, cast bronze, with lockshield and removable handwheel or tee-handle, one inch external thread inlet, 0.75 inch external hose thread outlet with automatic draining vacuum breaker. Hydrant shall be of sufficient length to extend through walls and place the valve seat inside the building or in the crawl space. Bonnet and valve stem shall be removable from outside of the building.

7. Combination Pressure and Temperature Relief Valves: ANSI Z21.22 copper alloy body, automatic reseating, test lever, and discharge capacity based on AGA temperature steam rating.

8. Pressure Relief Valves: ANSI Z21.22 copper alloy body, automatic reseating with test lever.

9. Water Temperature Mixing Valves: Provide copper alloy or cast-iron body valve of the pressure equalizing type. Valve shall be of the adjustable thermostatic type and shall mix the hot water and cold water to deliver hot water at set temperature.

10. Water Pressure Reducing Valves: ASSE 1003.

C. Strainers shall have blow off outlet with pipe nipple and gate valve and discharge pipe nipple. Copper alloy or cast-iron body. Provide stainless steel strainer element with perforations of 0.047 inch.

D. Pressure Gages: Provide single style pressure gage for water with 4.5 inch dial, brass or aluminum case, bronze tube, gage cock, pressure snubber, and syphon. Provide scale range suitable for the intended service.

E. Thermometers: Provide bi-metal dial type thermometers with stainless steel case, stem, and fixed thread connection; 5 inch diameter dial with glass face gasketed within the case; accuracy within 2 percent of scale range. Provide scale range suitable for the intended service.

F. Dielectric Connections: Provide dielectric unions or flanges at connections between copper and ferrous metal piping materials.

G. Water Hammer Arresters: PDI WH201.

H. Backflow Preventers: Reduced pressure principle type.Furnish proof that each make, model/design, and size of backflow preventer being furnished for the project is approved by and has a current "Certificate of Approval" from the FCCCHR-USC or local code. Listing of the particular make, model/design, and size in the current FCCCHR-USC or local code will be acceptable as the required proof.

2.3 MISCELLANEOUS PIPING MATERIALS

A. Flanges: ASME/ANSI B16.1, Class 125, for use in ferrous piping; ASME/ANSI B16.22 or ANSI B16.24 for use in copper tubing; with MIL-R-6855 full face flat type synthetic rubber gaskets.

B. Escutcheon Plates: Provide one piece or split hinge metal plates for piping entering floors, walls, and ceilings in exposed spaces. Provide chromium-plated or polished stainless steel finish on copper alloy plates in finished spaces. Provide paint finish on metal in unfinished spaces.

C. Pipe Sleeves

1. Sleeves in Masonry and Concrete Walls, Floors, Roofs: ASTM A 53, Schedule 40 or Standard Weight, hot-dip galvanized steel, ductile-iron or cast-iron pipe sleeves.

2. Sleeves in Non-Masonry or -Concrete Walls, Floors, and Roofs: Provide 26 gage hot-dip galvanized steel sheet.

D. Pipe Hangers and Supports: Provide MSS SP-58 and MSS SP-69, Type 1 with adjustable type steel support rods, except as specified or indicated otherwise.Attach to steel joists with Type 19 or 23 clamps and retaining straps. Attach to Steel W or S beams with Type 21, 28, 29, or 30 clamps.Attach to steel angles and vertical web steel channels with Type 20 clamp with beam clamp channel adapter. Attach to horizontal web steel channel and wood with drilled hole on centerline and double nut and washer.Attach to concrete with Type 18 insert or drilled expansion anchor. Provide Type 40 insulation protection shield for insulated piping.

E. Access Doors: Provide 12 by 12 inch factory prefabricated and primed flush face steel access doors including steel door frame with continuous hinges and turn-screw-operated latch. Door frame shall be for installation in plaster and masonry walls. Furnish doors under this section to provide proper access to concealed valves; install doors under the appropriate section of this specification.

2.4 FIXTURES, FITTINGS, ACCESSORIES, AND SUPPLIES: Provide control-stop valves in each supply to each fixture.The finish of fittings, accessories, and supplies exposed to view shall be chromium-plated per ASME A112.18.1M. Centerset faucets shall be top-mounted with inlets on not greater than 4 inch centers. Provide special roughing-in for wheelchair fixtures.

A. Flush Valve Type Water Closets (WC-1): ASME A112.19.2M, white vitreous china, floor-mounted, floor or wall outlet as indicated, siphon jet, elongated bowl, black solid plastic elongated open-front seat, and ASME A112.19.5 trim. Provide large diaphragm (not less than 2.625 inches upper chamber inside diameter at the point where the diaphragm is sealed between the upper and lower chambers) nonhold-open flush valve of chrome plated cast brass, including vacuum breaker and angle (control-stop) valve with back check, mounted approximately 39 to 44 inches above floor. The water flushing volume of the flush valve and water closet combination shall not exceed 3.5 gallons per flush from 15 to 90 psi.

B. Wheelchair Water Closets (WC-2): Provide same as specified for water closets (WC-1) except water closet height to top of seat shall be 17 to 19 inches above floor.

C. Flush Valve Type Urinals (UR-1): ASME A112.19.2M, white vitreous china, wall-mounted, wall outlet, siphon jet, integral trap, extended side shields, and ASME A112.19.5 trim. Provide large diaphragm (not less than 2.625 inches upper chamber inside diameter at the point where the diaphragm is sealed between the upper and lower chambers), nonhold-open flush valve of chrome plated cast brass, including vacuum breaker and angle (control-stop) valve with back check.Water flushing volume of the flush valve and urinal combination shall not exceed 1.5 gallons per flush from 15 to 90 psi. Provide ASME A112.6.1M concealed wall hangers with thru-bolts and back plates for mounting.

D. Wheelchair Flush Valve Type Urinals (UR-2): ASME A112.19.2M, white vitreous china, wall-mounted, wall outlet, blowout action, integral trap, elongated projecting bowl, 20 inches long from wall to front of flare, and ASME A112.19.5 trim. Provide large diaphragm (not less than 2.625 inches upper chamber inside diameter at the point where the diaphragm is sealed between the upper and lower chambers), nonhold-open flush valve of chrome plated cast brass conforming to ASTM B 584, including vacuum breaker and angle (control-stop valve with back check. The water flushing volume of the flush valve and urinal combination shall not exceed 1.5 gallons per flush from 15 to 90 psi. Furnish urinal manufacturer's certification of conformance. Provide ASME A112.6.1M concealed chair carriers. Mount urinal with front rim a maximum of 17 inches above floor and flush valve handle a maximum of 44 inches above floor for use by handicapped on wheelchair.

E. Lavatories for Wheelchairs (L-1): ASME/ANSI A112.19.1M, white enameled cast-iron or ASME A112.19.2M white vitreous china with ASME A112.6.1M concealed arm carrier support, straight back type, minimum dimensions of 19 inches wide by 16 inches front to rear, 29 inches minimum clearance from bottom of front rim to floor, 34 inches front rim height above floor. Provide ASME A112.18.1M copper alloy centerset faucets, gooseneck spout with aerator 5 inches above rim, 4 inch wrist action handles, perforated grid strainers with offset tailpiece, and 1.25 inch adjustable P-trap.Faucets with wrist action handles shall open within one-quarter turn in opposite directions. Provide ASME A112.6.1M concealed chair carriers.

F. Service Sink (SS-1): ASME/ANSI A112.19.1M, white enameled cast-iron or ASME A112.19.2M white vitreous china, wall mounted and floor supported by wall outlet cast-iron P-trap, minimum dimensions of 22 inches wide by 18 inches front to rear with 9 inch splashback, and stainless steel rim guard. Provide ASME A112.18.1M copper alloy back-mounted combination faucets with vacuum breaker and 0.75 inch external hose threads.

G. Countertop Kitchen Sinks (KS-1): ASME/ANSI A112.19.3M, 20 gage stainless steel with integral mounting rim, minimum dimensions of 33 inches wide by 22 inches front to rear, two compartments with ledge back and undersides coated with sound dampening material. Provide top-mounted ASME A112.18.1M copper alloy faucets, swing spout with aerator, and stainless steel drain outlets with cup strainers. Provide 1.5 inch adjustable P-trap with drain piping to vertical vent stack. Provide UL 430 waste disposer unit in right compartment.

H. Wheelchair Electric Water Cooler (EWC-1): ARI 1010, wall-mounted bubbler style with ASME A112.6.1M concealed chair carrier, air-cooled condensing unit, 4.75 gph minimum capacity, stainless steel splash receptor, and all stainless steel cabinet, with 27 inch minimum knee clearance from front bottom of unit to floor and 36 inch maximum spout height above floor. Bubblers shall also be controlled by push levers, by push bars, or touch pads one on each side or one on front and both sides of the cabinet.

I. Hand-Held Shower Head (SH-1): ASSE 1014, adjustable spray hand-held shower head with swivel fitting, pushbutton flow control, 60 inch minimum flexible polished stainless steel hose and in-line vacuum breaker wall bracket to mount hand spray 25 inch grab bar with sliding spray holder that locks at any height to allow the use of the unit as either a hand-held spray or a fixed shower head.

J. Mop Sink (MS-1): Terrazzo shall be made of marble chips cast in white Portland cement to produce a compressive strength of not less than 3000 psi 7 days after casting. Provide brass body drains with nickel bronze strainers cast integral with terrazzo. Provide stainless steel rim guard.

K. Plastic Shower Stall Units (SH-1): ANSI Z124.2, white plastic receptor with slip-resistant bathing surfaces and three walls integrally molded in one piece or made in sections for field assembly. Provide brass body shower drains with nickel bronze perforated grid strainers and 2 inch adjustable P-trap. Provide shower supply fittings as specified herein.

L. Combination Emergency Shower and Eyewash (ESEW-1): ANSI Z358.1, column mounted on a floor flange.Design combination unit so components can be operated individually from a common fixture supply line.Provide a 10 inch diameter copper alloy stainless steel deluge shower head with elbow, stay-open ball valve operated by pull rod and 8 inch diameter ring or triangular handle, and eyewash with stainless steel receptor and two spray outlets.Provide eyewash with stay-open ball valve operated by foot treadle and push handle.

2.8 DOMESTIC WATER HEATERS (ELECTRIC): UL 174, electric water heaters with double heating element, glass-lined steel tanks, high efficiency type insulated with polyurethane foam insulation, replaceable anodes, with adjustable range thermostat to allow hot water settings between 110 and 160 degrees F. Provide posted operating instructions for water heaters.

PART 3 - EXECUTION

3.1 INSTALLATION: Installation of plumbing systems including fixtures, equipment, materials, and workmanship shall be in accordance with the Plumbing Code, except as modified herein. When fixtures require both hot water and cold water supplies, provide the hot water supply to the left of the cold water supply.

A. Threaded Connections: Jointing compound for pipe threads shall be polytetrafluoroethylene (PTFE) pipe thread paste, pipe cement and oil, or PTFE powder and oil; apply only on male threads. Provide exposed ferrous pipe threads with one coat of primer applied to a minimum dry film thickness of 1.0 mil.

B. Solder End Valves: Remove stems and washers and other item subject to damage by heat during installation. Reassemble valve after soldering is completed. Valves without heat sensitive parts do not require disassembly but shall be opened at least two turns during soldering.

C. Pipe Supports (Hangers): Provide additional supports at the concentrated loads in piping between supports, such as for inline water pumps and flanged valves.

1. Piping to Receive Insulation: Provide temporary wood spacers between the insulation protection shield and the pipe in order to properly slope the piping and to establish final elevations. Temporary wood spacers shall be of the same thickness as the insulation to be provided under Section 15250, "Insulation of Mechanical Systems."

2. Maximum Spacing Between Supports

a. Vertical Piping: Support metal piping at each floor, but at not more than 10 foot intervals, with pipe riser clamps or offset pipe clamps. Support plastic and glass piping at each floor and at midpoint between floors, but at not more than 5 foot intervals.

b. Horizontal Piping: Support cast-iron piping at 5 foot intervals, except for pipe exceeding 5 foot length, provide supports at intervals equal to the pipe length but not exceeding 10 feet. Support plastic and glass piping at 5 foot intervals and support plastic piping at each change of direction. Support steel piping and copper tubing as follows:

MAXIMUM SPACING (FEET)

Nominal Pipe Size (inches)	One and under	1.25	1.5	2	2.5	3	3.5	4	5	6
Steel Pipe	7	8	9	10	11	12	13	14	16	17
Copper Tube	6	7	8	8	9	10	11	12	13	14

D. Ductile Iron Pipe Aboveground: Provide flanged joints.

E. Encased Buried Piping: Completely encase buried copper water piping and cast iron DWV and water piping with polyethylene tube or sheet in accordance with AWWA C105/A21.5.

F. Installation of Pipe Sleeves: Provide pipe sleeves where piping passes through walls, floors, roofs, and partitions.Secure sleeves in proper position and location during construction. Provide sleeves of sufficient length to pass through entire thickness of walls, floors, roofs, and partitions. Provide not less than 0.25 inch space between exterior of piping or pipe insulation and interior of sleeve or core-drilled hole. Firmly pack space with mineral wool insulation. Seal at both ends of the sleeve or core-drilled hole with plastic waterproof cement which will dry to a firm but pliable mass, or provide a mechanically adjustable segmented elastomeric seal. Seal both ends of penetrations through fire walls and fire floors to maintain fire resistive integrity with UL listed fill, void, or cavity material. Extend sleeves in floor slabs 3 inches above the finished floor, except sleeves are not required where DWV piping passes through concrete floor slabs located on grade.

3.2 NAMEPLATES: Provide laminated plastic nameplates for equipment, gages, thermometers, and valves; stop valves in supplies to fixtures will not require nameplates. Laminated plastic shall be 0.125 inch thick melamine plastic, black with white center core.Surface shall be a matte finish. Corners shall be square.Accurately align lettering and engrave into the white core. Minimum size of nameplates shall be 1.0 by 2.5 inches.Lettering shall be minimum of 0.25 inch high normal block lettering. Key nameplates to a chart and schedule for each system. Frame charts and schedules under glass and place where directed near each system.Furnish two copies of each chart and schedule. Each inscription shall identify its function.Equipment nameplates shall show the following information:

1. Manufacturer, type, and model number
2. Contract number and accepted date
3. Capacity or size
4. System in which installed
5. System which it controls

3.4 FIELD QUALITY CONTROL

A. Inspections: Prior to initial operation, inspect piping system for compliance with drawings, specifications, and manufacturer's submittals.

B. Field Testing: Before final acceptance of the work, test each system as in service to demonstrate compliance with the contract requirements.Perform the following tests in addition to the tests specified in the Plumbing Code, except as modified herein. Correct defects in the work provided by the Contractor, and repeat tests until work is in compliance with contract requirements. Furnish water, electricity, instruments, connecting devices, and personnel for performing tests.

1. Domestic Water Piping: Before applying insulation, hydrostatically test each piping system at not less than 120 psig system working pressure with no leakage or reduction in gage pressure for 2 hours.

2. DWV Piping: Before the installation of fixtures, cap ends of each system, fill piping with water to the roof, and allow to stand until a thorough inspection has been made. If the system is tested in sections, each opening shall be plugged and each section tested with not less than a 10 foot head or water. After plumbing fixtures have been set and their traps filled with water, subject the entire sanitary system to a final air pressure test of not more than 1.0 inch of water column) and a smoke or peppermint test.Perform the air and smoke test with an approved smoke testing machine which shall show a clear passage of smoke and air throughout the entire system. The entire system shall be proven absolutely tight under such test.

3. Backflow Preventers shall be tested by a locally approved and certified backflow assembly tester. A copy of the test report shall be provided to the Construction Manager prior to placing the domestic water system into operation, or no later than 5 days after the test.

3.5 DISINFECTION" Disinfect new water piping and existing water piping affected by Contractor's operations in accordance with AWWA C651. Fill piping systems with solution containing minimum of 50 parts per million (ppm) of available chlorine and allow solution to stand for minimum of 24 hours. Flush solution from the systems with domestic water until maximum residual chlorine content is within the range of 0.2 to 0.5 ppm, or the residual chlorine content of domestic water supply. Obtain at least two consecutive satisfactory bacteriological samples from new water piping, analyze by a certified laboratory, and submit the results prior to the new water piping being placed into service. Disinfection of systems supplied by nonpotable water is not required.

3.6 SCHEDULE

Product	English Unit of Measurement
Water Closet	3.5 gallons/flush
Urinal	1.5 gallons/flush
Lavatory	20 in. wide x 18 in.
Service Sink	22 x 18 in.
Water Cooler	4.0 gal/hr
Shower Heads	3 gpm
Deluge Shower Heads	10 in. diameter

END OF SECTION

SECTION 15488

LOW PRESSURE COMPRESSED AIR SYSTEMS (NON-BREATHING AIR TYPE)

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI B16.24	(1991; Errata 1991) Cast Copper Alloy Pipe Flanges and Flanged Fittings Class 150, 300, 400, 600, 900, 1500, and 2500

AIR-CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 520	(1990) Positive Displacement Refrigerant Compressors, Compressor Units and Condensing Units

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME/ANSI B16.22	(1989) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME/ANSI B16.26	(1988) Cast Copper Alloy Fittings for Flared Copper Tubes
ASME/ANSI B16.34	(1988) Valves - Flanged, Threaded, and Welding End
ASME/ANSI B16.39	(1986) Malleable Iron Threaded Pipe Unions Classes 150, 250, and 300
ASME B31.1	(1992) Power Piping
ANSI/ASME B40.1	(1991; Special Notice 1992) Gauges - Pressure Indicating Dial Type - Elastic Element
ASME BPVC SEC VIII D1	(1992; Addenda 1992 and 1993) Boiler and Pressure Vessel Code: Section VIII Pressure Vessels, Division 1
ASME BPVC SEC IX	(1992; Addenda 1992 and 1993) Boiler and Pressure Vessel Code: Section IX Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 193	(1993; Rev. A) Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service

ASTM A 194	(1993; Rev. B) Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service
ASTM B 88	(1993; Rev. A) Seamless Copper Water Tube)

AMERICAN WELDING SOCIETY, INC. (AWS)

AWS D1.1	(1992) Structural Welding Code Steel
ANSI/AWS Z49.1	(1988) Safety in Welding and Cutting

CODE OF FEDERAL REGULATIONS (CFR)

29 CFR 1910.219	Mechanical Power Transmission Apparatus

FEDERAL SPECIFICATIONS (FS)

FS PPP-T-66	(Rev. E Reinst) Tape, Packaging, Vinyl Plastic Film
FS WW-U-516	(Rev. B) Unions, Brass or Bronze, Threaded Pipe Connections and Solder-Joint Tube Connections
FS QQ-B-654	(Rev. A) Brazing Alloys, Silver
FS WW-T-696	(Rev. E) Traps, Steam and Air
FS WW-S-2739	Strainers, Sediment: Pipeline, Water, Air, Gas, Oil, or Steam

MILITARY SPECIFICATIONS (MIL)

MIL-G-1149	(Rev. C) Gasket Materials, Synthetic Rubber, 50 and 65 Durometer Hardness
MIL-V-24384	(Rev. B) Valves, Pressure Regulating, for Low Pressure Air or Nitrogen Systems

MILITARY STANDARDS (MIL-STD)

MIL-STD-101	(Rev. B) Color Code for Pipelines and for Compressed Gas Cylinders

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY, INC. (MSS)

MSS SP-58	(1993) Pipe Hangers and Supports - Materials, Design and Manufacture
MSS SP-69	(1991) Pipe Hangers and Supports - Selection and Application
MSS SP-80	(1987) Bronze Gate, Globe, Angle and Check Valves
MSS SP-84	(1990) Valves - Socket Welding and Threaded Ends
MSS SP-89	(1991) Pipe Hangers and Supports - Fabrication and Installation Practices

PLUMBING AND PIPING INDUSTRY COUNCIL (PPIC)

PPIC GFSR (1982) Guidelines for Seismic Restraints (GFSR) of Mechanical Systems and Plumbing Piping Systems

SOCIETY OF AUTOMOTIVE ENGINEERS, INC. (SAE)

SAE J 513 (1993) Refrigeration Tube Fittings

1.2 RELATED REQUIREMENTS: Section 15011, "Mechanical General Requirements," applies to this section, with the additions and modifications specified herein.

1.3 SUBMITTALS: Submit the following in accordance with Section 01300, "Submittals."

A. Manufacturer's Catalog Data

Air compressor
Air receiver
Pipe
Fittings
Valves
Pressure gages
Hangers and supports
Quick disconnect couplings
Filters
Strainers
Traps
Lubricators
Flexible connections
Dielectric unions
Hose reel assembly
Identification labels for piping
Tubing

For receivers, include Manufacturer's Data Report Form U-1 or U-1A

B. Instruction

Air receiver. Include manufacturer's recommended certification test procedure and recommended procedure for cleaning, external painting, and delivery preparation.

C. Statements

Brazing procedures
Brazing procedure qualifications
Brazer qualifications
Cleaning and flushing procedures

D. Test Reports

Air compressor
Air receiver
Hydrostatic tests
Leak tightness tests

E. Records

Posted operating instructions for air compressor

F. Operation and Maintenance Manuals

Air compressor

G. Equipment Data: Submit the following data for equipment listed for "Operation and Maintenance Instructions, Parts and Testing".

1. Name and address of authorized branch or service department.

2. Characteristic curves.

3. Following applicable data completely filled in:

Manufacturer and model number
Operating speed
Capacity (CFM)
Type of bearings in unit
Type of lubrication
Type and adjustment of drive
Capacity of tank
Electric motor: Manufacturer, frame and type
Motor speed RPM
Current characteristics and kW (hp) of motor
Thermal cut-out switch: Manufacturer, type and model
Starter: Manufacturer: Type and model

1.4 QUALITY ASSURANCE: Design, fabrication, installation, and testing of compressed air systems shall conform to ASME B31.1, ASME BPVC SEC VIII D1, and ASME BPVC SEC IX, except as specified otherwise. In ASME B31.1, ASME BPVC SEC VIII D1, and ASME BPVC SEC IX, the advisory provisions shall be considered mandatory, as though the word "shall" had been substituted for "should" wherever it appears; reference to the "authority having jurisdiction" and "owner" shall be interpreted to mean the Construction Manager.

A. Brazing Procedure Qualifications: Qualification of the brazing procedures is required for each group of materials to be brazed as indicated in ASME BPVC SEC IX. Record in detail and qualify the "Brazing Procedure Specifications" for every brazing procedure proposed. Include provisions for repairs. Qualification for each brazing procedure shall conform to the requirements of ASME B31.1 and to this specification. The brazing procedures shall specify end preparation for brazed joints, including cleaning, alignments, and fit-up clearances.Submit copies of the brazing procedure specifications for each type of brazing required in accordance with the paragraph "Submittals." Approval of any procedure does not relieve the Contractor of the sole responsibility for producing acceptable brazes. This information shall be submitted on the forms printed in ASME BPVC SEC IX, or their equivalent. Brazing procedure qualifications shall be identified individually and shall be referenced on the shop drawings or suitably keyed to the contract drawings.

B. Brazing Operator and Brazer Qualifications: Qualify each brazer and brazing operator assigned to work covered by this specification by performance tests using equipment, positions, procedures, base metals, and filler metal from the same specification, classification, or group number that will be encountered on his assignment. Brazers or brazing operators who make acceptable procedure qualification tests will be considered performance-qualified for the brazing procedure used. Determine performance qualification in accordance with ASME B31.1 and as specified.

C. Certification: Before assigning brazers or brazing operators to the work, provide the Construction Manager with their names, together with certification that each individual is performance-qualified as specified. No brazing work shall start prior to procedure qualification. The certification shall state the type of brazing and positions for which each is qualified, the code and procedure under which each is qualified, date qualified, and the firm and individual certifying the qualification tests. When requested by the Construction Manager, provide copies of qualification records and laboratory test reports.

D. Renewal of Qualification: Requalification of a brazer or brazing operator shall be required under any of the following conditions:

1. When a brazer or brazing operator has not used the specific brazing process for a period of 6 months.

2. There is specific reason to question his ability to make brazes that will meet the requirements of the specifications.

E. Qualification of Pressure Vessel (receiver) Inspectors: State Certification of Competency and active commission from the National Board of Boiler and Pressure Vessel Inspectors (NBBI), Columbus, Ohio.

1.5 SAFETY PRECAUTIONS

A. Temperature Restriction: Compressors or other equipment shall not discharge compressed air to the piping systems above 100 degrees F) unless approved by the Construction Manager. Aftercoolers or other devices shall be provided to comply with the temperature restriction.

B. Rotating Equipment: Fully guard couplings, motor shafts, gears and other exposed rotating or rapidly moving parts in accordance with OSHA 29 CFR 1910.219. Provide rigid and suitably secured guard parts readily removable without disassembling guarded unit.

C. Brazing: Safety in cutting and brazing of pipe shall conform to ANSI/AWS Z49.1.

PART 2 - PRODUCTS

2.1 AIR COMPRESSOR UNIT: Air compressor unit shall be provided complete with the following standard equipment.

A. Compressor and receiver capacity, size as indicated. Air delivered at indicated pressure.

B. Inlet Air Filter shall be mounted directly on the inlet valve and shall be 99.9 percent efficient at 3 microns and above.

C. Airend shall consist of 2 asymmetric profile, oil flooded, forged steel rotors in a cast iron housing. The rotors shall be fitted with cylindrical roller bearings at the drive end and duplex tapered roller bearings at the discharge end.

D. Drive Motor: The electric motor shall be a squirrel cage induction motor with Class F insulation. The compressors shall be supplied as standard with tri-voltage, 480V/3ph/60hz totally enclosed fan cooled (TEFC) motors.

E. Belt Drive: The motor and airend shall be over-under design. Transmission from the motor to the airend shall be by pulleys and a V-belt.

F. Coolant Filter: The spin-on coolant filter shall have a 10 micron element with internal pressure bypass.

G. Separator: The separator shall perform 2 functions: It shall remove coolant from the compressed air and it shall act as a sump or reservoir for the coolant. It shall have the following features:

Pressure relief valve
Coolant drain cap
Coolant filler plug
Coolant sight level
Scavenger line to airend inlet
Minimum pressure/check valve

H. Coolers: The Compressors shall be provided with aircooled oil coolers and aircooled aftercoolers. The coolers shall be side-by-side tube and fin and shall be rated for ambient air temperatures to 115 degrees F. The aftercooler shall have 25 degree F. CTD. The cooling fan for these units shall be mounted on the main motor shaft.

I. Thermostatic Control Valve shall control the amount of coolant which passes through the oil cooler and the bypass line. This shall ensure that the compressor is kept at the correct operating temperature and shall aid in the warm-up during starting.

J. Capacity Control shall be online/offline with automatic start/stop.

K. Base: Compressor shall be mounted on a fabricated steel base.

L. Enclosure: The complete unit shall be factory enclosed in a sheet metal, noise attenuating enclosure.

M. Starter: A 480V/3ph/60hz full voltage starter shall be mounted and wired to the compressor in a NEMA 1 starter box. The starter shall include a 115V control circuit transformer.

N. Control Panel: The controller shall be mounted above the starter box. The microprocessor based controller shall have a finger touch panel for control of all primary compressor functions. Operation of the controls shall be simple and user friendly. The controller shall constantly monitor prime compressor operation parameters. In the event that any of these parameters should deviated from its pre-programmed limit, the controller shall automatically stop the compressor. it shall include LED's for diagnostic information. The controller shall also provide for advanced protection for the compressor in the event of voltage loss or instability.

2.3 LOW PRESSURE AIR RECEIVER: ASME BPVC SEC VIII D1, labeled and rated for 125 psig, equipped with required valves and trimmings, including gage and automatic drain valve and ASME BPVC SEC VIII D1 and ASME BPVC SEC IX pressure safety relief valve. Pressure as indicated. Sandblast exterior and interior to SSPC SP 10, near-white. Lining shall be a factory applied 8 mil minimum white epoxy coating. Exterior finish shall be standard factory finish two coats of rust inhibitor primer and one coat epoxy enamel.

2.4 LOW PRESSURE COMPRESSED AIR DRYERS: Provide low pressure compressed air dryers of the mechanical refrigeration type, equipped with an automatic temperature shutdown switch to prevent freezing, a regenerative air to air exchanger in capacity sizes above 10 or 60 scfm as standard with the manufacturer, and a main compressed air cooling exchanger. Refrigeration system shall cool compressed air to dry the air. Dryer shall have no internal traps or filters and shall have pressure drop not greater than 3 psi. Provide internal tubing, wiring, and piping complete, such that only connections to air inlet and outlet, to refrigerant compressor contactor, and to condensate drain are necessary.

A. Air Circuit

1. Regenerative Heat Exchanger: Inlet compressed air to outlet compressed air heat exchanger (in capacity sizes above 10 or 60 scfm as standard with the manufacturer) designed to reduce cooling load at design conditions minus 20 degrees F by inlet air precooling.

2. Main Heat Exchanger: Single-pass, with air in the tubes, heat sink, direct expansion, or flooded cooler type.

3. Separator: Fabricated in accordance with ASME B31.1; code stamp not required; moisture separator low velocity type incorporating change of air flow direction to prevent moisture carryover.

4. Dryer Operating Pressure: 125 psig working pressure.

5. Drain Line: Provide with exterior mounted condensate trap to facilitate servicing.

B. Refrigeration System

1. Refrigeration Compressor: ARI 520. Hermetic, semi-hermetic, or open reciprocating type equipped with automatic start-stop or unloading capacity control; standard components include inherent motor protection, crankcase oil strainer, and suction screen. Refrigerant shall be R-22.

2. Dryer Controls: Capable of automatic 0 to 100 percent capacity control. Refrigeration controls shall maintain pressure dew point within the specified range without freezing of condensate. Controls shall include such devices as capillary tube, expansion valve, suction pressure regulator, thermostat, or other approved devices as standard with the manufacturer. Dryer shall have automatic shutdown switch sensor located at point of lowest temperature to prevent freezing.

3. Refrigerant dryer and suction line strainer.

4. Air-cooled condenser, with condenser fan and motor.

C. Instrumentation and Control: Include control panel in dryer cabinet containing:

1. Indicators for the Following Services: Inlet air pressure gage, discharge air pressure gage, inlet air temperature gage, main exchanger temperature gage, refrigeration compressor suction pressure gage, refrigeration compressor discharge pressure gage, green "Power On" light, power interruption light, and high temperature light.

2. Electrical Relays: Locate in an enclosed portion of the panel, accessible for ease of servicing.

3. Controls and Interlocks: To maintain required compressed air dew point and to cycle air-cooled condenser with refrigeration compressor while maintaining head pressure control with low ambient temperature.

2.7 LOW PRESSURE COMPRESSED AIR PIPING AND ACCESSORIES: Low pressure compressed air piping and accessories 125 psig at 150 degrees F, shall conform to the following:

A. Copper Tubing

1. Tubing: ASTM B 88, Type K or L, hard drawn, Class 1.

2. Fittings: ASME/ANSI B16.22 wrought copper or bronze, with silver brazed joints.

3. Brazing filler metal: FS QQ-B-654, Class III.

4. Unions: bronze, FS WW-U-516, brazed joint type.

5. Flanges and flanged fittings: ANSI B16.24, bronze, Class 150, gaskets, oil resistant synthetic rubber, MIL-G-1149, bolts ASTM A 193/A 193M, Grade B7, and nuts ASTM A 194/A 194M, Grade 7.

6. Flared fittings: ASTM B 88, Type K or L, annealed, with ASME/ANSI B16.26 or SAE J 513 flared fittings.

B. Valves

1. Bronze Gate Valves: MSS SP-80, Class 150, 2 inches and smaller, wedge disc, rising stem, inside screw type, with brazed joints ends when used with copper tubing.

2. Bronze globe and angle valves: MSS SP-80, Class 150, 2 inches and smaller, Class 200, except that Class 150 valves with brazed ends may be used for copper tubing. Valves shall have renewable seats and discs except brazed-end valves which shall have integral seats.

3. Pressure Reducing Valves: MIL-V-24384, Type I - Pressure Reducing, spring or dome loaded type, with nominal pressure rating of not less than inlet system pressure indicated. Provide pressure reducing valves capable of being adjusted to specified flow and pressure, and suitable for intended service.Provide pilot valve for dome loaded type if required for proper operation.

4. Safety Valves: ASME BPVC SEC VIII D1 and ASME BPVC SEC IX Code stamped safety valve, 125 psig, for unfired pressure vessels, bronze, with threaded or flanged connections; factory set and sealed.

5. Check Valves: MSS SP-80, Bronze body with brazed joint or threaded ends or steel body with flanged end, ASME/ANSI B16.34, or threaded ends, MSS SP-84. The check valve shall have a perforated piston with closed downstream end, in line with the pipe and held closed by a steel poppet return spring.

6. Pressure Regulators: Diaphragm type, air loaded, tight closing single seat, brass body with integral filter and bowl. Pressure regulators used to deliver compressed air for cleaning shall be factory set at not more than 30 psig and shall be nonadjustable.

7. Needle Valves: One-piece bodies with integral or screwed bonnet, stems of hardened stainless steel with fine thread for metering and ease of adjusting, teflon packing; and shall be of the pressure balanced type. Needle valves shall be of the slow opening type.

8. Pressure Gages: ANSI/ASME B40.1, Accuracy Grade A, for air, with steel or brass case, and nonshatterable safety glass, and a pressure blowout back to prevent glass from flying out in case of an explosion. Gages shall have a 3 1/2 inch minimum diameter dial and a dial range of approximately twice working pressure.

D. Hangers and Supports: Provide pipe hangers and supports conforming to MSS SP-58, MSS SP-69, and ASME B31.1, except as specified or indicated otherwise. Furnish zinc plated pipe hangers and supports except for copper plated inserts for copper piping. Provide tubing supports of U-shaped steel bolts and nuts firmly secured to adequately support structures such as walls, columns, floors, or brackets.Clips shall fit closely around piping but shall have sufficient clearance to permit longitudinal movement of piping during normal expansion and contraction. Provide supports at valves, fittings, branch lines, outlets, changes in direction, equipment, and accessories.

E. Quick Disconnect Couplings: All brass and suitable for a working pressure of not less than 125 psig. Female side of coupling (fixed end) shall have male thread connection with automatic shutoff. Provide male side of coupling with hose stem and ball check to bleed pressure from hose and prevent hose whipping.

F. Single Cartridge Type Filters: 125 psig operating pressure and filter housing of brass or bronze. Provide cellulose cartridge filters of graded density construction capable of removing liquids and solids of 5 microns and larger. Filter capacity shall be compatible with rated flow of equipment or pressure reducing valves provided.

G. Strainers: FS WW-S-2739.Bronze or malleable iron body, Class 125, Style Y, Type II, simplex type, with 20-mesh Monel or stainless steel screen.

H. Traps: FS WW-T-696 to drain water and other liquids from system.Type of traps, as indicated, and rated working pressure not less than system operating pressure.

I. Lubricators: Brass body, 125 psig minimum rating, with clear plastic bowl and metal guard.

J. Flexible Connections: Vibration isolation, wire braid reinforced corrugated metal hose type, line-sized, with bronze end connections, suitable for pressure indicated. Length as recommended by manufacturer but not less than 18 inches.

K. Dielectric Unions: Steel female pipe thread end and copper solder-joint ends, conforming to dimensional, strength and pressure requirements of ASME/ANSI B16.39, Class 1. Steel parts shall be galvanized or plated. Union shall have a water-impervious insulation barrier capable of limiting galvanic current to one percent of the short-circuit current in a corresponding bimetallic joint. When dry, it shall also be able to withstand a 600-volt breakdown test.

L. Tetrafluoroethylene Tape: MIL-T-27730 for screw-jointed pipe.

M. Hose Reel Assembly: Complete with 50 foot hose rated for a minimum of 125 psig, ball stop, hose extension with air coupler, hose rollers, reel enclosure, nonsparking ratchet pawl, and required accessories.

2.8 SLEEVES

A. Floor Slabs, Roof Slabs, and Outside Walls Above and Below Grade: Galvanized-steel pipe having an inside diameter at least 1/2 inch larger than the outside diameter of the pipe passing through it. Provide sufficient sleeve length to extend completely through floors, roofs, and walls, so that sleeve ends are flush with finished surfaces except that ends of sleeves for floor slabs shall extend 1/2 inch above finished floor surface.Sleeves located in waterproofed construction shall include flange and clamping ring.

B. Partitions: Galvanized sheet steel, 26 gage or heavier, of sufficient length to completely extend through partition thickness with sleeve ends flush with partition finished surface.

2.9 IDENTIFICATION LABELS FOR PIPING: Labels for pipes 3/4 inch o.d. and larger shall bear printed legends to identify contents of pipes and arrows to show direction of flow. Except that of pipes smaller than 3/4 inch o.d., labels shall have color coded backgrounds to signify levels of hazard in accordance with MIL-STD-101. Legends and type and size or characters shall also conform to MIL-STD-101. Labels shall be made of plastic sheet in conformance with FS PPP-T-66 with pressure-sensitive adhesive suitable for the intended applications or they may be premolded of plastic to fit over specific pipe outside diameters 3/4 inch and larger. For pipes smaller than 3/4 inch o.d., furnish brass identification tags 1 1/2 inches in diameter with legends in depressed black-filled characters.

2.10 FRESH WATER: Fresh water for cleaning, flushing, and testing shall be clean and potable.

2.11 SOURCE QUALITY CONTROL: Test air compressors and compressed air dryers at the factory to assure proper operation. Certify satisfactory accomplishment of tests.

PART 3 - EXECUTION

3.1 INSTALLATION: Install materials and equipment as indicated and in accordance with the manufacturer's recommendations.

A. Piping: Unless specifically stated to the contrary, fabrication, assembly and brazing shall conform to ASME B31.1 for all piping of the air system. Piping shall follow the general arrangement shown.Cut piping accurately to measurements established for the work. Work piping into place without springing or forcing, except where cold-springing is specified. Piping and equipment within buildings shall be entirely out of the way of lighting fixtures and doors, windows, and other openings. Locate overhead piping in buildings in the most inconspicuous positions. Do not bury or conceal piping until it has been inspected, tested, and approved. Where pipe passes through building structure, pipe joints shall not be concealed, but shall be located where they may be readily inspected and building structure shall not be weakened. Avoid interference with other piping, conduit, or equipment. Except where specifically shown otherwise, vertical piping shall run plumb and straight and parallel to walls. Piping connected to equipment shall be installed to provide flexibility for vibration. Adequately support and anchor piping so that strain from weight of piping is not imposed on the equipment.

B. Fittings: Use long radius ells where appropriate to reduce pressure drops. Pipe bends in lieu of fittings may be used for low pressure piping where space permits. Pipe bends shall have a uniform radius of at least five times the pipe diameter and must be free from any appreciable flattening, wrinkling, or thinning of the pipe. Mitering of pipe to form elbows, notching straight runs to form full sized tees, or any similar construction shall not be used.

C. Cleaning and Flushing Procedures: Before jointing and erection of piping or tubing, thoroughly clean interiors of pipe sections, tube, and components. Blow out copper tube and components with compressed air at 100 psig or more. Maintain cleanliness by closure of tube openings with caps or plugs. Before making final terminal connections, blow out complete system with compressed air at 100 psig or more.

D. Changes in Pipe Size: Use reducing fittings for changes in pipe size. The use of bushings will not be permitted.

E. Drainage and Flexibility: Compressed air piping shall be free of unnecessary pockets and pitched approximately 3 inches per 100 feet in the direction of flow to low points. Where pipes must be sloped so that condensate flows in opposite direction to air flow, slope 6 inches per 100 feet or greater. Provide flexibility by use of fittings, loops, and offsets in piping. Install branches at top of a main to prevent carryover of condensate and foreign matter.

F. Threaded Joints: Apply thread tape to male threads only. Work piping into place without springing or forcing. Backing off to permit alignment of threaded joints will not be permitted. Engage threads so that not more than three threads remain exposed.

G. Brazing Procedures: Perform brazing in accordance with qualified procedures using qualified brazers. Do not perform brazing when the quality of the completed braze could be impaired by the prevailing working or weather conditions. The Construction Manager will determine when weather or working conditions are unsuitable for welding. Welding of hangers, supports, and plates to structural members shall be in accordance with AWS D1.1.

1. Cleaning for Brazing: Surfaces to be brazed shall be free from loose scale, slag, rust, paint, oil, and other foreign material. Joint surfaces shall be smooth and free from defects which might affect proper brazing.

2. Stress Cracking During Brazing: For material susceptible to stress corrosion cracking from molten brazing filler metal, avoid applying stress during brazing.

3. Brazing of Valves: Disassemble valves subject to damage from heat during brazing and reassemble after installation. Open valves two or three turns off the seat when not subject to heat damage during brazing; do not backseat valve.

E. Flare Fittings: Provide flare fittings only where necessary to connect copper tubing to equipment. Use short sections of annealed tubing soldered or brazed to hard drawn tubing using couplings on expanded ends on the annealed tubing made with special tools designed for that purpose. Make flares with the appropriate flaring tools. Cut annealed tubing only with cutting wheel tool. Do not ream out inside burr or lip left by the cutting wheel but fold back lip with flare tool to form seal/gasket inside flare. When new, the flare should cover not more than 75 percent of the flare seating surface of either the male or female flare fittings. Put the flare nut on the tube before making the flare.

F. Valves: ASME B31.1.Install valves at the locations indicated and elsewhere as required for the proper functioning of the system.

1. Gate Valves: Provide gate valves unless otherwise directed. Install valves in positions accessible for operation and repair. Install valve with stem horizontal or above.

2. Globe Valves: Install globe valves so that the pressure will be below the disk. Install globe valves with the stems vertical.

3. Pressure-Reducing Valves Provide compressed air entering each pressure-reducing valve with a strainer. Provide each pressure-reducing valve unit with two block valves and with a globe or angle bypass valve and bypass pipe. Provide a bypass around a reducing valve of reduced size to restrict its capacity to approximately that of the reducing valve. Provide each pressure reducing valve unit with an indicating gage to show the reduced pressure, and a safety valve on the low pressure side. These requirements do not apply to small pressure regulating valves used to adjust pressure for pneumatic equipment.

G. Hangers and Supports: Selection, fabrication and installation of piping hangers and supports shall conform to MSS SP-58, MSS SP-69, and MSS SP-89 except that spacing of the hangers and supports shall be as per Table I. Provide seismic restraints for piping in accordance with PPIC GFSR.

TABLE I. MAXIMUM SPAN FOR PIPE (FEET-INCHES)

DIAMETER INCHES	COPPER TUBE TYPE K	COPPER TUBE TYPE L
1/2	3'-9"	3'-6"
3/4	4'-3"	4'-3"
1	5'-0"	4'-9"
1 1/2	5'-9"	5'-6"
2	6'-6"	6'-6"

H. Pressure Gages: Provide pressure gages with a shut-off valve or petcock installed between the gage and the line.

I. Strainers: Provide strainers with meshes suitable for the services where indicated, or where dirt might interfere with the proper operation of valve parts, orifices, or moving parts of equipment.

J. Equipment Foundations: Provide equipment foundations of sufficient size and weight and of proper design to preclude shifting of equipment under operating conditions or under any abnormal conditions which could be imposed upon the equipment. Provide foundations which meet the requirements of the equipment manufacturer, and when required by the Construction Manager, obtain from the equipment manufacturer approval of the foundation design and construction for the equipment involved. Equipment vibration shall be maintained within acceptable limits, and shall be suitably dampened and isolated.

K. Equipment Installation: Install equipment strictly in accordance with these specifications, and the manufacturers' installation instructions. Grout equipment mounted on concrete foundations before piping is installed. Install piping in a manner that does not place a strain on any of the equipment. Do not bolt flanged joints tight unless they match properly. Extend expansion bends adequately before installation. Grade, anchor, guide and support piping without low pockets.

M. Cleaning of System: Clean the various system components before final closing as the installations are completed. Remove foreign matter from equipment and surrounding areas.

Preliminary or final tests will not be permitted until the cleaning is approved by the Construction Manager.

N. Pipe Sleeves: Provide pipe sleeves where pipes and tubing pass through masonry or concrete walls, floors, roofs, and partitions. Hold sleeves securely in proper position and location before and during construction. Sleeves shall be of sufficient length to pass through entire thickness of walls, partitions, or slabs. Extend sleeves in floor slabs 2 inches above the finished floor. Pack space between the pipe or tubing and the sleeve firmly with oakum and caulk both ends of the sleeve with elastic cement.

O. Floor, Wall, and Ceiling Plates: Provide chromium-plated steel or nickel-plated cast iron plates on pipes passing through floors and partitions of finished rooms. Provide painted cast-iron, malleable iron, or steel for other areas.

P. Flashing for Buildings: Provide flashing as required in accordance with Section 07600, "Flashing and Sheet Metal" where pipes pass through building roofs and outside walls.

Q. Unions and Flanges: Provide unions and flanges where necessary to permit easy disconnection of piping and apparatus, and as indicated. Provide a union for each connection having a screwed-end valve. Provide unions or flanges not farther apart than 100 feet. Provide unions or flanges as indicated. Provide unions on piping under 2 inches in diameter, and provide flanges on piping 2 inches and over in diameter. Install dielectric unions or flanges between ferrous and non-ferrous piping, equipment, and fittings; except that bronze valves and fittings may be used without dielectric couplings for ferrous-to-ferrous or non-ferrous to non-ferrous connections.

R. Painting of Piping and Equipment: Paint piping and equipment in accordance with Section 09900, "Painting."

S. Identification of Piping: Identify piping in accordance with MIL-STD-101. Use commercially manufactured piping identification labels. Space identification marking on runs not farther apart than 50 feet. Provide two copies of the piping identification code framed under glass and install where directed.

3.2 CLEANING SILVERBRAZED PIPING: Clean silverbrazed piping to remove residual flux remaining in the system after fabrication. Use one of the procedures below. The hot flush and hot recirculating flush are preferred. Minimum flow rate through any part of the system in gallons per minute shall be 1.5 times the inside diameter of the pipe in inches. For any flushing method used, the system shall be full of water so that joints are completely submerged at all times.

A. Hot Flushing Method: Hot flush the system for one hour using heated fresh water. No part of the system shall go below 110 degrees F.

B. Hot Recirculating Flush Method: Perform hot recirculating flush for one hour. Heat water during flushing so that no part of the system falls below 110 degrees F. After completing the hot recirculating flush, flush the system with cold fresh water for 15 minutes.

C. Cold Soak Method: Cold soak the system using fresh water at not less than 60 degrees F for 12 hours. Following the 12 hour soak, flush the system with fresh water at not less than 60 degrees F for 4 hours.

3.3 FIELD QUALITY CONTROL

A. Examinations

1. Brazing Examinations: The Contractor shall perform brazing examinations.Visually examine all compressed air systems as follows:

a. Check brazed joint fit-up. Diametrical clearances shall conform to brazing procedure requirements.

b. Check base material of pipe and fitting for conformance to the applicable drawing or specification.

c. Check grade of brazing alloy for conformance to the brazing procedure before fit-up or brazing.

d. Check completed brazed joint for a complete ring of brazing alloy between the outside surface of the pipe and the face of the fitting, and for a visible fillet.

e. Check stainless steel and other susceptible material for evidence of stress cracks. Check inside of joint if possible with borescope or other aids.

2. Defective joints may be repaired. However, no more than two attempts to repair by reheating and additional face feeding of brazing filler metal will be permitted, after which the defective joint shall be unsweated, reprepared as a new joint, examined for defects on pipe and fittings, and rebrazed.

B. Testing

1. General Requirements, Testing: Perform testing after cleaning. Contractor shall provide everything required for tests. Tests shall be subject to the approval of the Construction Manager. Calibrate the test pressure gages with a dead weight tester within 15 days before use and certify by initial and date on a sticker applied to dial face. Pressurize each piping system individually and check to assure that there are no cross-connections between different systems prior to hydrostatic and operational tests.

2. Hydrostatic Tests and Leak Tightness Tests

a. Preliminary Preparation: Remove or isolate from the system the compressor, air dryer, filters, instruments, and equipment which would be damaged by water during hydrostatic tests and reinstall after successful completion of tests.

b. Performance of Hydrostatic Tests: Hydrostatically test piping systems in accordance with ASME B31.1. Vent or flush air from the piping system. Pressurize system for 10 minutes with water at one and one-half times design working pressure, then reduce to design working pressure and check for leaks and weeps.

c. Compressed Air Leak Test: After satisfactory completion of hydrostatic pressure test, blow systems dry with clean, oil-free compressed air, and test with clean, dry air at design working pressure. Brush joints with soapy water solution to check for leaks. Install a calibrated test pressure gage in piping system to observe any loss in pressure. Maintain required test pressure for a sufficient length of time to enable an inspection of joints and connections.

3. Operational Tests: Test equipment as in service to determine compliance with contract requirements and warranty. During the tests, test equipment under every condition

of operation. Test safety controls to demonstrate performance of their required function. Completely test system for compliance with specifications.

3.4 INSTRUCTION TO INSTITUTE PERSONNEL: Provide 2 man-days of instruction to 2 Institute personnel in accordance with Section 15011, "Mechanical General Requirements" for each type of compressor and compressed air dryer in the project.

END OF SECTION

SECTION 15682

WATER CHILLERS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AIR-CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 480	(1987) Refrigerant-Cooled Liquid Coolers, Remote Type
ARI 520	(1990) Positive Displacement Refrigerant Compressors, Compressor Units and Condensing Units
ARI 550	(1990) Centrifugal or Rotary Water-Chilling Packages

AMERICAN SOCIETY OF HEATING, REFRIGERATING, AND AIR CONDITIONING ENGINEERS, INC. (ASHRAE)

ASHRAE 90A	(1980; 90A-a 1987) Energy Conservation in New Building Design

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME-16	(1992) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage

NATIONAL ELECTRICAL MANUFACTURER'S ASSOCIATION (NEMA)

NEMA 250	(1991) Enclosures for Electric Equipment (1000 Volts Maximum)

1.2 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data

1. Design Analysis and Calculations shall be submitted for Chillers indicating the manufacturer's recommended power ratings, rotational speeds, and piston speeds.

2. Equipment Foundation Data shall be submitted for the following items including equipment weight and operating loads, location and projection of anchor bolts, and horizontal and vertical clearances for installation, operation, and maintenance. Data shall also include dimensions of foundations and relative elevations, and installation requirements such as noise abatement, vibration isolation, and utility services.

Water Chillers
Compressors
Condensers

Coolers
Purge System
Motors

3. Equipment and Performance Data shall be submitted for Water Chillers indicating the guaranteed maximum brake power at 75-, 50-, 25-, and 10- percent points of full compressor capacity at design condenser water temperature. This information shall be developed from data indicated and specified herein.

4. Manufacturer's Catalog Data shall be submitted for the following items:

Water Chillers
Compressors
Condensers
Coolers
Purge System
Motors
Control and Control Panels
Insulation
Vibration Isolation
Special Tools
Spare Parts

B. Drawings

1. Connection Diagrams shall be submitted indicating the relations and connections of the following items. Drawings shall indicate the general physical layout of all controls, and internal tubing and wiring details.

Water Chillers
Compressors
Condensers
Coolers
Purge System
Motors
Control and Control Panels

2. Control Diagrams shall be submitted for Chiller Units showing the physical and functional relationship of equipment. Electrical diagrams shall show the size, type, and capacity of the system.

3. Installation Drawings shall be submitted for Chiller Systems in accordance with the paragraph entitled, "Installation," of this section. Drawings shall indicate overall physical features, dimensions, ratings, service requirements, and equipment weights.

4. As-Built Drawings shall be submitted for Chiller Units providing current factual information including deviations from, and amendments to, the drawings and concealed and visible changes in the work.

C. Schedules: Material, Equipment, and Fixture Lists shall be submitted for Chiller Systems including manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

D. Statements: Listing of Product Installation shall be submitted for Chiller Units showing at least 5 installed units, similar to those proposed for use, that have been in successful service for a minimum period of 5 years. List shall include purchaser, address of installation, service organization, and date of installation.

E. Reports: Test Reports for chiller units shall be submitted indicating the results of Performance Tests performed in accordance with the paragraph entitled, "Field Testing," of this section.

F. Certificates of Compliance shall be submitted for following items showing conformance with the referenced standards contained in this section.

Water Chillers
Compressors
Condensers
Coolers
Purge System
Motors
Control and Control Panels
Insulation
Vibration Isolation
Special Tools
Spare Parts

G. Samples: Manufacturer's Standard Color Chart shall indicate the manufacturer's standard color selections and finishes for Chiller Units.

H. Operation and Maintenance Manuals: Contractor shall submit 6 copies of the Operation and Maintenance Manuals 30 days prior to testing the Chiller System. Data shall be updated and resubmitted for final approval no later than 30 days prior to contract completion.

1.3 GENERAL REQUIREMENTS: Section 15003, "General Mechanical Provisions," applies to work specified in this section. Section 15245, "Vibration Isolation for Air Conditioning Equipment," applies to work specified in this section.

PART 2 - PRODUCTS

2.1 WATER CHILLERS (90 Ton Nominal Capacity):

A. General: Units are leak and pressure tested at 450 psig high side, 300 psig low side, then evacuated and charged. All air cooled Series chillers are factory tested to confirm operation prior to shipment. Units ship with a full operating charge of oil and refrigerant.

1. Unit panels, structural elements and control boxes are constructed of 12-gauge galvanized steel and mounted on a welded structural steel base. Unit panels and control boxes are finished with a baked on powder paint, and the structural base with an air dry paint. All paint meets the requirement for outdoor equipment of the U.S. Navy and other federal government agencies.

2. Evaporator: The evaporator is a tube-in-shell heat exchanger design with internally finned copper tubes roller expanded into the tube sheet. The evaporator is designed, tested and stamped in accordance with ASME for a refrigerant side working pressure of 300 psig. The evaporator is designed for a water side working pressure of 215 psig. Water connections are grooved pipe. The evaporator has one water pass with a series of internal baffles. Each shell includes a vent, a drain and fittings for temperature control sensors and is insulated with

3/4 inch Armaflex II or equal insulation (K = 0.26). Heat tape with thermostat is provided to protect the evaporator from freezing at ambient temperatures down to -20 F.

3. Condenser and Fans: Air-cooled condenser coils have aluminum fins mechanically bonded to internally finned seamless copper tubing. The condenser coil has an integral subcooling circuit and also provides oil cooling for the compressor bearing and injection oil. Condenser are factory proof and leak tested a 506 psig.

a. Direct-drive vertical discharge condenser fans are dynamically balanced. Three-phrase condenser fans motors with permanently lubricated ball bearing and internal thermal overload protection are provided. Standard 240-400 ton units will start and operate down to 0 F ambient.

4. Compressor and Lube Oil System: The rotary screw compressor is semihermetic, direct drive, 3600 rpm, with capacity control slide valve, rolling element bearings, differential refrigerant pressure oil pump and oil heater. The motor is a suction gas cooled, hermetically sealed, two-pole squirrel cage induction motor.

a. Oil separator and filtration devices are provided separate from the compressor. Check valves in the compressor discharge and lube oil system and a solenoid valve in the lube system are provided.

5. Refrigeration Circuits: Each unit has two refrigerant circuits, with one or two rotary screw compressors per circuit includes a compressor suction and discharge service valve, liquid line shutoff valve, removable core filter drier, liquid line sight glass with moisture indicator, charging port and an electronic expansion valve. Fully modulating compressors and electronic expansion valves provide variable capacity modulation over the entire operating range.

6. Unit Controls: All unit controls are housed in a weathertight enclosure with removable plates to allow for customer connection of power wiring and remote interlock. All controls, including sensors, are factory mounted and tested prior to shipment. All cataloged units are UL listed.

a. Microcomputer controls provide all control functions including start-up and shut down, leaving chilled water temperature control, compressor and electronic expansion valve modulation, fan sequencing, antirecycle logic, automatic lead/lag compressor starting and load limiting.

b. The unit control module, utilizing microprocessor, automatically takes action to avoid unit shutdown due to abnormal operating conditions associated with low refrigerant temperature, high condensing temperature and motor current overload. Should the abnormal operating condition continue until a protective limits is violated, the unit will be shut down.

c. Unit protective function include loss of chilled water flow, evaporator freezing, loss of refrigerant pressure, high refrigerant pressure, reverse rotation, compressor starting and running over current, phase loss, phase imbalance, phase reversal, and loss of oil flow.

d. A menu driven digital display indicated operating data points including chilled water setpoint, current limit setpoint, leaving chilled water temperature, evaporator and condenser refrigerant pressures and temperatures. Diagnostic checks are made and displayed when a problem is detected. The digital display can be read and advanced on the unit without opening any control panel doors.

e. Standard power connection include main three phase power and two 115 volt single phase power connections for control power and heat tape.

f. Control System will interface with FMCS (Facility Monitoring and Control System). FMCS shall be able to reset the operation set points such as leaving chilled water temperature, current limiting set point, and display the diagnostic checks.

7. Starter: Starters are household in weathertight enclosure with removable cover plate to allow for customer connection of power wiring. Across the line starters will be used.

8. Accessories: Hot gas bypass low ambient operation flow switches pressure gauges on suction and discharge (refrigerant).

B. Water Chiller (20 Ton Nominal Capacity)

1. General: Chillers are factory run-tested to confirm proper operation. Units are checked on a computer-based test stand at typical ambient and water conditions and control operation is monitored. Units ship with a full operating charge of refrigerant and oil.

a. Units are constructed of 14-gauge welded galvanized steel frame with 14 and 16-gauge galvanized steel panels and access doors. Unit surface is phosphatized and finished with an air-dry paint. This air-dry paint finish exceeds 672 consecutive hour salt spray resistance in accordance with ASTM B117.

2. Evaporator: The evaporator is a tube-in-shell design with seamless internally finned copper tubes, roller expanded into the tube sheets. Chiller is designed, tested and stamped in accordance with ASME code for a refrigerant side working pressure of 225 psig. The chiller is designed to withstand a waterside working pressure of 300 psig. It has one water pass with a series of internal baffles. Each shell includes a drain and a vent connection, fittings for temperatures for temperature control sensors and 3/4 inch insulation (K = 0.26). Heater tape, which is thermostat controlled, protects the evaporator to an ambient of -20 F.

3. Condenser: Air-cooled condenser coils have configurated aluminum fins mechanically bonded to seamless copper tubing and integral subcooling circuits. Condenser are factory leak-tested with air underwater at 425 psig air pressure.

a. Direct-drive vertical discharge condenser fans are statically and dynamically balanced. Three-phrase condenser fans motors with permanently lubricated ball bearings and three-phase thermal overload protection. Options low ambient units start and operate to 0 F with external damper assemblies for head pressure control.

b. Decorative grilles provide protection from exterior damage to coil surface and other interior unit components. Grilles are factory mounted, louvered, galvanized steel mesh panels finished with an air-dry paint. Grilles will cover all open ends of units.

4. Compressor: Scroll compressors have simple mechanical design with only three major moving parts. Scroll type compression provides inherently low vibration. 3-D compliance provides a completely enclosed compression chamber with no leakage paths and the ability for scroll plates to separate, allowing liquid refrigerant to pass through without damage to the compressor. Direct-drive, 3600 rpm, suction gas-cooled hermetic motor. Scroll compressor includes centifrugal oil pump, oil level sightglass and oil charging valve.

5. Refrigerant Circuits and Capacity Modulation: Twenty through 30-ton sizes have single refrigerant circuit. Forty through 60-ton sizes have dual refrigerant circuits. Each

refrigerant circuit has two Scroll compressors, piped in parallel, with a passive oil management system. Passive oil management system maintains proper oil levels within compressors and has no moving parts. Each refrigerant circuit includes an expansion valve, a filter drier, and a liquid line sightglass with moisture indicator. Capacity modulation is achieved by turning compressors on and off. Twenty and 30-ton sized have two capacity stages, and the 25-ton size has three capacity stages. Forty, 50 and 60-ton sizes have four capacity stages. The standard leaving chilled solution temperature range is 30 to 39 F.

6. Unit Controls: Compressor contactors and unit controls are in a weathertight enclosure with knockouts for jobsite installed wiring. Microcomputer controls provide all control functions including leaving chilled water temperature control, automatic compressor sequencing (except with hot gas bypass option), condenser fan sequencing, load limiting and anti-recycle functions. Failure protections include loss of chilled water flow, chiller freezing, compressor running overcurrent, phase loss, phase reversal, under-voltage, over-voltage, loss of charge, high motor winding temperature, high refrigerant pressure and low refrigerant pressure. Leaving water temperature sensor is factory installed. Controls include auto/stop switch, a leaving water temperature setpoint adjustment, a delta T adjustment, and a digital display. Display readout include operating codes, water temperatures, other operating readouts and diagnostic codes. The display can be read and advanced on the unit without opening any unit panels.

a. Power connections include main three-phase power and a single 115-volt, single-phase connection that handles both controls and the evaporator heat tape.

b. Unit accepts any of these jobsite supplied contact closures for:

c. External Auto/Stop - can be from a manual switch or a time clock. In auto, the unit will be allowed to operate if a load exists.

d. Chilled Waterflow Interlock - A chilled water pump interlock in combination with a flow switch is not required for unit protection since the unit controller senses loss of flow. If additional flow protection is required, or if the pump contactor is used to schedule the unit, this input may be used.

e. External Interlock - Contact opening turns unit off and requires that unit controller be manually reset.

f. Kw Demand Limit - Unit will only be allowed to operate one half of compressors.

g. Control System will interface with FMCS (Facility Monitoring and Control System). FMCS shall be able to reset the operation set points such as leaving chilled water temperature, current limiting set point, and display the diagnostic checks.

7. Accessories: Hot gas bypass, low ambient operation, flow switches, pressure gauges on suction and discharge (refrigerant).

2.3 VIBRATION ISOLATION: Vibration isolation provisions shall conform to requirements specified in Section 15245, "Vibration Isolation for Air Conditioning Equipment."

2.10 SPECIAL TOOLS: One complete set of special tools, as recommended by the manufacturer, shall be provided for field maintenance of the system. Tools shall be contained in a locked toolbox. Two keys shall be provided to the Construction Manager.

PART 3 - EXECUTION

3.1 INSTALLATION: Equipment shall be installed as specified, and in accordance with manufacturer's recommendations.

3.2 MANUFACTURER'S REPRESENTATIVE: Services of a competent factory-trained representative shall be provided to supervise the assembly, charging, testing, and startup of equipment; in addition, Institute personnel shall receive 8 hours of instructions in proper operation and maintenance procedures.

3.3 REFRIGERANT AND OIL CHARGE: Unit(s) shall be completely charged with refrigerant and oil before operation.

3.4 FIELD TESTING:

A. Upon completion of the installation, and within 60 days after the date of initial operation, performance tests shall be conducted in the presence of the Construction Manager. These tests shall be conducted until the performance of the system is proven, with 8 hours of successful operation as a minimum period. Any equipment defects or performance deficiencies shall be corrected, and the tests repeated until performance is fully satisfactory. Water flows shall be determined from pressure-drop across chiller and condenser, and from pump curves. Calibrated test instruments shall be provided. The Contractor shall provide load.

B. Each unit shall be tested for leaks under pressure and shall be evacuated and dehydrated to 35 degrees F, wet bulb, or an absolute pressure of not over 0.24 inch of mercury.

END OF SECTION

SECTION 15790

AIR COILS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AIR-CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 410	(1987) Forced-Circulation Air-Cooling and Air-Heating Coils

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 527	(1990) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality

1.2 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data

1. Design Analysis and Calculations shall be submitted for Fan Coil Units indicating the manufacturer's recommended power ratings, rotational speeds, and piston speeds.

2. Equipment and Performance Data shall be submitted for Fan Coil Units consisting of use life, system functional flows, safety features, and mechanical automated details. Curves indicating tested and certified equipment response and performance characteristics shall also be submitted.

3. Manufacturer's Catalog Data shall be submitted for the following coil types indicating, when applicable, coil pressure and temperature ratings, coil casings, headers, tubing, circuiting, and drainable coils.

Chilled-Water Cooling

B. Drawings

1. Connection Diagrams shall be submitted indicating the relations and connections of the following items. Drawings shall indicate the general physical layout of all controls, and internal tubing and wiring details.

Coils
Casings
Headers
Tubing
Circuiting

2. Fabrication Drawings shall be submitted for Coil Units consisting of fabrication and assembly details to be performed in the factory.

3. Installation Drawings shall be submitted for Coil Systems in accordance with the paragraph entitled, "Installation," of this section. Drawings shall indicate overall physical features, dimensions, ratings, service requirements, equipment weights and layout and arrangement details of equipment room.

4. As-Built Drawings shall be submitted for Coil Systems providing current factual information including deviations from, and amendments to, the drawings and concealed and visible changes in the work.

C. Reports: Test Reports shall be submitted for the following tests in accordance with the paragraph entitled, "Tests," of this section.

Pressure Tests
Vacuum Tests

D. Certificates of Compliance shall be submitted for following items showing conformance with the referenced standards contained in this section.

Coils
Casings
Headers
Tubing
Circuiting
Spare Parts

E. Samples: Manufacturer's Standard Color Chart shall indicate the manufacturer's standard color selections and finishes for Coil Units.

F. Records of Existing Conditions shall be submitted consisting of the results of Contractor's survey of work area conditions and features of existing structures and facilities within and adjacent to the jobsite. Commencement of work shall constitute acceptance of existing conditions.

G. Operation and Maintenance Manuals: Contractor shall submit 6 copies of the Operation and Maintenance Manuals 30 days prior to testing the Coil Systems. Data shall be updated and resubmitted for final approval no later than 30 days prior to contract completion.

1.3 GENERAL REQUIREMENTS: Section 15003, "General Mechanical Provisions," applies to work specified in this section.

1.4 LABEL: Coils shall bear the ARI certification seal indicating compliance with ARI 410.

PART 2 - PRODUCTS

2.1 GENERAL

A. Coil Pressure and Temperature Ratings:

1. Coils shall be designed for the following fluid operating pressures and temperatures.

Service	Pressure (psi)	Temperature (Degrees F)
Chilled water	200	250

2. Coils shall be air-pressure tested under water at the following minimum pressures:

Service	Pressure (psi)
Chilled water	250

B. Coil Casings

1. Coil casings shall be mill-galvanized 16-gage, minimum, sheet metal with not less than 1.25 ounces of zinc per square foot of two-sided metal surface conforming to ASTM A 527. Casing shall be flanged on four sides for bolted assembly, except as otherwise specified.

2. Where coils are stacked, casing shall be of double-bend construction.

3. Duct-mounted reheat coil casings not over 36 inches in length shall be fabricated from a minimum 20-gage galvanized steel conforming to above specified requirements; casings shall be flanged or suitable for drive-slip assembly.

4. Coil mounting within housing shall be either fixed or slide-out type, except as otherwise specified. Coils shall be slide-out type for ceiling-suspended package units, and for other package units whose capacity exceeds 15,000 cubic feet per minute.

C. Coil Headers shall be copper.

D. Coil Tubing

1. Coils shall be constructed of copper tubing with aluminum or copper fins. Helical coil fins shall be wound tight to the tubes and solder-coated. Plate fins shall have spacer collars in metallic contact with the adjacent fin, and fins shall be mechanically bonded to the tube. No bare tube surface shall be visible within the finned portion of the coil.

2. Cooling coils of helical wound copper design shall be solder-coated.

3. Coil tubes in water service shall be parallel and shall have sufficient intermediate full coil depth supports to prevent sagging of unsupported span due to working fluid pressures and temperatures and summer and winter coil-ambient conditions. Sagging shall be unacceptable if tube centerline is displaced by more than 3/16 inch from centerline of tube connection at outlet header when coils are more than two rows deep and when installed in accordance with the manufacturer's instructions. Provisions for expansion and contraction shall be adequate to preclude sagging and distortion under thermal loads applied in indicated or specified service. Tubes shall be sloped to be free draining.

4. Coil face tube spacing for cooling coils immediately followed by water-cooling coils shall not exceed 1-1/2 inches on center.

5. Tubes shall be straight, turns shall be made through headers or return U-bends, and connections and joints shall be brazed, except as otherwise specified.

6. Coil tube material shall be seamless deoxidized copper.

7. Raw coil tube stock wall minimum thickness shall be 0.035 inch.

8. Where mechanical insert devices are used to increase liquid turbulence within tubes, the wall thickness of these tubes shall be increased by 0.010 inch over the minimum raw coil tube stock specified for the service.

9. Tube minimum od shall be 1/2 inch.

E. Coil Circuiting: Standard or full-circuited water coils shall have as many full-length tubes in each circuit as the number of tubes in the depth of the coil face; double-circuit water coils shall have twice as many as standard coils; and half-circuit water coils shall have half as many as standard coils and to the next larger whole number where odd numbers are involved. Coils more than two rows deep shall be counterflow type, except that in the case of double- or half-circuit coils, reasonable deviation from counterflow arrangement will be permitted, provided the pressure drop and capacity requirements are met.

F. Drainable Coils

1. Drainable coils shall be capable of being purged free of water with compressed air.

2. Self-draining coils shall have a drain point at the end of every tube and shall be pitched to that point. Drain provisions shall include:drained headers; U-bends with integral plugs; or nonferrous plugs in cast-iron headers. Each tube shall drain substantially dry by gravity alone when drains and vents are open.

3. Where necessary, the coil shall be filled with water to the end of the manufacturer's header connections and drainage volume shall be checked against the manufacturer's data.

2.2 COIL TYPES

A. Chilled-Water Cooling

1. Type CA shall be continuous circuit, drainable type, limited to two rows depth.

2. Type CB shall be self-draining, counterflow type.

3. Type CC shall be self-draining, cleanable, counterflow type. Tubes shall be straight-through type, rolled or brazed into steel tube sheets. Headers shall be enclosed with gasketed and bolted removable cover plates to provide access to tube internals from either one end or both ends of coil.

PART 3 - EXECUTION

3.1 INSTALLATION: Coils shall be installed in accordance with the manufacturer's recommendations.

3.2 TESTS

A. For drainable types:

1. Coil pitch and leveling shall be field checked for drainability in the presence of the Construction Manager.

2. Coils shall be pressure tested, dehydrated, vacuum tested, purged with inert gas, and sealed.

END OF SECTION

SECTION 15850

AIR HANDLING

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

ANTI-FRICTION BEARING MANUFACTURERS ASSOCIATION, INC. (AFBMA)

AFBMA 11	(1990) Load Ratings and Fatigue Life for Roller Bearings
AFBMA 9	(1990) Load Ratings and Fatigue Life for Ball Bearings

AIR MOVEMENT AND CONTROL ASSOCIATION, INC. (AMCA)

AMCA 300	(1989) Test Code for Sound Rating Air Moving Devices
AMCA 301	(1976) Methods for Calculating Fan Sound Ratings from Laboratory Test Data
AMCA 302	(1973) Application of Sone Loudness Ratings for Non Ducted Air Moving Devices
AMCA 401	(1986) Classifications for Spark Resistant Construction
AMCA 99	(1986; AMCA 99-0401) Standards Handbook

AMERICAN SOCIETY OF HEATING, REFRIGERATING, AND AIR CONDITIONING ENGINEERS, INC. (ASHRAE)

ASHRAE 51	(1985) Laboratory Methods of Testing Fans for Rating

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B15.1	(1984) Safety Standard for Mechanical Power Transmission Apparatus

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 527	(1990) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality

STEEL STRUCTURES PAINTING COUNCIL (SSPC)

SSPC SP 10	(1989) Near-White Blast Cleaning
SSPC SP 5	(1989) White Metal Blast Cleaning

1.2 SUBMITTALS; The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data

1. Design Analysis and Calculations shall be submitted for Fans indicating the manufacturer's recommended sound pressure level ratings, self alignment and thrust load requirements, horsepower ratings, and required system rpm's.

2. Equipment and Performance Data shall be submitted for Fans consisting of use life, system functional flows, safety features, and mechanical automated details. Curves indicating tested and certified equipment response and performance characteristics shall also be submitted.

3. Manufacturer's Catalog Data shall be submitted for the following items:

Vibration Isolation
Type VA-F, Vane Axial Fan
Type TC-F Tubular Centrifugal Fan
Type C-F Cabinet Fans
Shutters
Dampers
Bearings
Drives
Sheaves
Belts
Motors
Casings and Enclosures
Fan Inlet
Fan Wheels
Spare Parts

B. Drawings

1. Fabrication Drawings shall be submitted for Fans consisting of fabrication and assembly details to be performed in the factory.

2. Installation Drawings shall be submitted for Fans in accordance with the paragraph entitled, "Installation," of this section. Drawings shall indicate overall physical features, dimensions, ratings, service requirements, and equipment weights.

C. Statements: Listing of Product Installations shall be submitted for Fans showing a minimum of 5 installed units, similar to those proposed for use, that have been in successful service for a minimum period of 5 years. List shall include purchaser, address of installation, service organization, and date of installation.

D. Certificates of Compliance shall be submitted for following items showing conformance with the referenced standards contained in this section.

Type VA-F, Vane Axial Fan
Type TC-F Tubular Centrifugal Fan
Type C-F Cabinet Fans
Shutters
Dampers
Bearings

Drives
Sheaves
Belts
Motors
Casings and Enclosures
Motors
Fan Inlet
Fan Wheels
Spare Parts

E. Samples: Manufacturer's Standard Color Chart shall indicate the manufacturer's standard color selections and finishes for Fans.

F. Operation and Maintenance Manuals

1. Contractor shall submit 6 copies of the Operation and Maintenance Manuals 30 days prior to testing the Fan Assemblies. Data shall be updated and resubmitted for final approval no later than 30 days prior to contract completion.

2. Operation and Maintenance Manuals shall be consistent with manufacturer's standard brochures, schematics, printed instructions, general operating procedures, and safety precautions. Test data shall be legible and of good quality.

1.3 GENERAL REQUIREMENTS

A. Section 15003, "General Mechanical Provisions," applies to work specified in this section.

B. Section 15245, "Vibration Isolation for Air Conditioning Equipment," applies to work specified in this section.

PART 2 - PRODUCTS

2.1 GENERAL FAN REQUIREMENTS

A. General

1. Performance data for all fans shall be determined in accordance with the provisions of ASHRAE 51.

2. Sound pressure level ratings of ducted fans shall comply with AMCA 301 and shall be the result of tests made in accordance with AMCA 300.

3. Sound pressure level ratings of nonducted fans shall comply with AMCA 301 and shall be the result of tests made in accordance with AMCA 300. Application of sound pressure level ratings shall conform to AMCA 302. Unit construction shall conform to applicable standards contained in AMCA 99 and to requirements specified.

4. Safety provisions for power transmission equipment and nonducted inlets and outlets shall include guards and screens, unless other provisions are required, and shall be constructed in accordance with applicable provisions of ASME B15.1. Installation shall be such that fan vibration-isolation provisions are not negated.

5. Fan wheels shall be statically and dynamically balanced at the factory.

6. Dynamic balancing shall be in two planes.

B. Bearings

1. Bearings shall be antifriction ball or roller type, unless otherwise specified, with provisions for self-alignment and thrust-load requirements that may be imposed by the service. Bearings shall be constructed of vacuum degassed or processed steel alloys and shall have a certified AFBMA 9 or AFBMA 11, L-10 minimum life expectancy rating of 40,000 hours under load conditions the service will impose. Bearings shall have dusttight seals suitable for lubricant pressures encountered. Housings shall be cast iron unless otherwise specified or approved.

2. Bearings shall be grease lubricated. Lubrication provisions shall preclude overheating due to excess lubricant. Grease supply fittings shall be surface ball check type. Where necessary, manual or automatic grease pressure relief fittings shall be provided. Bearing and seal construction permitting, relief fittings shall be located on the side opposite the supply fitting. Relief fittings shall be visible from normal maintenance locations. Lubrication provisions shall include extension tubes where necessary.

3. Bearings shall be dowelled in place with AISI 18-8 corrosion-resistant steel spiral wrapped or split pins, unless otherwise specified or approved. Taper pins are not acceptable.

4. Factory sealed antifriction bearings which conform to above specified materials and AFBMA 9, L-10 life expectancy requirements shall be provided for fans driven by motors smaller than 1/2 horsepower.

5. Sleeve-type bearings shall be provided where indicated. Bearings shall be premounted, self-aligning, continuous-oil supply, single- or double-ring lubricated, insert type, with suitable provisions for shaft expansion and for such thrust as may be imposed by service loads. Maximum shaft surface speed shall not exceed 1,200 feet per minute (fpm) without water cooling, and bearing loading pressure shall not exceed 70 pounds per square inch (psi) based on effective bearing area. Each sleeve bearing shall be provided with approximately 16-ounce capacity constant-level oiler and oil-level gage.

C. Drives: Fan drives shall be direct driven.

D. Motor Requirements

1. Motors shall conform to Section 16405, "Motors," and the following requirements. Motors located in unfiltered airstreams shall be totally enclosed.

2. Air-over-motor units shall be provided with NEMA-rated Class H insulation for all services where airstream temperature exceeds 100 degrees F. Air velocity over motor surfaces shall be sufficient to maintain insulation temperatures within NEMA standards at maximum fan horsepower.

2.3 TYPE TA-F TUBULAR AXIAL FAN:

A. Fan shall bear AMCA certified rating seal. Fan shall have a flanged, cylindrical casing with provisions for support requirements indicated.

B. Fan Casing shall be constructed of not less than 8-gage welded or fabricated aluminum.

2.4 TYPE VA-F, VANE AXIAL FAN

A. Fan shall bear an AMCA certified rating seal.

B. Fan shall have a flanged, cylindrical casing with provisions for support requirements indicated.

C. [Construction shall be spark-resistant in accordance with AMCA 401 and the following:]

edit this as appropriate

[Type A - All parts of fan in contact with the air or gas being handled shall be made of nonferrous material.]

[Type B - Fan shall have an entirely nonferrous wheel and a nonferrous ring about the opening through which the shaft passes.]

[Type C - Fan shall be so constructed that a shift of the wheel will not permit ferrous parts of the fan to rub or strike other ferrous parts.]

[Unit shall be direct-drive type.]

[Unit shall be V-belt type with an enclosure covering the drive components.]

[Weather-exposed motor shall be provided with weatherproof housing.]

[Motor pulley and belts shall be guarded.]

D. Fan Casing

select one of the following

Casing shall be constructed of not less than 8-gage welded or fabricated aluminum.

Casing shall be constructed of not less than 10-gage welded carbon steel.

Stationary, airfoil-shaped, securely attached guide vanes shall be provided behind fan wheel.

select 2 of the following 3

[Casing shall be fitted with a bolted-panel inspection door.]

[Casing shall be fitted with one hinged and gasketed access door secured with quick-acting lug-type closure devices.]

[Casing shall be fitted with two hinged and gasketed access doors secured with quick-acting lug-type closure devices. Wheel, shaft and bearings shall be removable as a unit from removable, gasketed, inner drive enclosure.]

E. Fan Inlet

select one of these

[Casing shall be fitted with an efficient inlet bell.]

[Casing shall be fitted with efficient inlet and outlet cones.]

[Fan inlet shall be fitted with a heavy-duty galvanized inlet screen.]

[Fan inlet shall be fitted with a vortex breaker.]

[Fan shall be fitted with variable inlet vanes, manually adjustable, and with provisions for positive position lock.]

F. Fan Wheel

1. Wheel shall be constructed of high-strength cast aluminum and shall have airfoil blades.

2. Wheel shall be constructed of carbon steel with bronze blade tips, or entirely of high-strength cast aluminum with airfoil blades.

3. Wheel shall be manually adjustable pitch type, constructed of high-strength cast aluminum with airfoil blades.

4. Wheel shall be fixed-pitch or manually adjustable pitch type, constructed of high-strength cast aluminum with airfoil blades.

5. Adjustable pitch wheels shall have blade angles factory preset to match system characteristics.

6. Wheel shall be statically and dynamically balanced. Relationship between drive supports, wheel speed, and number of blades shall be such that fundamental blade frequency is avoided. Wheel hub shall be streamlined, and shaft shall be sealed at drive-enclosure penetration to prevent the entry of particulate matter. Wheel shall be keyed to shaft.

2.5 TYPE C-F CABINET FANS

A. Unit cabinet shall be suitable for pressure class indicated and shall have leaktight joints, closures, penetrations, and access provisions. Cabinet shall not expand or contract perceptibly during starting and stopping of fans, and cabinet shall not pulsate during operation. Surface deflections in excess of 1/240th of unsupported span shall be additionally reinforced prior to acceptance by the Contracting Officer. Pulsating panels which produce low-frequency noise due to diaphragming of unstable panel walls shall be stiffened to raise natural frequency to an easily attenuated level. Enclosure shall be fabricated from mill-galvanized or primed and painted carbon-steel sheet of required thickness. Mill-galvanized sheet metal shall conform to ASTM A 527 and shall be coated with not less than 1.25 ounces of zinc per square foot of two-sided surface. Mill-rolled structural steel shall be hot-dip galvanized or primed and painted. Cut edges, burns, and scratches in galvanized surfaces shall be corrosion-protected. Primed and painted black carbon-steel cabinet construction shall comply with requirements specified herein.

B. Unit cabinet shall be suitable for pressure class indicated, and shall have leaktight joints, closures, penetrations, and access provisions. Cabinet shall not expand or contract perceptibly during starting and stopping of fans, and cabinet shall not pulsate during operation. Surface deflections in excess of 1/360th of unsupported span shall be additionally reinforced prior to acceptance by the Contracting Officer. Pulsating panels which produce low-frequency noise due to diaphragming of unstable panel walls shall be stiffened to raise natural frequency to an easily attenuated level. Enclosure shall be fabricated from mill-galvanized or primed and painted carbon-steel sheet of required thickness. Mill-galvanized sheet metal shall conform to

ASTM A 527 and shall be coated with not less than 1.25 ounces of zinc per square foot of two-sided surface. Mill-rolled structural steel shall be hot-dip galvanized or primed and painted. Cut edges, burns, and scratches in galvanized surfaces shall be corrosion-protected. Primed and painted black carbon-steel cabinet construction shall comply with requirements specified herein.

C. Cabinet fans shall be forward-curved or nonoverloading centrifugal-scroll type, unless otherwise specified. Cataloged fan capacity shall have been determined with fan installed within cabinet. Nonoverloading type shall be backward curved or single- or double-skin airfoil-blade type. Fans shall be selected to avoid instability in service, and shall be constructed so that the relationship of wheel diameter to outlet area conforms to AMCA 99. Forward-curved-blade fans shall, in addition, conform to the following requirements:

1. Duty point shall be to the right of the second-peak static-pressure point from shutoff and at approximately 60 percent overall efficiency.

2. Forward-curved fans shall operate in a stable manner when filters are dirty and when system dampers respond to automatic environment controls.

3. [Forward-curved-blade fans shall be used only where fan-wheel diameter is less than 12-1/4 inches.]

4. Two forward-curved fans shall not be substituted where a single fan is specified or indicated.

5. [For fan wheel sizes 27 inches and larger, blades shall be airfoil type.]

6. Fan wheels, on shafts supported by flanged bearings mounted on the cabinet, shall be balanced after mounting in cabinet.

7. Fan scroll shall be fabricated from mill-galvanized steel. Wheel shall be fabricated from aluminum or mill-galvanized steel and coated with the manufacturer's standard corrosion-protection coating.

2.6 SHUTTERS

A. General

1. Shutters shall be provided where indicated. Shutter frames shall be sealed construction with gaskets and elastomer calk as necessary to prevent bypass.

2. Minimum distance between fan wheel and shutter shall be 8 inches, unless otherwise recommended by the manufacturer.

3. Shutter effective-opening size shall be coordinated with fan wheel size to ensure maximum operating efficiency.

B. Type MS (Motorized Shutter)

1. Type MS shall be a motorized shutter, opened and closed by electric motor, consisting of frame, blades and linkage. Shafts shall be 3/16-inch diameter, full-blade length. Shaft bearings shall be oil-impregnated bronze or graphite-impregnated nylon. Maximum blade

width shall be 4 inches and maximum blade length shall be 36 inches. Blade edges shall have mechanically retained edge seals. Frames shall be 14-gage mill-galvanized steel.

2. For velocities to 1,800 fpm, blades shall be 24-gage, 2-mil dry-film clear acrylic coated, Aluminum Association Alloy 5052 or 6063 aluminum.

3. For velocities to 2,500 fpm, blades shall be 22-gage, 2-mil dry-film clear acrylic coated, Aluminum Association Alloy 5052 or 6063 aluminum.

4. Linkage shall preclude distortion of blades under operation.

5. [Motorized shutters shall be provided for all supply fans. Shutter operating circuit shall have a time-delay relay complete with motor-controller interlocks to ensure full-open shutter position before fan starts.]

2.6 GRAVITY BACKDRAFT AND RELIEF DAMPERS

A. Frame shall be constructed of not less than 1-1/2- by 4-inch, adequately reinforced, 16-gage galvanized carbon steel. Frames and mullions shall be solidly secured in place and sealed with elastomer calking against air bypass.

B. Blade maximum width shall be 9 inches, and maximum length shall be 36 inches. Blade material shall be 16-gage galvanized steel, 14-gage Aluminum Association Alloy 6063 or 5052 aluminum, or 18-gage AISI 18-8 corrosion-resistant steel. Blades shall be provided with mechanically retained seals and 90-degree limit stops.

C. Dampers used for relief service shall have blades linked together to open not less than 30 degrees on 0.05-inch water gage differential pressure.

D. Shaft bearings shall be graphite-impregnated nylon or oil-impregnated bronze.

E. Counterbalanced dampers shall be equipped with fixed and adjustable counterbalancing weights.

F. Gravity backdraft dampers in sizes 18 by 18 inches or smaller, when furnished integral with air moving equipment, shall be equipment manufacturer's standard construction.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment shall be installed as indicated, as specified herein, and in accordance with manufacturer's recommendations.

B. Laminates of fans with duty-point operating speeds that do not exceed the wheel diameter and rpm relationship tabulated hereunder shall be classed as standard design and shall be tested and inspected in accordance with the manufacturer's standard procedures. Directly proportional interpolation for different wheel sizes is permissible.

C. Laminates of fans with duty points that exceed standard design wheel diameter and rpm relationships tabulated above but do not exceed the same relationships tabulated hereunder shall be classed as high-speed design, and in addition to the manufacturer's standard construction, testing, and inspection, shall be subject to minimum special requirements which include: ultrasonic or dye checking of wheel laminates; high tensile filament winding of high-stress wheel areas; and visual inspection of wheel with high intensity light. Proportional variations in wheel sizes are permissible.

END OF SECTION

SECTION 15855

AIR HANDLING UNITS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AIR MOVEMENT AND CONTROL ASSOCIATION, INC. (AMCA)

AMCA 211	(1989) Certified Ratings Program - Air Performance
AMCA 99	(1986; AMCA 99-0401) Standards Handbook

AIR-CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 430	(1989) Central-Station Air-Handling Units

AMERICAN SOCIETY OF HEATING, REFRIGERATING, AND AIR CONDITIONING ENGINEERS, INC. (ASHRAE)

ASHRAE 51	(1985) Laboratory Methods of Testing Fans for Rating

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 527	(1990) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality
ASTM B 117	(1990) Standard Test Method of Salt Spray (Fog) Testing

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(1993) Standard for the Installation of Air Conditioning and Ventilating Systems

1.2 GENERAL REQUIREMENTS: Section 15003, "General Mechanical Provisions," applies to work specified in this section.

1.3 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data

1. Equipment and Performance Data shall be submitted for Air Handling Units in accordance with the specification. Data shall consist of use life, total static pressure and coil face area classifications, and performance ratings.

2. Manufacturer's Catalog Data shall be submitted for the following items:

Unit Cabinet
Fans

Drain Pans
Insulation
Plenums
Multizone AHU
Blow-Through AHU
Spare Parts
Vibration Isolation

C. Drawings: Installation Drawings shall be submitted for Air Handling Units in accordance with the paragraph entitled, "Installation," of this section.

D. Statements: Listing of Product Installations shall be submitted for Air Handling Units showing a minimum of 5 installed units, similar to those proposed for use, that have been in successful service for a minimum period of 5 years. List shall include purchaser, address of installation, service organization, and date of installation.

E. Certificates of Compliance shall be submitted for following items showing conformance with the referenced standards contained in this section.

Unit Cabinet
Fans
Drain Pans
Insulation
Plenums
Multizone AHU
Blow-Through AHU
Spare Parts

F. Operation and Maintenance Manuals: Contractor shall submit Operation and Maintenance Manuals prior to testing the Air Handling Units. Data shall be updated and resubmitted for final approval no later than 30 days prior to contract completion.

PART 2 - PRODUCTS

2.1 AIR HANDLING UNIT (AHU)

A. Air handling unit (AHU) shall be central-station type, factory fabricated, and sectionally assembled. AHU shall include components and auxiliaries in accordance with ARI 430.

B. Total static pressure and coil face area classification shall conform to AMCA 99.

C. Fans with enlarged outlets shall not be permitted.

D. AHU fan shall be double-width, double-inlet, centrifugal scroll type.

2.2 UNIT CABINET

A. AHU cabinet shall be suitable for pressure class shown and shall have leaktight joints, closures, penetrations, and access provisions. Cabinet shall not expand or contract perceptibly during starting and stopping of fans and shall not pulsate during operation. Cabinet surfaces with deflections in excess of 0.004167 of unsupported span shall be reinforced prior to acceptance. Pulsating panels, which produce low frequency noise due to diaphragming of unstable panel walls, shall be stiffened to raise natural frequency to an easily attenuated level. Enclosure shall be fabricated from mill-galvanized or primed and painted carbon steel sheet of required thickness. Mill-galvanized sheet metal shall conform to ASTM A 527/A 527M and shall be coated with not less than 1.25 ounces of zinc per square foot of two-sided surface. Mill-rolled structural steel shall be hot-dip galvanized or primed and painted. Cut edges, burns, and scratches in galvanized surfaces shall be corrosion protected. Primed and painted black carbon steel cabinet construction shall comply with this specification.

B. AHU cabinet shall be suitable for pressure class indicated and shall have leaktight joints, closures, penetrations, and access provisions. Cabinet shall not expand or contract perceptibly during starting and stopping of fans and shall not pulsate during operation. Cabinet surfaces with deflections in excess of 0.002778 of unsupported span shall be reinforced prior to acceptance by the Contracting Officer. Pulsating panels, which produce low frequency noise due to diaphragming of unstable panel walls, shall be stiffened to raise natural frequency to an easily attenuated level. Enclosure shall be fabricated from mill-galvanized or primed and painted carbon steel sheet of required thickness. Mill-galvanized sheet metal shall conform to ASTM A 527 and shall be coated with not less than 1.25 ounces of zinc per square foot of two-sided surface. Mill-rolled structural steel shall be hot-dip galvanized or primed and painted. Cut edges, burns, and scratches in galvanized surfaces shall be corrosion protected. Primed and painted black carbon steel cabinet construction shall comply with this specification.

C. Where cabinet size is such that personnel access is possible, cabinet floor shall be strengthened to permit entry without damage to any component. Access doors and panels shall be hinged and latched at a spacing sufficiently close to preclude leaks caused by distortion, and shall be effectively gasketed.

D. Black carbon steel cabinet construction shall be acceptable when the following conditions are met:

1. All interior and exterior surfaces, including lapped contacting surfaces, shall be coated with a corrosion-protective coating.

2. Coating shall be certified as passing a 500-hour exposure salt-spray fog test in accordance with ASTM B 117.

3. Immediately after completion of the test, the specimen shall show no signs of wrinkling, cracking or loss of adherence, and no signs of rust creepage beyond 1/8 inch on either side of the scratch mark.

4. After 11 months of service and prior to expiration of guarantee, cabinet shall pass inspection of interior and exterior surfaces for the same defects as the salt-spray fog test specimen.

E. Interior surfaces of cabinets constructed of intact mill-galvanized steel shall require no further protection.

F. Exterior surfaces of cabinets constructed of mill-galvanized steel shall be left unpainted.

2.3 FAN

A. Overall fan-section depth shall be equal to or greater than the manufacturer's free-standing fan.

B. Location of fan inlet shall provide not less than one-half fan-wheel diameter clearance from cabinet wall or adjacent fan inlet where double wheels are permitted.

C. AHU fan drive shall be mounted external to casing.

D. AHU fan motor and drive shall be installed inside fan cabinet. Motor shall be installed on an adjustable base. An access door of adequate size for servicing motor and drive shall be provided. A belt guard shall be provided inside the cabinet, or the access door shall be interlocked with the supply fan so that power to the fan will be interrupted when the access door is opened.

2.4 DRAIN PANS

A. Intermediate-coil, 3-inch deep drip pans shall be provided for each tiered coil bank.

B. Top pan shall extend 12 inches beyond face of coil, and bottom pan shall extend not less than 24 inches beyond face of coil. Where more than two pans are used, pan extension shall be proportional. Adequate supports shall be made from the same type material as pans or hot-dip galvanized angle iron with isolation at interface. Pan material shall be 22-gage AISI Type 304 corrosion-resistant steel with silver-soldered joints. Minimum side of drain opening shall be 1-1/4 inches. Pan shall be piped to drain.

C. Integral cabinet drain pan shall extend under all areas where condensate must be collected and shall be watertight with welded or brazed joints, piped to drain, corrosion protected in condensate collection area, and insulated against sweating. Sheet metal shall be minimum 14-gage, except that 16-gage double-drain-pan construction shall be acceptable.

D. Cooling coil ends shall be enclosed by cabinet and shall be factory insulated against sweating or shall drain to drain pan.

2.5 INSULATION: Unit shall be internally fitted at the factory with a sound-attenuating, thermal-insulating, fibrous-glass material not less than 1 inch thick and shall have a surface deeply impregnated with chloroprene. Insulation effectiveness shall preclude condensation on any exterior cabinet surface under conditions normal to the unit's installed location. Acoustic treatment shall attenuate fan noise in compliance with specified noise criteria. Material shall be applied to the cabinet with adhesive on 100-percent coverage basis. Adhesive and insulating material shall be in accordance with NFPA 90A.

PART 3 - EXECUTION

3.1 AHU EQUIPMENT INSTALLATION: Equipment shall be installed in accordance with manufacturer's recommendations.

3.2 AHU TESTING: AHU and components shall be performance tested and rated in accordance with AMCA 211 and ASHRAE 51. AHU ratings shall be in accordance with ARI 430.

END OF SECTION

SECTION 15870

VANE AXIAL FANS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN NATIONAL STANDARDS (ANSI)

ANSI A58.1	(1982) Minimum Design Loads for Buildings and Other Structures

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 527	(1990) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality

AMERICAN SOCIETY OF HEATING, REFRIGERATING, AND AIR CONDITIONING ENGINEERS, INC. (ASHRAE)

ASHRAE-02	(1992) HVAC Systems and Equipment (IP Edition)

FEDERAL SPECIFICATIONS (FS)

FS QQ-A-250	(Rev F) Aluminum and Aluminum Alloy Plate and Sheet

1.2 SUBMITTALS The following shall be submitted in accordance with Section 01300 "Submittals," in sufficient detail to show full compliance with the specification:

A. Data

1. Equipment and Performance Data shall be submitted for vane axial fan.

2. Manufacturer's Catalog Data shall be submitted for the following items:

Housings
Fans
Motors
Bases
Roof Curbs
Dampers
Bird Screens
Sound Baffles
Spare Parts

B. Drawings

1. Installation Drawings shall be submitted for Power Roof Ventilator in accordance with the paragraph entitled, "Installation," of this section.

2. As-Built Drawings shall be submitted for Power Roof Ventilators providing current factual information such as deviations from, and amendments to, the drawings and concealed and visible changes in the work.

C. Reports: Test Reports shall be submitted for System Operational Tests in accordance with the paragraph entitled, "Tests," of this section.

1.3 GENERAL REQUIREMENTS: Section 15003, "General Mechanical Provisions," applies to work specified in this section.

1.4 QUALITY ASSURANCE: Ventilators shall be rated and labeled in accordance with the applicable standards of the Air Movement Control Association, and shall be licensed to bear the AMCA seal for both air and sound.

PART 2 - PRODUCTS

2.1 DIRECT DRIVE CONTROLLABLE PITCH VANE AXIAL FAN:

A. Fans shall be types and capacities shown on the drawings.

B. Fan housing shall be hot rolled steel conforming to ASTM A 283 with a minimum 3/8" thickness with 1/2" end flanges. End flanges shall be continuously welded around the entire periphery of fan housing and shall be provided with bolt holes for bolting to inlet bell, cones, companion flanges, and ducts. Housing shall be continuously welded and shall be expanded by mechanical means to ensure concentricity. Housing shall be shotblasted or sandblasted to ensure good pain adherence inside and outside. Not less than 8 stationary guide vanes of 3/16" thickness shall be welded inside the fan housing . The motor support plate shall be 3/4" plate steel and welded to fan housing by means of motor support ring and vanes. Motor support ring shall be not less than 1/3" on hub sizes 17" and under and not less than 3/8" on hub sizes 21" and larger. Support ring shall be continuously welded to motor support blade. On 2-stage fans a second straightening van section shall be provided downstream of the second stage impeller, and shall be of identical construction to the vane section contained within the main fan housing, including number of straightening vanes, matching material thickness and mating flanges. This vane section shall be removable for access to the second stage impeller.

C. Each fan rotor hub and blades shall be of cast aluminum construction. Hub shall be cast of No. 356-T6 aluminum alloy, heat-treated, and blades shall be cast of No. 356 aluminum alloy. Fan blades shall be airfoil shaped for maximum efficiency and shall vary in twist and width from hub to tip to obtain equal air distribution along with blade length. Blade tip clearance to fan housing shall not exceed 0.050" for fan diameters to 36" and 0.100 for fan diameters to 60". Blades shall be fabricated to an average surface smoothness of 100 microinches.

D. Fan blades shall be automatically controlled through the design pitch range to vary volume and pressure characteristics across this range. Variable pitch settings shall be capable of stepless control across the complete range with a minimum of hysteresis while the motor is operating at design speed. The blades in the controllable pitch hub shall have individual holding bearings designed to eliminate the need for periodic relubrication and shall be remote controlled by an electric actuator furnished by the fan manufacturer.

E. Controllable pitch fan blade setting angles shall be controlled through an actuator bar connected to an external electric actuator furnished, installed and tested by the fan manufacturer. Field supplied and mounted actuators are not acceptable. Fan blades shall be automatically controlled through the design pitch range to vary volume and pressure characteristics across the entire range. Blade pitch settings shall be capable of stepless control across the complete range of performance settings while the motor is running at design speed. For lubrication the de-spin bearing shall have grease fittings extended to the outside of the fan housing. Grease to be used shall be no offgasing type similar to Braycoat No. 601. The entire controllable pitch mechanism is to be serviceable from the fan inlet. Periodic overhaul or routine maintenance shall not require disassembly of the controllable pitch rotor (blades and hub) assemblies. The controllable pitch actuator shall be mounted external to the fan housing for accessibility and service. To avoid the possibility of hysteresis and to ensure a precise blade pitch angle setting for any given control signal pressure, regardless of the direction of travel, the electric actuators shall be gear driven in both directions. Actuators having a spring return or actuators depending upon aerodynamic or rotational forces on the blades for return are not acceptable. Electric actuators shall control the blades over the entire pitch range using a 4 to 20 milliamp signal, unless otherwise specified. Fan actuators shall be Barber Coleman Series MP9000 with electric actuator drive Series 9810, or equal. On 2-stage fans, one actuator shall drive both stages simultaneously to assure exact tracking and optimum performance.

F. Fans shall be direct motor driven as indicated on the drawings and as follows:

1. Direct drive fans shall be arrangement No. 4 with motor inside the fan housing and fan rotor assembly attached directly to motor shaft, properly keyed and secured by means of a ball bearing lock nut an washer for a positive locking method of securing rotor to fan shaft.

2. The fan rotor shall be whirl tested to 125 percent of operating speed and shall be statically and dynamically balanced on fan motor shaft.

3. Motor shall be equipped with ball bearings, AFBMA, rated with a minimum of 20,000 hour, B-10 target lift, with Class "F" insulation using thermo setting, non-hygroscopic insulating varnish to allow operation in a 40 degree C. ambient. External copper grease leads for lubrication of motor bearing shall be provided. Grease shall be non-offgasing similar to Braycoat No. 601. Motor shall be capable of operating at the voltages indicated on the drawings.

4. Fan motors shall be NEMA standard, totally enclosed air over (TEAO), "C" face, flange mounted, squirrel cage induction, single speed, single winding, continuous duty variable torque, and suitable for operation in vertical or horizontal or angular positions. Motors shall be Reliance Premium-Efficiency type or equal. The motor "C" face shall be positively held in a counter-bored fit in the motor support plate to preclude any shear effect on the bolts.

5. A conduit box shall be mounted on the exterior of fan casing and lead wires from the motor conduit box shall be protected from the airstream by being encased in an airtight metal conduit pipe.

G. All fans shall be coarse balanced at the factory to 0.50 mil peak-to-peak. The fans shall be loaded with design static pressure and tested for compliance from minimum blade angle to maximum design blade angle. Readings shall be taken at both fan inlet and fan outlet planes.

H. All fan motors shall be precision balanced to 0.20 mil peak-to-peak.

I. At final installation all fans shall be balanced in the field as directed by the manufacturer to a final balance of 0.30 mil peak-to-peak.

J. All vane axial fans shall be provided with supports for horizontal mounting where indicated. Horizontal fan supports shall be provided by the fan manufacturer and shall be bolted to the inlet and discharge flanges of the fan. Supports shall be cross-braced to prevent misalignment and add structural rigidity. Supports shall be constructed of 3/8" thick carbon steel plates.

K. Fan isolation bases shall be designed and provided by the fan manufacturer to achieve design vibration criteria. isolation bases shall provide equal distribution of weight to each load point to equalize static loading.

L. Provide published performance curves, based on tests complying with AMCA standard 210-85. Curves shall be drawn in accordance with AMCA Standard 210, paragraph 10.2.1.

M. Provide the following accessories, as indicated:

1. Steel inlet bells and screens.
2. Outlet cones or duct diffusers/silencers.
3. Outlet dampers for parallel operation.
4. Companion flanges, as necessary.

N. Comply with manufacturer's recommendations for field storage and start-up.

O. Furnish published sound power level data based on actual test data on fans sizes required for the project, in accordance with AMCA standards. Data shall define ducted sound power levels (PWL) re 10-12 watts, for each of the 8 octave bands. Estimated data is not acceptable. The systems acoustical design shall be based on specified diameter and sizes of fans. Fan sound power levels shall not exceed those listed below. If data submitted exceeds specified level, provide the services of an acoustical consultant, approved by the Construction Manager, to recommend necessary noise reduction devices to provide sound power within specified levels. The design and implementation of devices to meet this criteria shall be provided without additional cost to the Institute.

Octave Bands	1	2	3	4	5	6	7	8
db re 10^{-12} watts								

PART 3 - EXECUTION

3.1 INSTALLATION: Vane axial fans shall be installed in accordance with manufacturer's installation instructions. Installation of fans shall be properly coordinated with other work. Anchors, attachments, and other items to be built shall be coordinated for installation as the work progresses. Fans shall be rigidly installed in a weathertight and watertight manner and shall be free from vibration. Refer to Section 15245, "Vibration Isolation for Air Conditioning Equipment," for vibration isolation considerations.

3.2 TESTS: After installation, each vane axial fan shall be tested to demonstrate proper operation at indicated and specified performance requirements including running, balance, noise, and proper direction of fan rotation.

A. Performance Test:

1. The volume pressure characteristic of each fan shall be determined by taking 24 readings of static pressure and 24 readings of velocity pressure at 8 throttle settings from free flow (unrestricted outlet) to shutoff (full restricted outlet or zero flow conditions).

2. In addition to pitot tube traverse readings. the voltage amperage, input power, fan speed, barometric pressure, air inlet and duct temperatures shall be recorded.

3. The recorded data shall be used to calculate the fan characteristics using the methods outlined in AMCA 210. The results shall be calculated for an air density of 0.07 pounds per cubic foot. The results shall be plotted to provide a curve showing the fan characteristics from fee flow to shutoff conditions.

B. Acoustic Testing:

1. Each fan shall be tested in an AMCA rated laboratory. Testing shall be in accordance with AMCA 300 reverberant room method and shall provide sound levels at each of eight frequencies across the spectrum.

END OF SECTION

SECTION 15887

FILTERS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN SOCIETY OF HEATING, REFRIGERATING, AND AIR CONDITIONING ENGINEERS, INC. (ASHRAE)

ASHRAE 52	(1976) Method of Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 526	(1990) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Commercial Quality
ASTM A 527	(1990) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality
ASTM D 92	(1990) Standard Test Method for Flash and Fire Points by Cleveland Open Cup
ASTM E 84	(1991a) Standard Test Method for Surface Burning Characteristics of Building Materials

FEDERAL STANDARDS (FED-STD)

FED-STD 209	(Rev C) Clean Room and Work Station Requirements, Controlled Environment

MILITARY STANDARDS (MIL-STD)

MIL-STD 282	(Notice 3) Filter Units, Protective Clothing, Gas-Mask Components, and Related Products:Performance-Test Methods

MILITARY SPECIFICATIONS (MS)

MS MIL-F-29177	(Rev A) Filter, Air-Extended Area, Initial Installation
MS MIL-F-51079	(Rev D; Int Am 1) Filter Medium, Fire-Resistant, High-Efficiency

NATIONAL INSTITUTE FOR STANDARDS AND TECHNOLOGY (NIST)

NIST PS 1	(1983) Construction and Industrial Plywood

UNDERWRITERS LABORATORIES (UL)

UL 586	(1990; 7th Ed) UL Standard for Safety High-Efficiency Particulate, Air Filter Units
UL 723	(1983; 6th Ed., April 28, 1987) UL Standard for Safety Test for Surface Burning Characteristics of Building Materials
UL 900	(1987; Rev 1988) Test Performance of Air Filter Units

1.2 SUBMITTALS; The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data

1. Equipment and Performance Data shall be submitted for Air Filters consisting of use life, system functional flows, safety features, and mechanical automated details. Curves indicating tested and certified equipment responses and performance characteristics shall also be submitted.

2. Manufacturer's Catalog Data shall be submitted for the following items:

Air Filters
Filter Gages
Manometers
Spare Parts

B. Drawings: Installation Drawings shall be submitted for the following items in accordance with the paragraph entitled, "Installations," of this section.

C. Reports: Test Reports shall be submitted for Air Filters in accordance with ASHRAE 52.

D. Certificates of Compliance shall be submitted for the following items showing conformance with the reference standards contained in this section.

Air Filters
Filter Gages
Manometers
Spare Parts

1.3 GENERAL REQUIREMENTS: Section 15003, "General Mechanical Provisions," applies to work specified in this section.

PART 2 - PRODUCTS

2.1 FILTERS:

A. General:

1. Filters shall have a net effective filtering area and a face area to provide the required airflow at the indicated initial pressure-drop.

2. Filter assembly shall be suitable for space provided with sufficient clearance for maintenance and operation.

3. Filter-holding frames shall be constructed of extruded aluminum. All frame assemblies and fasteners shall be corrosion-resistant metal or carbon steel with a corrosion-resistant finish to preclude surface degradation.

4. Viscous-impingement framed panel filter gaskets shall be made from a material inert to filter impregnants. Minimum thickness after compression shall be 1/8 inch.

5. Dry filter gaskets shall be closed-cell foamed neoprene or urethane elastomer of sufficient hardness to compress to not more than 40 percent of original thickness when filter is in position.

B. Filters, Disposable Type

1. Minimum acceptable performance for the air filter shall be as listed below:

DIMENSIONS (INCHES)	INITIAL RESISTANCE (INCH WG)	ARRESTANCE (PERCENT)	DUST-HOLDING CAPACITY (GM/SQ FT)
14 by 20 by 1	0.04	65	145
16 by 20 by 1	0.04	65	145
16 by 25 by 1	0.04	65	145
20 by 20 by 1	0.04	65	145
20 by 25 by 1	0.04	65	145
16 by 20 by 2	0.08	75	190
16 by 25 by 2	0.08	75	190
20 by 20 by 2	0.08	75	190
20 by 25 by 2	0.08	75	190

2. For all sizes of filters, final resistance value shall be 0.50 inch, air volume shall be 1,200 cubic feet per minute, and airflow velocity shall be 300 feet per minute.

C. Filters, Replaceable Type

1. Filters shall conform to MS MIL-F-29177, Type I or Type II. Filter efficiency shall be based on ASHRAE 52. Efficiency, by definition, is dust-spot efficiency using atmospheric dust. Arrestance is weight efficiency using test dust. Type III filter arrestance efficiencies shall be in accordance with MIL-STD 282 DOP test.

2. Each air filter shall consist of a permanent corrosion-resistant holding frame and a replaceable factory-assembled filter element. Permanent holding frame shall be supplied with suitable gaskets and shall be designed to maintain a positive pressure seal between the frame and the filter element(s).

3. Air filters shall be designed and constructed to facilitate field maintenance. Adjustments and replaceable accessories shall be readily accessible. Conditions which may be hazardous to personnel or deleterious to equipment shall not be permitted.

4. Filter element shall be nonallergenic and nontoxic, with no detectable odor. Filter element shall have no adverse effect on the health of personnel handling or served by the filter element.

5. Adhesive coatings used on filters shall have a flashpoint of not less than 325 degrees F and shall conform to ASTM D 92.

6. Filters shall be Type 1, Grade A, 30 percent commercially rated efficiency, and shall conform to UL 900, Class 2, and requirements specified herein. Filter initial efficiency shall be not less than 20 percent, and the average efficiency shall be not less than 25 percent. Dust-holding capacity (grams per square foot), at a rated air flow (cubic feet per minute) shall be not less than 600 at 1,500 respectively.

7. Filter shall be Type I, Grade B, 40 percent commercially rated efficiency, and shall conform to UL 900, Class 2, and requirements specified herein. Filter initial efficiency shall be not less than 20 percent, and the average efficiency shall be not less than 35 percent. Dust-holding capacity (grams per square foot), at a rated air flow (cubic feet per minute) shall be not less than 500 at 1,500 respectively.

8. Filter shall be Type II, Grade C, 85 percent commercially rated efficiency minimum of 58 percent per ASHRAE 52 using atmospheric dust, and shall conform to UL 900, Class 2 and requirements specified herein. Filter initial efficiency shall be not less than 58 percent, and the average efficiency shall be not less than 76 percent. Dust-holding capacity (grams per square foot), at a rated air flow (cubic feet per minute) shall be not less than 300 at 1,500 respectively.

9. Filter shall be Type II, Grade D, 95 percent commercially rated efficiency minimum of 78 percent per ASHRAE 52 using atmospheric dust, and shall conform to UL 900, Class 2 and requirements specified herein. Filter initial efficiency shall be not less than 80 percent, and the average efficiency shall be not less than 90 percent. Dust-holding capacity (grams per square foot), at a rated air flow (cubic feet per minute) shall be not less than 220 at 1,500 respectively.

10. Filters shall be Type III, Grade E, 95 percent rated efficiency DOP test using 0.2-micrometer particles, and shall conform to UL 900, Class 2 Class 1 and requirements specified herein. Filter initial pressure drop shall not exceed 0.75 inch wg with face velocity of 500 fpm on 12-inch-deep filter and final pressure drop shall not exceed 1.5 inches wg with face velocity of 510 fpm on 12-inch deep filter. Filter efficiency shall be not less than 95 percent and shall be determined in accordance with MIL-STD 282, using 0.3-micrometer particle of thermally generated DOP smoke.

D. Filters, High-Efficiency Particulate Air (HEPA)

1. HEPA filters shall be fire-resistant type and shall be capable of withstanding a minimum of 90-percent relative humidity determined dynamically at temperatures between 70 and 100 degrees F.

2. Filtering element shall conform to MS MIL-F-51079.Filter shall be individually certified to have an efficiency of not less than 99.97 percent. However, the certification shall not be earned by the DOP test specified in FED-STD 209. An acceptable method for certification is to remove a filter from a production run prior to testing, then test the five filters before and after the removed filter in accordance with the DOP test (99.97 percent). Successful passing of the test by the five filters before and five filters after the untested filter shall be the acceptance criteria for the untested filter. Clean filter static pressure drop shall not exceed 1.0 inch wg when the filter is tested at rated capacity.

3. Filtering element shall contain no holes, cracks, slits, or other visual imperfections. Every splice required in the assembly of a filter pack shall be joined with not less than 1-1/2 inches of fire-retardant adhesive for a continuous coating along the entire width of the element. Filter element shall be glass paper with a minimum tensile strength of 3 pounds per inch of width and shall retain 50 percent of its tensile strength when folded flat upon itself. Elongation before rupture shall be a minimum of 1 percent. Element shall be water-proofed and shall retain 50 percent of its original tensile strength after being immersed in water.

4. Results of test penetration, test resistance, test flow rate, together with direction of test airflow, manufacturer's name, model number, and serial number of the filter unit, shall be registered legibly and indelibly on the frame of the filter unit.

5. Frames shall be 3/4-inch plywood, Grade A-B EXT-DFPA or better, conforming to NIST PS 1. Plywood shall be treated to exhibit a flame-spread of not more than 30 when tested according to UL 723 or ASTM E 84. Flathead wood screws shall be countersunk after drilling lead holes. Corner joints shall have positive seal by coating adjoining surfaces with a suitable adhesive having the characteristics specified below. Particle board conforming to the flame-spread requirements specified for plywood may be used in lieu of plywood.

6. Inside face of frame members of materials shall be coated entirely with an adhesive before assembly with filter pack. Following assembly, a continuous bead of the same adhesive shall be formed to seal between cut edges of filter pack and edges of abutting frame member on both faces of the filter unit. Filter unit shall be square to a diagonal tolerance of 1/8 inch.

7. Adhesive, when cured, shall be resilient and water-resistant and shall withstand a temperature of 250 degrees F for 8 hours. If capable of ignition, the adhesive shall be self-extinguishing and shall meet general operating conditions without change in physical properties and without loss of seal. Cured adhesive shall contain no cracks, checks, alligatoring, or separation.

8. HEPA filters shall be in accordance with UL 586.

9. Separators shall be constructed of aluminum that will not contribute to fire, will remain structurally intact under fire exposure, and will not be damaged by exposure to the humidity and temperature.

10. Gasket shall be 1/4-inch thick closed cellular construction neoprene or approved elastomer of 20 to 40 Shore A durometer hardness. Gasketing shall be attached firmly and continuously to the frame with rubber-based adhesive.

11. Filter unit shall be assembled to provide uniformity of materials and construction, surface smoothness and finish, cleanliness, and freedom from protrusions and obvious flaws.

2.2 FILTER GAGES AND MANOMETERS

A. Air-filter gages or manometers shall be provided for each type filter assembly.

B. Gages shall be the dial-indicator type, graduated to read 0 to 2 inches wg, except that gages for HEPA filters shall read 0 to 3 inches wg. Manometers shall measure from minus 0.5 to 3 inches wg and be equipped with a built-in indicator bubble. Gage or manometer shall be connected to static-pressure ports of approved design and located so that resistance to airflow will be correctly indicated.

PART 3 - EXECUTION

3.1 FILTER INSTALLATION: Filter supports and retention elements shall be coordinated to provide a substantial, structurally sound, leakproof installation.

3.2 HOLDING FRAME INSTALLATION: Holding frames shall be gasketed on perimeter, or calked to each other, to supplementary steel, or to closures with elastomeric compounds recommended by the filter manufacturer. Substrate shall be prepared in accordance with theelastomer manufacturer's instructions, including the priming of surfaces in areas where the elastomer is not confined.

END OF SECTION

SECTION 15895

LOW PRESSURE DUCTWORK

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 123	(1989a; E1) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 36	(1991) Standard Specification for Structural Steel
ASTM A 527	(1990) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality
ASTM F 1137	(1988) Standard Specification for Phosphate/Oil and Phosphate/Organic Corrosion Protective Coatings for Fasteners

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC S328	(1986) Specification for Structural Steel Buildings Load and Resistance Factor Design

AMERICAN SOCIETY OF HEATING, REFRIGERATING, AND AIR CONDITIONING ENGINEERS, INC. (ASHRAE)

ASHRAE-01	(1993) Handbook, HVAC Applications (IP Edition)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(1993) Standard for the Installation of Air Conditioning and Ventilating Systems

SHEET METAL AND AIR CONDITIONING CONTRACTORS NATIONAL ASSOCIATION, INC. (SMACNA)

SMACNA-06	(1985; 1st Ed) HVAC Duct Construction Standards - Metal and Flexible

UNDERWRITERS LABORATORIES (UL)

UL 181	(1990; 7th Ed) UL Standards for Safety Factory-Made Air Ducts and Air Connectors
UL 555	(1990; 4th Ed) Ul Standard for Safety Fire Dampers

1.2 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data

1. Design Analysis and Calculations shall be submitted for Low Pressure Ductwork Systems indicating the manufacturer's recommended air velocities, maximum static pressures, temperature calculations and acoustic levels.

2. Manufacturer's Catalog Data shall be submitted for the following items:

Galvanized Steel Ductwork Materials
Flexible Ductwork Materials
Dampers
Flexible Connecters
Wall Collars

B. Drawings

1. Connection Diagrams shall be submitted for Low Pressure Ductwork Systems indicating the relation and connection of devices and apparatus by showing the general physical layout of all controls, the interconnection of one system (or portion of system) with another, and internal tubing, wiring, and other devices.

2. Fabrication Drawings shall be submitted for Low Pressure Ductwork Systems consisting of fabrication and assembly details to be performed in the factory.Drawings shall show details of equipment room layout and design.

3. Installation Drawings shall be submitted for Low Pressure Ductwork Systems in accordance with the manufacturer's recommended instructions.

4. As-Built Drawings shall provide current factual information including deviations from, and amendments to the drawings and concealed or visible changes in the work, for Low Pressure Ductwork Systems.

C. Schedules: Material, Equipment, and Fixture Lists shall include the manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

D. Reports: Test Reports shall be submitted for low pressure ductwork systems on the following tests in accordance with the paragraph entitled, "Ductwork Leakage Tests" and "Fire Damper Tests," of this section.

Operational Tests
Leakage Tests

E. Samples: Manufacturer's Standard Color Chart shall indicate the manufacturer's standard color selections and finishes for Low Pressure Ductwork.

F. Records: Records of Existing Conditions shall be submitted consisting of the results of Contractor's survey of work area conditions and features of existing structures and facilities within and adjacent to the jobsite.Commencement of work shall constitute acceptance of existing conditions.

G. Operation and Maintenance Manuals

1. Operation and maintenance manuals shall be consistent with manufacturer's standard brochures, schematics, printed instructions, general operating procedures and safety precautions.

2. Operation and maintenance manuals shall be provided for:

Power Operated Dampers
Fire Dampers and Wall Collars

1.3 PERFORMANCE REQUIREMENTS: Section 15003, "General Mechanical Provisions," applies to work specified in this section. Section 15245, "Vibration Isolation for Air Conditioning Equipment," applies to work in this section.

1.4 DESIGN REQUIREMENTS: Low-pressure systems shall encompass ductwork and plenums where maximum air velocity is 2,000 feet per minute (fpm) and maximum static pressure is 2 inches water gage (wg), positive or negative.

PART 2 - PRODUCTS

2.1 GALVANIZED STEEL DUCTWORK MATERIALS: Galvanized steel ductwork sheet metal shall be carbon steel, of lock-forming quality, hot-dip galvanized, with regular spangle-type zinc coating, conforming to ASTM A 527, G90. Duct surfaces to be painted shall be treated by phosphatizing. Sheet metal gages and reinforcement thickness shall conform to SMACNA-06.

A. Duct Hangers in contact with galvanized duct surfaces shall be galvanized steel painted with inorganic zinc.

B. Mill-Rolled Reinforcing and Supporting Materials

1. Mill-rolled structural steel shall conform to ASTM A 36 and, whenever in contact with sheet metal ducting, shall be galvanized in accordance with ASTM A 123.

2. Equivalent strength, proprietary-design, rolled-steel structural support systems may be submitted for approval in lieu of mill-rolled structural steel.

2.2 FLEXIBLE DUCT MATERIALS

A. Flexible duct connectors shall be in accordance with UL 181, Class 1 material and shall comply with NFPA 90A.

B. Metal duct shall be bendable through 180 degrees without damage, with an inside bend radius not greater than one-half the diameter of duct. Metal shall be carbon steel zinc-coated ASTM A 123.

C. Wire-reinforced cloth duct shall consist of a [chloroprene] [vinyl-impregnated and coated] fibrous-glass cloth bonded to and supported by a corrosion-protected spring steel helix. Fabric may be a laminate of metallic film and fibrous glass. Working pressure rating of ducting shall be not less than three times maximum system pressure, and temperature range shall be minus 20 to plus 175 degrees F.

D. Wire-reinforced fibrous-glass duct shall consist of a minimum 1 pound density fibrous glass bonded to and supported by corrosion-protected spring helix. Vapor barrier shall be a 4 mil minimum, pigmented polyvinylchloride film. Duct shall be bendable without damage through 180 degrees with an inside bend radius not greater than two duct diameters. Minimum wall thickness shall be 1 inch. Thermal conductivity shall be not greater than 0.23 Btu per hour per square foot per degrees F at 75 degrees F mean. Permeance shall be not greater than 0.10 perm. Working pressure range shall be from minus 1/2 -inch wg to plus 1-1/2 inches wg. Working temperature shall range from minus 20 to plus 250 degrees F. Minimum sustained velocity without delamination shall be 2,400 fpm. Materials shall conform to NFPA 90A.

2.3 MANUAL VOLUME DAMPERS

A. Volume damper construction shall conform to SMACNA-06.

B. Dampers shall be equipped with an indicating quadrant regulator with a locking feature externally located and easily accessible for adjustment. Where damper rod lengths exceed 30 inches , a regulator shall be provided at each end of damper shaft.

C. All damper shafts shall have two-end bearings.

D. Splitter damper shall be 22-gage sheet metal 2 gages heavier than duct in which installed.Hinges shall be [full length piano-type] [1/8-inch thick door type].

E. Damper shaft shall be full length and shall extend beyond damper blade. A 3/8-inch square shaft shall be used for damper lengths up to 20 inches and a 1/2-inch square shaft shall be used for damper lengths 20 inches and larger. Where necessary to prevent damper vibration or slippage, adjustable support rods with locking provisions external to duct shall be provided at damper blade end.

F. Dampers in ducts having a width perpendicular to the axis of the damper that is greater than 12 inches shall be multiblade type having a substantial frame with blades fabricated of 16-gage metal. Blades shall not exceed 10 inches in width and 48 inches in length and shall be [pinned] [welded] to 1/2-inch diameter shafts. Dampers greater than 48 inches in width shall be made in two or more sections with intermediate mullions, each section being mechanically interlocked with the adjoining section or sections. Blades shall have [graphite-impregnated nylon] [oil-impregnated sintered bronze] bearings and shall be connected so that adjoining blades rotate in opposite directions.

2.4 GRAVITY BACKDRAFT AND RELIEF DAMPERS

A. Frame shall be constructed of not less than 1-1/2- by 4-inch reinforced 16-gage galvanized carbon steel. Frames and mullions shall be solidly secured in place and sealed with elastomer calking against air bypass.

B. Maximum blade width shall be 9 inches, and maximum blade length shall be 36 inches. Blade material shall be 16-gage galvanized steel, [6063] [5052] alloy aluminum] [18-gage AISI 18-8 corrosion-resistant steel]. Blades shall be provided with mechanically retained seals and 90-degree limit stops.

C. Dampers used for relief service shall have blades linked together to open not less than 30 degrees on 0.05-inch wg differential pressure.

D. Shaft bearings shall be [graphite-impregnated nylon] [oil-impregnated bronze].

E. Counterbalanced dampers shall be equipped with fixed or adjustable counterbalancing weights.

F. Gravity backdraft dampers in sizes 18 by 18 inches or smaller, when furnished integral with air moving equipment, may be equipment manufacturer's standard construction.

2.5 POWER-OPERATED DAMPERS: Dampers shall conform to applicable requirements specified under Section 15970, "Control Systems."

2.6 FLEXIBLE CONNECTORS FOR SHEET METAL: Connectors shall be UL-listed, 20-ounce, fire-retardant, airtight, woven fibrous-glass cloth impregnated with chloroprene. Clear width, not including clamping section, shall be 3 to 5 inches.

2.7 FIRE DAMPERS AND WALL COLLARS

A. Fire damper locations shall be in accordance with NFPA 90A.

B. Fire dampers in ductwork shall be provided at firewall barriers.

C. Fire dampers shall be constructed and labeled in accordance with UL 555 to provide damper and mounting fire-resistance that equals or exceeds fire-resistance of the construction in which installed. For link loads in excess of 20 pounds, UL-approved quartzoid links shall be provided.

D. Wall collars shall be constructed in accordance with UL 555.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Sheet metal construction shall be provided in accordance with the SMACNA-06 and NFPA 90A.

B. Construction methods for any other items that are not covered herein shall be in accordance with ASHRAE-01.

C. Supplementary steel shall be designed and fabricated in accordance with AISC S328.

D. Fabrication shall be airtight and shall include necessary reinforcements, bracing, supports, framing, gasketing, sealing, and fastening to provide rigid construction and freedom from vibration, airflow-induced motion, noise, and excessive deflection at specified maximum system air pressure.

E. Dampers located behind architectural intake or exhaust louvers shall be enclosed by a rigid sheet metal collar and sealed to building construction with elastomers for complete air tightness.

F. Outside air-intake ducts and plenums shall be sheet metal and shall have soldered watertight joints.

G. Offsets and transformations shall be provided as required to avoid interference with the building construction, piping, or equipment.

H. Wherever ducts pass through firewalls or through walls or floors dividing conditioned spaces from unconditioned spaces, a flanged segment shall be provided in that surface during surface construction.

I. Sheet metal surfaces to be painted or surfaces to which adhesives will be applied shall be clean and free of oil, grease, and deleterious substances.

J. Where interiors of ducting may be viewed through air diffusion devices, the viewed interior shall be sheet metal and shall be painted flat black.

K. Duct strength shall be adequate to prevent failure under pressure or vacuum created by fast closure of ductwork devices. Leaktight automatic relief devices shall be provided.

L. Plenum anchorage provisions, sheet metal joints, and other areas shall be made airtight and watertight by calking mating galvanized steel and concrete surfaces with a two-component elastomer.

3.2 RECTANGULAR SHEET METAL DUCTS

A. Angle iron frames shall be welded at corners and ends, whenever possible. Angle iron reinforcements shall be riveted or welded to ducts not more than 6 inches on center, with not less than two points of attachment. Spot welding, where used, shall be 3 inches on center.

B. Standard seam joints shall be sealed with an elastomer compound.

C. Crossbreaking shall be limited to 4 feet and shall be provided on all ducts 8 inches wide and wider. Bead reinforcement shall be provided in lieu of crossbreaking where panel popping may occur. Where rigid insulation will be applied, crossbreaking is not required.

D. Longitudinal Duct Seams: For duct sizes through 12 inches, corner seams shall be button-punch snap lock. For duct sizes 13 inches and larger corner locks shall be used.

E. Joints and Gaskets: Companion angle flanges shall be bolted together with 1/4-inch diameter bolts and nuts spaced 6 inches on center. Flanged joints shall be gasketed with chloroprene full-face gaskets 1/8 inch thick, with Shore A 40 durometer hardness. Gaskets shall be one piece and [vulcanized] [dovetailed] at joints.

F. Flexible Duct Joints: Joints between flexible duct without sheet metal collars and round metal ductwork connections shall be made by trimming the ends, coating the inside of the flexible duct for a distance equal to depth of insertion with elastomer calk, and by securing with sheet metal screws or binding with a strap clamp.

G. Square Elbows: Single-vane duct turns shall be provided in accordance with SMACNA-03, and may be used on ducts 12 inches wide and narrower. Double-vane duct turns shall be provided in accordance with SMACNA-06.

H. Radius Elbows shall conform to SMACNA-06.Radius elbows shall have an inside radius equal to the width of the duct. Where installation conditions preclude use of standard elbows, the inside radius may be reduced to a minimum of 0.25 times duct width and turning vanes shall be installed in accordance with the following schedule.

WIDTH OF ELBOWS INCHES	RADIUS OF TURNING VANES IN PERCENT OF DUCT WIDTH VANE NO. 1	VANE NO. 2	VANE NO. 3
Up to 16	56	--	--
17 to 48	43	73	--

49 and over	37	55	83

Where two elbows are placed together in the same plane in ducts 30 inches wide and larger, the guide vanes shall be continuous through both elbows rather than spaced in accordance with above schedule.

I. Outlets, Inlets, and Duct Branches

1. Branches, inlets, and outlets shall be installed so that air turbulence will be reduced to a minimum and air volume properly apportioned. Adjustable splitter dampers shall be installed at all supply junctions to permit adjustment of the amount of air entering the branch. Wherever an air-diffusion device is shown as being installed on the side, top, or bottom of a duct, and whenever a branch takeoff is not of the splitter type, a commercially manufactured air extractor shall be provided to allow adjustment of the air quantity and to provide an even flow of air across the device or duct it services.

2. Where a duct branch is to handle more than 25 percent of the air handled by the duct main, a complete 90-degree increasing elbow shall be used with an inside radius of 0.75 times branch duct width. Size of the leading end of the increasing elbow within the main duct shall have the same ratio to the main duct size as the ratio of the related air quantities handled.

3. Where a duct branch is to handle 25 percent or less of the air handled by the duct main, the branch connection shall have an inside radius of 0.75 times duct branch width, a minimum arc length of 45 degrees, and an outside radius of 1.75 times duct branch width. Arc shall be tangent to duct main.

J. Duct Transitions

1. Where the shape of a duct changes, the angle of the side of the transition piece shall not exceed 15 degrees from the straight run of duct connected thereto.

2. Where equipment is installed in ductwork, the angle of the side of the transition piece from the straight run of duct connected thereto shall not exceed 15 degrees on the upstream side of the equipment and 22-1/2 degrees on the downstream side of the equipment.

K. Branch Connections: Radius tap-ins shall be constructed in accordance with SMACNA-06.

L. Access Openings

1. Access doors and panels shall be installed in ductwork upstream and downstream from coils] adjacent to fire dampers] [at controls or at any item requiring periodic inspection, adjustment, maintenance, or cleaning] [where indicated].

2. Minimum size of access opening shall be 12 by 18 inches, unless precluded by duct dimensions or otherwise indicated.

3. Access door construction shall be in accordance with SMACNA-06, except that sliding doors may be used only for special conditions upon prior approval. Insulated doors shall be double-panel type.

4. Access doors that leak shall be made airtight by adding or replacing hinges and latches or by construction of new doors adequately reinforced, hinged, and latched.

5. Duct access shall be particularly suitable for commercial duct cleaning methods utilizing vacuum devices. Access openings shall be spaced with a frequency and at points which will permit ready access to duct internals with essentially no duct or insulation cutting. Where access through an air-diffusion device or through access doors specified herein is not available at a specific point, 8-inch diameter, 16-gage access plates shall be provided not more than 10 feet on center. Where duct is insulated and vapor-sealed, mastic seals shall be provided around circumference of access. When access plate is in place and insulated, the location shall be externally identified.

M. Duct Supports

1. Selection of hanging system shall be at the Contractor's option. The following support sizes, configurations, and spacings are given to show the minimal type of supporting component required. Where installed loads are excessive for the specified hanger spacings, hangers, and accessories, [heavier-duty components shall be provided] [the hanger spacing may be reduced]. After system startup, any duct support device which, due to length, configuration, or size, vibrates or causes possible failure of a member or damage to ducting shall be replaced or the condition shall be alleviated.

2. Hanger rods, angles, and straps shall be attached to beam clamps. Concrete inserts and masonry anchors and fasteners shall be approved for the application.

3. Hardened high-carbon spring-steel fasteners fitted onto beams and miscellaneous structural steel are acceptable upon prior approval of each proposed application and upon field demonstration of conformance to specification requirements. Fasteners shall be made from steel conforming to AISI Type [C1055] [C1070], and shall be treated and finished in accordance with ASTM F 1137, zinc phosphate base. A 72-hour load-carrying capacity shall be verified by a certified independent laboratory. Hanger spacing shall be limited to provide 20-to-1 safety factor for supported load. Maximum weight supported by any two fasteners shall be 100 pounds. Friction rod assemblies are not acceptable.

4. Where support from metal deck systems is required, support requirements shall be coordinated with installation of metal deck.

5. Ductwork and equipment shall not be hung from roof deck, piping, or other ducts or equipment. Maximum span between any two points shall be 10 feet with lesser spans for duct assemblies, interferences, and loads imposed or permitted.

6. There shall be not less than one set of hangers for each point of support. Hangers shall be installed on both sides of all duct turns, branch fittings, and transitions.

7. Hangers shall be sufficiently cross-braced to eliminate vertical and lateral sway.

8. Rectangular ducts up to 36 inches shall be supported by strap hangers attached at not less than three places to not less than two duct surfaces in different planes.

9. Perforated strap hangers shall not be acceptable.

10. Rectangular ducting, 36 inches and larger, shall be supported by trapeze hangers. Ducts situated in unconditioned areas and required to have insulation with a vapor-sealed

facing shall be supported on trapeze hangers. Hangers shall be spaced far enough out from the side of the duct to permit the duct insulation to be placed on the duct inside of the trapeze. Under no circumstances shall duct hangers penetrate the vapor-sealed facing.

11. Where trapeze hangers are used, the bottom of the duct shall be supported on angles sized as follows:

WIDTH OF DUCT, INCHES	MINIMUM BOTTOM ANGLE SIZE, INCHES
30 and smaller	1-1/4 by 1-1/4 by 1/8
31 to 48	1-1/2 by 1-1/2 by 1/8
49 to 72	1-1/2 by 1-1/2 by 3/16
73 to 96	2 by 2 by 1/4
97 and larger	3 by 3 by 1/4

12. Where ductwork system contains heavy equipment, excluding air-diffusion devices and single-leaf dampers, such equipment shall be hung independently of the ductwork by means of rods or angles of sizes adequate to support the load.

13. Ducting supported from roof purlins shall be supported at points not greater than one-sixth of the purlin span from the roof truss. Load per hanger shall not exceed 400 pounds when support is from a single purlin or 800 pounds when hanger load is applied halfway between purlins by means of auxiliary support steel provided under this section. When support is not halfway between purlins, the allowable hanger load shall be the product of 400 times the inverse ratio of the longest distance to purlin-to-purlin spacing.

14. When the hanger load exceeds the above limits, reinforcing of purlin(s) or additional support beam(s) shall be provided. When an additional beam is used, the beam shall bear on the top chord of the roof trusses and bearing shall be over gusset plates of top chord. Beam shall be stabilized by connection to roof purlin along bottom flange.

15. Purlins used for supporting fire-protection sprinkler mains, electrical lighting fixtures, and electrical power duct or cable tray shall be considered fully loaded, and supplemental reinforcing or auxiliary support steel to support ductwork shall be provided for these purlins.

16. Duct supports shall be vibration isolated from the structure.

17. Vibration isolators shall be provided in discharge ducting system for a distance not less than 50 feet beyond the air handling unit.Deflection of duct and equipment mountings shall be coordinated.

18. Refer to Section 15245, "Vibration Isolation for Air Conditioning Equipment," for additional requirements.

3.3 PLENUM CONSTRUCTION

A. Intake and discharge plenum shall have companion angle joints with the following minimum thickness of materials:

LONGEST ANGLES	SHEET METAL	REINFORCEMENT

SIDE INCHES	USS GAGE ALL SIDES	COMPANION ANGLES INCHES	INCHES, 24 INCHES ON CENTER MAXIMUM
To 48	20	1-1/2 by 1-1/2 by 1/8	1-1/2 by 1-1/2 by 1/8
49 to 84	18	2 by 2 by 1/8	2 by 2 by 3/16
85 to 120	16	2 by 2 by 1/8	2 by 2 by 1/8
121 and larger	14	2 by 2 by 3/16	2 by 2 by 3/16

B. At the floor line and other points where plenums join masonry construction, panels shall be bolted 12 inches on center to 2- by 2- by 3/16 inch thick hot-dip galvanized steel angle that has been secured to the masonry with masonry anchors and bolts 24 inches on center and calked tight to the masonry.

C. Panels shall be anchored to curbing by not less than 2- by 2- by 3/16 inch thick hot-dip galvanized steel angle iron. Concrete curbing shall include angle iron nosing with welded studs for the anchoring of panels. Nosing shall be level at curb height within plus or minus 1/16 inch.

D. Plenum access doors shall be constructed in accordance with SMACNA-06 except that access doors smaller than man-access doors shall have door openings framed with angle iron that is one commercial size smaller than specified panel reinforcement.

E. Man-access door size shall be per SMACNA-06 and paragraph entitled, "Access Openings," of this section. Insulated and uninsulated construction shall be per SMACNA-06. Door openings shall be framed with channel iron. Doors shall be framed with angle iron. Channel iron and angle iron shall be approximately the same size as specified panel reinforcement. Exterior door skin shall be 16 gage. Latches shall be fabricated steel, hinges shall be at least 4 inches long, and bolting shall be at least 3/8-inch diameter.

F. Angle iron and channel iron shall have welded and ground miter corners.

3.4 MANUAL VOLUME DAMPERS

A. Balancing dampers of the splitter, butterfly, or multilouver type, shall be provided to balance each respective main and branch duct.

B. Dampers regulated through ceilings shall have regulator concealed in box mounted in the ceiling, with a cover finish aesthetically compatible with ceiling surface. Where ceiling is of removable construction, regulators shall be above ceiling, and location shall be marked on ceiling in a manner acceptable to the Construction Manger.

3.5 FLEXIBLE CONNECTORS FOR SHEET METAL

A. Air handling equipment, ducts crossing building expansion joints, and fan inlets and outlets shall be connected to upstream and downstream components by treated woven-cloth connectors.

B. Connectors shall be installed only after system fans are operative, and vibration isolation mountings have been adjusted. When system fans are operating, connectors shall be free of wrinkle caused by misalignment or fan reaction. Width of surface shall be curvilinear.

3.6 INSULATION PROTECTION ANGLES

A. Galvanized 20-gage sheet steel, formed into an angle with a 2-inch exposed long leg with a 3/8-inch stiffening break at outer edge, and with a variable concealed leg, depending upon insulation thickness shall be provided.

B. Angles shall be installed over insulation edges terminating by butting against a wall, floor foundation, frame, and similar construction. Angles shall be fastened in place with blind rivets through the protection angle, insulation, and sheet metal duct or plenum. Angles shall be installed after final insulation covering has been applied.

3.7. DUCT PROBE ACCESS: Holes shall be provided with neat patches, threaded plugs, or threaded or twist-on caps where indicated, and where necessary, for air-balancing pitot tube access. Extended-neck fittings shall be provided where probe access area is insulated.

3.8. OPENINGS IN ROOFS AND WALLS: Building openings are fixed and equipment shall be provided to suit. Contractor may propose to alter these openings upon prior approval, and at his expense. Openings indicated in outside walls and roof are approximate.

3.9 DUCTWORK CLEANING PROVISIONS: Open ducting shall be protected from construction dust and debris in a manner approved by the Construction Manger. Dirty assembled ducting shall be cleaned by subjecting main and branch interior surfaces to air streams moving at velocities two times the specified working velocities, at static pressures within maximum ratings. Ducting shall be cleaned by a method approved by the Construction Manger. Compressed air used for cleaning ducting shall be water- and oil-free. Prior to acceptance of the work, dust and debris shall be removed from exterior surfaces.

3.10 FIRE DAMPER TESTS: Operation tests shall be performed on each fire damper in the presence of the Construction Manger by enervating fusible link with localized heat. New links shall be provided and installed after successful testing.

3.11 DUCTWORK LEAKAGE TESTS: Contractor shall conduct leakage test on new duct in accordance with Section 15990, "Testing, Adjusting and Balancing." Test shall be performed prior to installing ductwork insulation.

END OF SECTION

SECTION 15896

MEDIUM/HIGH PRESSURE DUCTWORK

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC S328	(1986) Specification for Structural Steel Buildings Load and Resistance Factor Design

AMERICAN SOCIETY OF HEATING, REFRIGERATING, AND AIR CONDITIONING ENGINEERS, INC. (ASHRAE)

ASHRAE-02	(1992) HVAC Systems and Equipment (IP Edition)
ASHRAE-03	(1993) Handbook, Fundamentals (IP Edition)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 123	(1989a; E1) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 36	(1991) Standard Specification for Structural Steel
ASTM A 525	(1991b) Standard Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
ASTM A 527	(1990) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality
ASTM C 1071	(1991) Standard Specification for Thermal and Acoustical Insulation (Glass Fiber, Duct Lining Material)
ASTM D 257	(1991) Standard Test Methods for D-C Resistance or Conductance of Insulating Materials
ASTM E 90	(1990) Standard Test Method for Laboratory Measurement of Airborne-Sound Transmission Loss of Building Partitions

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8	(1989) Specification for Filler Metals for Brazing

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(1993) Standard for the Installation of Air Conditioning and Ventilating Systems

SOCIETY OF AUTOMOTIVE ENGINEERS, INC. (SAE)

SAE AMS 2480D	(1986) Phosphate Treatment Paint Base

SHEET METAL AND AIR CONDITIONING CONTRACTORS NATIONAL ASSOCIATION, INC. (SMACNA)

SMACNA-06	(1985; 1st Ed) HVAC Duct Construction Standards - Metal and Flexible
SMACNA-09	(1989; 1st Ed) HVAC Duct Systems Inspection Guide

STEEL STRUCTURES PAINTING COUNCIL (SSPC)

SSPC Chapter 4.2	(1982; 2nd Ed) Good Painting Practice, Volume 1

1.2 DESIGN REQUIREMENTS

Section 15003, "General Mechanical Provisions," apply to work specified in this section.]

Section 15245, "Vibration Isolation for Air Conditioning Equipment" applies to work in this section.]

Section 15055, "Welding Mechanical," applies to work specified in this section.]

1.3 SCOPE OF WORK

High velocity systems shall encompass ductwork where:

Minimum air velocity exceeds 2,000 feet per minute (fpm) or static pressure exceeds 2 inches water gage (wg).

Medium static pressure ranges from over 2 inches wg through 3 inches wg, positive or negative, or over 3 inches wg through 6 inches wg positive.]

High static pressure ranges from over 6 inches wg through 10 inches wg, positive.]

1.4 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data

1. Design Analysis and Calculations shall be submitted for Medium/High Pressure Ductwork Systems indicating the manufacturer's recommended air velocities, maximum static pressure, and temperature calculations.

2. Equipment and Performance Data shall be submitted for Medium/High Pressure Ductwork Systems consisting of use life, system functional flows, safety features, and mechanical automated details. Curves indicating tested and certified equipment response and performance characteristics shall also be submitted.

3. Manufacturer's Catalog Data shall be submitted for the following items:

Galvanized Steel Ductwork Materials

Brazing Materials
Mill-Rolled Reinforcing and Supporting Materials
Round Sheet Metal Duct Fittings
Round, High-Pressure, Double-Wall Sheet Metal Ducts
Turning Vanes
Dampers
Sound Traps
Flexible Connecters

B. Drawings

1. Connection Diagrams shall be submitted for Medium/High Pressure Ductwork Systems indicating the relation and connection of devices and apparatus by showing the general physical layout of all controls, the interconnection of one system (or portion of system) with another, and internal tubing, wiring, and other devices.

2. Fabrication Drawings shall be submitted for Medium/High Pressure Ductwork Systems consisting of fabrication and assembly details to be performed in the factory.

3. Installation Drawings shall be submitted for Medium/High Pressure Ductwork Systems. Drawings shall show details of equipment room layout and design.

4. As-Built Drawings shall provide current factual information including deviations from, and amendments to, the drawings and concealed or visible changes in the work, for Medium/High Pressure Ductwork Systems.

C. Schedules: Material, Equipment, and Fixture Lists shall include the manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

D. Statements: Listing of Product Installations for Medium/High Pressure Ductwork Systems shall include identification of at least 5 units, similar to those proposed for use, that have been in successful service for a minimum period of 5 years. List shall include purchaser, address of installation, service organization, and date of installation.

E. Reports: Test Reports shall be submitted for Medium/High Pressure Ductwork Systems in accordance with the paragraphs entitled, "Ductwork Leakage Tests" and "Fire Damper Tests," of this section.

Leakage Tests
Operational Tests

F. Certificates of Compliance shall be submitted, showing conformance with the referenced standards contained in this section for:

Galvanized Steel Ductwork Materials
Brazing Materials
Mill-Rolled Reinforcing and Supporting Materials
Round Sheet Metal Duct Fittings
Round, High-Pressure, Double-Wall Sheet Metal Ducts
Turning Vanes
Dampers
Sound Traps
Flexible Connecters

G. Records of Existing Conditions shall be submitted consisting of the results of Contractor's survey of work area conditions and features of existing structures and facilities within and adjacent to the jobsite. Commencement of work shall constitute acceptance of existing conditions.

H. Operation and Maintenance Manuals: Contractor shall submit 6 copies of the Operation and Maintenance Manuals 30 days prior to testing the Medium/High Pressure Ductwork.Data shall be updated and resubmitted for final approval no later than 30 days prior to contract completion.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Galvanized Steel Ductwork Materials

1. Galvanized steel ductwork sheet metal shall be carbon steel, of lock-forming quality, hot-dip galvanized, with regular spangle-type zinc coating, conforming to ASTM A 527/A 527M and ASTM A 525, Designation G90. Duct surfaces to be painted shall be treated by phosphatizing.

2. Sheet metal gages and reinforcement thickness shall conform to ASHRAE-02, Chapter 16, ASHRAE-03, Chapter 32 and SMACNA-06.

B. Brazing Materials shall be silicon bronze conforming to AWS A5.8.

C. Mill-Rolled Reinforcing and Supporting Materials

1. Mill-rolled structural steel shall conform to ASTM A 36/A 36M and, wherever in contact with sheet metal ducting, shall be galvanized to commercial weight of zinc or coated with materials conforming to ASTM A 123 SSPC Chapter 4.2.

2. Equivalent strength, proprietary design, rolled-steel structural support systems may be submitted for approval in lieu of mill-rolled structural steel.

2.2 COMPONENTS

A. Round Sheet Metal Duct Fittings

1. Fittings shall be shop fabricated.

2. Fittings shall be manufactured as separate fittings, not as tap collars welded or brazed into duct sections.

3. Offset configurations shall be submitted for approval.

4. Miter elbows shall be two-piece type for angles less than 31 degrees, three-piece type for angles 31 through 60 degrees, and five-piece type for angles 61 through 90 degrees. Centerline radius of elbows shall be 1-1/2 times fitting cross section diameter.

5. Crosses, increasers, reducers, reducing tees, and 90-degree tees shall be conical type.

6. Cutouts in fitting body shall be equal to branch tap dimension or, where smaller, excess material shall be flared and rolled into smooth radius nozzle configuration.

B. Round, High-Pressure, Double-Wall Sheet Metal Ducts

1. Ducts and fittings shall be shop fabricated.

2. Construction shall comprise an airtight, vapor barrier, outer pressure shell, a 1-inch insulation layer, and a perforated-metal inner liner that completely covers the insulation throughout the system.Surfaces exposed to the air stream shall be chloroprene coated or protected with woven fibrous-gall cloth conforming to ASTM C1071. Application:double wall duct with perforated liner. Insulation shall conform to NFPA 90A and ASTM C 1071.Thermal conductivity shall be in accordance with ASTM D 257.

C. Duct and Fitting Gages

1. Outer pressure shell shall be as specified in ASHRAE-02 Chapter 16, ASHRAE-03, Chapter 32 and SMACNA-06; the inner liner shall be as recommended by the manufacturer but not lighter than 26-gage.

2. Perforations shall be 3/32-inch diameter, and the open area shall be 13 percent.

D. Reinforcement: Inner liners of both duct and fittings shall be supported by metal spacers welded in position to maintain spacing and concentricity.

E. Fittings

1. Divided flow fittings shall be made as separate fittings, not tap collars into duct sections, with the following construction requirements:

a. Sound, airtight, continuous welds at intersection of fitting body and tap

b. Tap liner securely welded to inner liner, with weld spacing not to exceed 3 inches

c. Insulation shall be packed around the branch tap area for complete cavity filling.

d. Branch connection shall be carefully fit to cutout openings in inner liner without spaces for air erosion of insulation and without sharp projections that cause noise and airflow disturbance.

2. Seams in the pressure shell of fittings shall be continuously brazed. Galvanized areas that have been damaged by welding shall be protected with manufacturer's standard corrosion-resistant coating.

3. Offset configurations shall be submitted for approval.

4. Elbows shall be two-piece type for angles through 35 degrees, three-piece type for angles 36 through 71 degrees, and five-piece type for angles 72 through 90 degrees.

5. Crosses, increasers, reducers, reducing tees, and 90-degree tees shall be conical type.

F. Turning Vanes shall be double-wall type, commercially manufactured for high-velocity system service.

G. Dampers: Low pressure drop, high-velocity manual volume dampers, and high-velocity fire dampers shall be constructed in accordance with ASHRAE-02, Chapter 16, ASHRAE-03, Chapter 32 and SMACNA-06.

H. Sound Traps

1. Sound traps shall be factory fabricated, and acoustic confirmation of cataloged attenuation shall be made by an independent laboratory in accordance with ASTM E 90. Pressure drop measurements shall be confirmed in accordance with ASHRAE-02, Chapter 18. Noise-reduction data shall include effects of flanking paths and vibration transmission. Testing shall be with standard metal inlet and outlet connections under indicated capacity flow.

2. Attenuation shall be in accordance with ASHRAE-03. Certification shall include a graphic system noise spectrum indicating proposed fan sound power level. Attenuation of ducting system proposed for installation based on ASHRAE-03 for bends, branches, and other duct system construction details; sound pressure level without sound trap; attenuation required; and excess attenuation compared to specific noise criteria curve.

3. Pressure drop at rated flow shall not exceed ratings in accordance with ASHRAE-02, Chapter 16, ASHRAE-03, Chapter 32 and SMACNA-06 or design criteria.

4. Trap shall be airtight when operating under an internal pressure of 0.37 pound per square inch. Air-side surface shall be capable of withstanding air velocities of 10,000 feet per minute without any particulate matter leaving the trap and being carried downstream.

5. Sound traps shall be double-metal walled, rectangular. Sheet metal shall be mill-galvanized steel with commercial weight of zinc, conforming to ASTM A 527/A 527M. Exterior metal shall act as a vapor barrier, and metal thickness shall be not less than that required for the pressure service, in accordance with ASHRAE-02, Chapter 16, ASHRAE-03, Chapter 32 and SMACNA-06, but not less than 22-gage. Absorbing material, on the sound-impinging side, shall be covered with formed perforated mill-galvanized steel of not less than 24-gage. Exterior sheet joints shall be continuously welded or made with lockseams filled, prior to forming, with a chloroprene mastic.

6. Interior surfaces shall be spot welded not more than 3 inches on center. Connections to duct transitions shall be flanged with through-bolted 1/8-inch by 1-inch continuous rubber gasketing. Supports shall be trapeze type, vibration isolated.

7. Absorption material shall be fibrous glass. Surface exposed to airstream shall be chloroprene coated or protected with woven fibrous-glass cloth conforming to ASTM C 1071. Total compressed thickness shall provide required attenuation and thermal insulation to preclude condensation on exterior surface under operating conditions normal to installed location. Compressed material density shall be approximately 4.5 pounds per cubic foot. Material shall conform to fire hazard requirements of NFPA 90A.

I. Flexible Connectors for Sheet Metal

1. Connectors shall be UL listed, 30-ounce per square foot, waterproof, fire-retardant, airtight, woven fibrous-glass cloth, double coated with chloroprene. Clear width, not including clamping section, shall be 6 to 8 inches.

2. Leaded vinyl sheet shall be provided as a second layer for sound attenuation. Leaded vinyl shall be not less than 0.055 inch thick, shall weigh not less than 0.87 pound per

square foot, and shall be capable of approximately 10-decibel attenuation in the 10- to 10,000-hertz range.

PART 3 - EXECUTION

3.1 PREPARATION

A. Sheet metal construction shall be provided in accordance with the recommendations for best practices in ASHRAE-02, Chapter 16, SMACNA-06, NFPA 90A, and ASHRAE-03, Chapter 32.

B. Where construction methods for certain items are not described in the referenced standards or herein, the work shall be performed in accordance with recommendations for best practice defined in ASHRAE-02.

C. Sheet metal surfaces to be painted and surfaces to which adhesives are to be applied shall be clean and free of oil, grease, and deleterious substances.

D. Duct strength shall be adequate to prevent failure under service pressure or vacuum created by fast closure of duct devices. Leaktight, automatic relief devices shall be provided.

E. Supplementary steel shall be designed and fabricated in accordance with AISC S328.

3.2 INSTALLATION

A. Fabrication shall be airtight and shall include reinforcements, bracing, supports, framing, gasketing, sealing, and fastening to provide rigid construction and freedom from vibration, airflow-induced motion and noise, and excessive deflection at specified maximum system air pressure and velocity.

B. Where ducts pass through firewalls, a flanged duct segment with fire damper and access door shall be provided in that surface during surface construction.

3.3 APPLICATION

A. Rectangular Sheet Metal Ducts

1. Medium-Pressure Gages, Joints, and Reinforcement

a. Minimum sheet metal gages, joints, and reinforcements between joints shall be in accordance with ASHRAE-02, Chapter 16, ASHRAE-03, Chapter 32 and SMACNA-06.

b. Sheet metal minimum thickness, transverse reinforcement between joints, and joints of ducts shall be in accordance with the following:

LONGEST SIDE INCHES	SHEET METAL GAGE ALL SIDES	COMPANION ANGLE INCHES	REINFORCEMENT ANGLES INCHES, 24 INCHES ON CENTER MAXIMUM (BACK TO BACK)
97 to 108	16	2 by 2 by 1/8, two tie rods	Two 2 by 2 by 1/8, two tie rods along

		along angle	angle
109 to 132	16	2 by 2 by 3/16, two tie rods along angle	Two 2 by 2 by 3/16, two tie rods along angle
133 and longer	14	2 by 2 by 3/16, with tie rods every 48 inches	Two 2 by 2 by 3/16, with tie rods every 48 inches

2. Medium- and High-Pressure Branches, Inlets, Outlets

a. Branches, inlets, and outlets shall be installed to minimize air turbulence and to ensure proper airflow.

b. Dampers shall be installed so that the amount of air entering duct mains can be adjusted.

c. Commercially manufactured air extractors shall be provided to allow adjustment of the air quantity and to provide an even flow of air across the device or duct served.

d. Where a duct branch is to handle over 25 percent of the air handled by the duct main, a complete 90-degree increasing elbow shall be used, with an inside radius of 0.75 times duct branch width. Size of the trailing end of the increasing elbow within the main duct shall be in the same ratio to the main duct size as the ratio of the relative air quantities handled.

e. Where a duct branch is to handle 25 percent or less of the air handled by the duct main, the branch connection shall have an inside radius of 0.75 times branch duct width, a minimum arc length of 45 degrees, and an outside radius of 1.75 times duct branch width. Arc shall be tangent to duct main.

3. High-Pressure Gages, Joints, and Reinforcement

a. Sheet metal minimum thickness, joints, and reinforcement between joints shall be in accordance with ASHRAE-02, Chapter 16, ASHRAE-03, Chapter 32 and SMACNA-06.

b. The following types of ASHRAE-02, Chapter 16, ASHRAE-03, Chapter 32 and SMACNA-06 transverse joints shall be used:

c. Welded flange joint [with] [without] angle

d. Companion angle flanged joint

e. The following types of longitudinal seams shall be used:

1) Approved lock seams, back brazed, or continuously brazed seams for ducts with largest dimension up to 72 inches

2) Continuously welded or brazed seams for ducts with largest dimension greater than 72 inches

f. Sheet metal minimum thickness, transverse reinforcement between joints, and companion angle joints of ducts with longest side greater than 96 inches shall be in accordance with the following:

LONGEST SIDE INCHES	SHEET METAL GAGE ALL SIDES	COMPANION ANGLE INCHES	REINFORCEMENT ANGLES INCHES, 24 INCHES ON CENTER MAXIMUM (BACK TO BACK)
97 to 108	16	2 by 2 by 1/8, two tie rods along angle	Two 2 by 2 by 1/8, two tie rods along angle
109 to 132	16	2 by 2 by 3/16, two tie rods along angle	Two 2 by 2 by 3/16, two tie rods along angle
133 and longer	14	2 by 2 by 3/16, with tie rods every 24 inches	Two 2 by 2 by 3/16, with tie rods every 24 inches

B. Round Sheet Metal Ducts

1. Duct Gages, Joints, and Reinforcement

a. Sheet metal minimum thickness, joints, and reinforcement between joints shall be in accordance with ASHRAE-02, Chapter 16, ASHRAE-03, Chapter 32 and SMACNA-06.

b. Longitudinal duct joint shall be manufactured by machine, with spiral lockseams to and including 60-inch diameters, and to dimensional tolerances compatible with fittings provided.

c. Ducts shall have supplemental girth angle supports, tack welded to duct.Girth angles shall be located as follows:

DIAMETER, INCHES	REINFORCEMENT-MAXIMUM SPACING, INCHES
25 to 36	1-1/4 by 1-1/4, 1/8 thick, 72 inches on center
37 to 50	1-1/4 by 1-1/4, 1/8 thick, 60 inches on center
51 to 60	1-1/2 by 1-1/2, 1/8 thick, 48 inches on center

Draw band girth joints are not acceptable.

d. Slip joints shall be made up by coating the male fitting with elastomer sealing materials, exercising care to prevent mastic from entering fitting bore, leaving only a thin annular mastic line exposed internally. Sheet metal screws shall be used to make assembly rigid, not less than four screws per joint, maximum spacing 6 inches. Pop rivets shall not be used.All joints shall be taped and heat sealed.

e. Bolt heads and nuts shall be hex-shaped, 5/16-inch diameter for ducts up to 50-inch diameter, and 3/8-inch diameter for 51-inch diameter ducts and larger.

f. Flanges shall be [continuously welded] [brazed] to duct on outside of duct and intermittently welded with 1-inch welds every 4 inches on inside joint face. Excess filler metal shall be removed from inside face. Galvanized areas that have been damaged by welding shall be protected with manufacturer's standard corrosion-resistant coating.

2. Duct Transitions

a. Where the shape of a duct changes, the angle of the side of the transition piece shall not exceed 15 degrees from the straight run of duct connected thereto.

b. Where equipment is installed in ductwork, the angle of the side of the transition piece from the straight run of duct connected thereto shall not exceed 15 degrees on the upstream side of the equipment and 22-1/2 degrees on the downstream side of the equipment.

C. Round, High Pressure, Sheet Metal Duct Installation

1. Joints: An inner coupling shall be provided to align the inner lining to maintain good airflow conditions equivalent to standard round high-pressure duct joints. Butt joints are not suitable for the inner liner. This alignment shall be accomplished by [extending the liner of the fitting for slip joint into the pipe] [by the use of a double concentric coupling with the two couplings held by spacers for rigidity and wall spacing]. For ducts over 34 inches inside diameter, a separate coupling for inner alignment, with the pressure shells joined by angle-ring flanged connections, shall be provided.

2. Insulation Ends: At the end of an uninsulated section or run where internally insulated duct connects to uninsulated spiral duct, fitting, fire damper or flexible duct, an insulation end-fitting shall be installed to bring the outer pressure shell down to nominal size.

D. Transverse Reinforcement Joints: Transverse reinforcements shall be [riveted with solid rivets to duct sides 6 inches on center] [spot welded 4 inches on center]. Transverse reinforcement shall be welded at [all corners] [ends] to form continuous frames.

E. Joint Gaskets: Flanged joints shall be gasketed with chloroprene full-face gaskets 1/8-inch thick, Shore A 40 durometer hardness. Gaskets shall be one piece, [vulcanized] [dovetailed] at joints.

F. Radius Elbows: Elbow proportions and radius elbows shall be fabricated in accordance with ASHRAE-02, Chapter 16, ASHRAE-03, Chapter 32 and SMACNA-06.

G. Plenum Connections

1. Round duct connections shall be welded joint bellmouth type.

2. Rectangular duct connections shall be bellmouth type, constructed in accordance with ASHRAE-02, Chapter 16, ASHRAE-03, Chapter 32 and SMACNA-06.

H. Access Openings

1. Access panels shall be installed in ductwork adjacent to fire dampers.

2. Minimum size of access opening shall be 12 by 18 inches, unless precluded by duct dimension.

3. Access openings shall be framed by welded and ground miter joint, 1/8-inch thick angle iron, with [1/4] [3/8]-inch studs welded to frame. Cover plate shall be not less than [16-gage, reinforced as necessary for larger sizes.

I. Duct Supports

1. Duct support shall be installed in accordance with ASHRAE-02, Chapter 16, ASHRAE-03, Chapter 32 and SMACNA-06. Duct hangers shall meet the minimum size specified in ASHRAE-02, Chapter 16, ASHRAE-03, Chapter 32 and SMACNA-06. Two hangers shall be provided where necessary to eliminate sway. Support attachment to duct surfaces, shall be by [solid rivet] [bolt] [welding] 4 inches on center.

2. Round, double-wall duct supports shall be as recommended by the manufacturer except that minimum hanger ring and strap size shall be 1-1/2 inches by 1/8 inch.

3. Selection of hanging system shall be at the Contractor's option, and shall take into account the location and precedence of work under other sections, interferences of various piping and electrical conduit, equipment, building configuration, structural and safety factor requirements, vibration, and imposed loads under normal and abnormal service conditions. Support sizes, configurations, and spacings are given to show the minimal type of supporting components required. If installed loads are excessive for the specified hanger spacing, hangers, and accessories [heavier-duty components shall be provided] [hanger spacing shall be reduced]. After system startup, any duct support device which, due to length, configuration, or size, vibrates or causes possible failure of a member, shall be replaced or the condition shall otherwise be alleviated. Special care shall be exercised to preclude cascade-type failures.

4. Hanger rods, angles, and straps shall be attached to beam clamps. Concrete inserts, masonry anchors, and fasteners shall be approved for the application.

5. Hardened high-carbon spring-steel fasteners fitted onto beams and miscellaneous structural steel are acceptable upon prior approval of each proposed application and upon field demonstration of conformance to specification requirements. Fasteners shall be made from steel conforming to AISI Type [1055] [1070], treated and finished in conformance with SAE AMS 2480D, Type Z (zinc phosphate base), Class 2 (supplementary treatment). A 72-hour load-carrying capacity shall be verified by a certified independent laboratory.

6. Hanger spacing shall provide a 20-to-1 safety factor for supported load.

7. Maximum load supported by any two fasteners shall be 100 pounds.

8. Friction rod assemblies are not acceptable.

9. Where support from metal deck systems is involved, support requirements shall be coordinated with installation of metal deck.

10. Ductwork and equipment shall not be hung from roof deck, piping, or other ducts or equipment. Maximum span between any two points shall be 10 feet, with lesser spans as required by duct assemblies, interferences, and permitted loads imposed.

11. There shall be not less than one set of hangers for each point of support. Hangers shall be installed on both sides of all duct turns, branch fittings, and transitions.

12. Hangers shall be sufficiently cross braced to eliminate sway vertically and laterally.

13. Rectangular ducts up to 36 inches shall be supported by strap-type hangers attached at not less than three places to not less than two duct surfaces in different planes.

14. Perforated strap hangers are not acceptable.

15. Rectangular ducting, 36 inches and larger, shall be supported by trapeze hangers. Ducts situated in unconditioned areas and required to have insulation with a vapor-sealed facing shall be supported on trapeze hangers. Hangers shall be spaced far enough out from the side of the duct to permit the duct insulation to be placed on the duct inside the trapeze. Duct hangers shall not penetrate the vapor-sealed facing. Where trapeze hangers are used, the bottom of the duct shall be supported on angles sized as follows:

WIDTH OF DUCT, INCHES	MINIMUM BOTTOM ANGLE SIZE, INCHES
30 and smaller	1-1/4 by 1-1/4 by 1/8
31 to 48	1-1/2 by 1-1/2 by 1/8
49 to 72	1-1/2 by 1-1/2 by 3/16
73 to 96	2 by 2 by 1/4
97 and wider	3 by 3 by 1/4

16. Where ductwork system contains heavy equipment, excluding air-diffusion devices and single-leaf dampers, such equipment shall be hung independently of the ductwork by means of rods or angles of sizes adequate to support the load.

17. Ducting, when supported from roof purlins, shall not be supported at points greater than one-sixth of the purlin span from the roof truss. Load per hanger shall not exceed 400 pounds when support is from a single purlin or 800 pounds when hanger load is applied halfway between purlins by means of auxiliary support steel provided under this section. When support is not halfway between purlins, the allowable hanger load shall be the product of 400 times the inverse ratio of the longest distance to purlin-to-purlin spacing.

18. When the hanger load exceeds the above limits, reinforcing of purlin(s) or additional support beam(s) shall be provided. When an additional beam is used, the beam shall bear on the top chord of the roof trusses, and bearing shall be over gusset plates of top chord. Beam shall be stabilized by connection to roof purlin along bottom flange.

19. Purlins used for supporting fire-protection sprinkler mains, electrical lighting fixtures, electrical power ducts, or cable trays shall be considered fully loaded, and supplemental reinforcing or auxiliary support steel shall be provided for these purlins.

20. Duct supports shall be vibration isolated from structure. Refer to Section 15245, "Vibration Isolation for Air Conditioning Equipment."

J. Flexible Connectors for Steel Metal

1. Air-handling equipment, ducts crossing building expansion joints, and fan inlets and outlets shall be connected to upstream and downstream components by treated woven-cloth connectors.

2. Connectors shall be installed only after system fans are operative and all vibration isolation mountings have been adjusted. When system fans are operating, connectors shall be free of wrinkles caused by misalignment or fan reaction. Width of surface shall be curvilinear.

K. Insulation Protection Angles

1. Galvanized 20-gage sheet, formed into an angle with a 2-inch exposed long leg with a 3/8-inch stiffening break at outer edge, and with a variable concealed leg, depending upon insulation thickness, shall be provided.

2. Angles shall be installed over all insulation edges terminating by butting against a wall, floor foundation, frame, and similar construction. Angles shall be fastened in place with blind rivets through the protection angle, insulation, and sheet metal duct or plenum. Angles shall be installed after final insulation covering has been applied.

L. Duct Probe Access: Holes shall be provided with neat patches, threaded plugs, or threaded or twist-on caps for air-balancing pitot tube access. Extended-neck fittings shall be provided where probe access area is insulated.

M. Openings in Roofs and Walls: Building openings are fixed and equipment shall be provided to suit.

3.4 FIELD QUALITY CONTROL

A. Fire Damper Tests: Operational tests shall be performed on each fire damper in the presence of the Construction Manager by enervating fusible link with localized heat. New links shall be provided and installed after successful testing.

B. Ductwork Leakage Test: Contractor shall conduct complete leakage test of new ductwork in accordance with Section 15990, "Testing, Adjusting and Balancing." Tests shall be performed prior to installing ductwork insulation.

C. Inspection: Ductwork shall be inspected in accordance with SMACNA-09.

3.5 DUCTWORK CLEANING PROVISIONS: Open ducting shall be protected from construction dust and debris in a manner approved by the Construction Manager. Dirty assembled ducting shall be cleaned by subjecting all main and branch interior surfaces to airstreams moving at velocities two times specified working velocities, at static pressures within maximum ratings. This may be accomplished by: filter-equipped portable blowers which remain the Contractor's property; wheel-mounted, compressed-air operated perimeter lances which direct the compressed air and which are pulled in the direction of normal airflow; and other means approved by the Construction Manager. Compressed air used for cleaning ducting shall be water- and oil- free. After construction is complete, and prior to acceptance of the work, construction dust and debris shall be removed from exterior surfaces.

END OF SECTION

SECTION 15930

AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AIR DIFFUSION COUNCIL (ADC)

ADC-01	(1984; 10th Edition) Directory of ADC Certified Products

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA 83	(1989) Designation of Sound Power Emitted by Machinery and Equipment

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 527	(1990) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(1993) Standard for the Installation of Air Conditioning and Ventilating Systems

1.2 SUBMITTALS" The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data

1. Equipment and Performance Data shall be submitted for the following items consisting of use life, system functional flows, safety features, and mechanical automated details. Curves indicating tested and certified equipment responses and performance characteristics shall also be submitted.

Mixing Boxes
Terminal Reheat Units

2. Manufacturer's Catalog Data shall be submitted for the following items:

High-Pressure Dual-Duct Mixing Boxes
Variable Constant-Volume Boxes
Spare Parts

B. Drawings

1. Fabrication Drawings shall be submitted for the following items consisting of fabrication and assembly details to be performed in the factory.

High-Pressure Dual-Duct Mixing Boxes
Variable Constant-Volume Boxes

Spare Parts

2. Installation Drawings shall be submitted for the following items in accordance with the paragraph entitled, "Installation," of this section.

High-Pressure Dual-Duct Mixing Boxes
Variable Constant-Volume Boxes

3. Outline Drawings for the following shall indicate overall physical features, dimensions, ratings, service requirements, and equipments weights.

High-Pressure Dual-Duct Mixing Boxes
Variable Constant-Volume Boxes

4. As-Built Drawings shall be submitted providing current factual information, including deviations and amendments to the drawings, and concealed and visible changes in the work.

C. Schedules: Materials, Equipment, and Fixture Lists shall be submitted for all materials, equipment, and fixtures to be incorporated in the work. Lists shall include manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

D. Statements: Listing of Product Installations for the following items shall include identification of at least 5 units, similar to those proposed for use, that have been in successful service for a minimum period of 5 years. List shall include purchaser, address of installation, service organization, and date of installation.

Mixing Boxes

E. Reports

1. Test Reports shall be submitted showing the following:

2. Reports for Mixing and Variable Volume Boxes shall include sound ratings submitted in terms of discharge sound-power levels in each of the second through sixth octave bands for specified or indicated inlet pressure ranges. A nominal space Noise Criteria (NC) index shall be shown for at least three operating points, including ratings at design, maximum, and minimum volume operation.

3. Reports for Reheat Units shall include sound-power levels, decibel reference 10 to the minus 12 power watts for each of the second through seventh octave bands, and for inlet pressures of 1 through 6 inches water gage (wg) for all operating conditions. A nominal space NC sound-pressure level index shall be shown for each of at least three volume ratings, including minimum and maximum. Index shall be the highest point of NC rating after deducting 18-decibel; (dB) room attenuation from the sound-power level in each octave band.

F. Certificates of Compliance shall be submitted for the following items showing conformance with the referenced standards contained in this section.

High-Pressure Dual-Duct Mixing Boxes
Variable Constant-Volume Boxes

G. Samples: Manufacturer's Standard Color Charts shall be submitted for the following items showing the manufacturer's recommended color and finish selections.

Mixing Boxes
Terminal Reheat Units

H. Records of Existing Conditions shall be submitted consisting of the results of Contractor's survey of work area conditions and features of existing structures and facilities within and adjacent to the jobsite. Commencement of work shall constitute acceptance of existing conditions.

I. Operation and Maintenance Manuals: Contractor shall submit 6 copies of the Operation and Maintenance Manuals 30 days prior to testing the following items. Data shall be updated and resubmitted for final approval no later than 30 days prior to contract completion.

1.3 GENERAL REQUIREMENTS

A. Section 15003, "General Mechanical Provisions," applies to work specified in this section.

B. Units shall be provided with the configuration, capacity, and static-pressure characteristics indicated.

C. Where dimensional data are given, these shall constitute nominal sizing, which shall be adjusted by the manufacturer when necessary to accommodate acoustic material thickness.

D. Units identical to the proposed units shall have at least 2 years of proven satisfactory field service.

E. Units shall be certified as having been ADC-01 tested and rated.

PART 2 - PRODUCTS

2.1 HIGH-PRESSURE DUAL-DUCT MIXING BOXES: Units shall be mechanical constant-volume control type with a mechanical controller that is operated by the entering mixed-airstream and maintains a constant airflow through the unit. Units shall be factory preset to deliver air volumes indicated.

A. Construction

1. Unit shall be factory assembled, complete with casing, air mixing valve assembly, single air mixing valve operator, and mechanical constant-volume control, ready for field mounting and connection to control.

2. Casing exterior shall be not less than 0.040-inch thick aluminum, or 20-gage mill-galvanized steel with not less than 1.25 ounces of zinc per square foot of two-sided surface, conforming to ASTM A 527/A 527M.

3. Casing interior shall be acoustically baffled and lined with fibrous glass thick enough to attain required sound power level performance and preclude condensation on any exterior surface, but in no case less than 1 inch. Air side of fibrous glass shall be chloroprene-impregnated and manufactured to resist delamination or surface erosion at air velocities to 4,000 feet per minute. Liner edges exposed to airstream shall be protected by metal turnovers. Liner and fibrous-glass baffle material shall conform to NFPA 90A.

4. Inlet valves and connecting linkage shall be constructed for modulation by a single operator. Hot inlet valve shall be normally open, and the cold inlet valve shall be normally closed. Hot and cold inlet ports shall be field reversible.

5. Mechanical constant-volume control shall be externally adjustable. A calibration chart shall be provided with each unit indicating capacity per revolution of mechanical constant-volume device. Each unit shall be labeled with minimum/maximum volume range to facilitate field adjustment.

6. Components subject to friction shall have oil-impregnated bronze bearings, graphite-impregnated or lubricant-impregnated nylon bearings; and lubricant-impregnated elastomers, corrosion-resistant steel, and similar materials.

7. Casing shall be fitted with rigid, airtight access panels, easily removable and of ample size to give free access to interior parts. Closure shall be achieved by spring-retained, quarter-turn, slotted-cam captive devices, or similar operating fasteners.

8. Calking compounds shall be chloroprene, polyurethane polysulfides, or silicone elastomers. Gaskets shall be chloroprene, polyurethane, or vinyl.

B. Casing Leakage: Casing joints shall be sealed to prevent leakage of more than 2 percent of rated capacity with all connections sealed and with an internal static pressure of 1 inch wg.

C. Inlet Valve Leakage: Leakage in fully closed valve position shall not exceed 2 percent of unit rated capacity against inlet pressure of 8 inches wg.

D. Mixed-Air Temperature Requirements: A thermometer traverse of all unit outlets shall show variation of not more than 5 percent of the difference, at the time, between the temperatures of equal quantities of cold and warm airstreams entering the unit.

E. Volume Control Requirements: Mechanical constant-volume control shall maintain design volume within plus or minus 5 percent, regardless of the modulation position of inlet valves or the fluctuation of inlet or outlet pressure, within limits of indicated minimum pressure.

F. Sound Level Requirements

1. Unit shall meet the airborne and radiated sound-power level (PWL) requirements scheduled, to attain the specified NC levels. An 18-dB space attenuation shall be assumed in all octave bands with consideration given to downstream duct construction and configuration in determining airborne NC levels.

2. The following ceiling sound-transmission loss (TL) characteristics, based on 1-inch acoustic lay-in panels and T-bar suspension, shall be assumed in computing resultant space radiated NC levels:

OCTAVE BAND	2ND	3RD	4TH	5TH	6TH	7TH
PWL-TL	-2	-4	-9	-10	-13	-15

G. Control Requirements

1. Operating-control power source shall be dry, compressed air of instrument quality at 15 pounds per square inch, gage, unless otherwise approved.

2. Air mixing valve operator shall be provided by the automatic temperature control manufacturer and installed by the unit manufacturer, unless field installation for specific construction is approved. Operator shall be controlled by a direct-acting thermostat.

3. Pneumatic control tubing shall be copper and shall be brought to the exterior of the casing for connection to automatic temperature control system.

2.2 VARIABLE CONSTANT-VOLUME BOXES

A. General:

1. Casing shall be fabricated from galvanized steel and shall have internal thermal and acoustic insulation. Insulation shall be coated to prevent erosion and shall conform to NFPA 90A.

2. Sound baffles shall be provided within the box to provide sound levels within the limits scheduled. Sound levels shall be tested in accordance with ASA 83. An 8-dB room attenuation shall be used in determining the NC level. Allowances shall be made for multiple outlets (power division) and duct attenuation.

3. Casing internal leakage shall be limited to 2 percent of nominal box capacity when the internal pressure is 1 inch wg.

4. Casing shall be fitted with rigid, airtight access panels, easily removable, and of ample size to give free access to all interior parts.

5. Each box shall be labeled with building location and factory-set air volume or field-set calibration curve.

B. Low Velocity Boxes: Inlet valve shall be self-seating, and leakage in full closed position shall not exceed 2 percent of unit rated capacity against inlet pressure of 1 inch wg.

C. Medium and High Velocity Boxes

1. Box shall be supplied with variable constant-volume regulator consisting of aluminum and coated-steel frame with aluminum vanes, corrosion-resistant steel adjusting spring, and neoprene pulsation snubber.

2. Volume reset shall be by pneumatic operator mounted directly on the variable constant-volume regulator.

3. Variable constant-volume regulator shall be factory set for an air capacity within plus 5 percent of the indicated maximum and minimum air quantities, regardless of variations in inlet static pressure from minimum to 6 inches wg.

4. Minimum air capacity shall be a percentage of the maximum air capacity indicated and shall be easily changed in the field.

5. A calibration chart indicating 100 percent air capacity versus adjusting screw shall be furnished with each box.

D. Control Requirements

1. Operating-control power source shall be dry, compressed air at 15 psig, unless otherwise approved.

2. Valve operator shall be provided by the automatic temperature control manufacturer and installed by the unit manufacturer, unless field installation for specific construction is approved. Operator shall be controlled by a thermostat.

3. Pneumatic control tubing shall be copper and shall be brought to the exterior of the casing for connection to automatic temperature control system.

PART 3 - EXECUTION

3.1 INSTALLATION: Equipment shall be installed as shown on the drawings and in accordance with the manufacturer's recommendations.

3.2 TESTS: Coils shall be tested under water at 150 percent of the working pressure or 300 psig for 200 pounds per square inch working pressure.

END OF SECTION

SECTION 15941

DIFFUSERS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN SOCIETY OF HEATING, REFRIGERATING, AND AIR CONDITIONING ENGINEERS, INC. (ASHRAE)

ASHRAE 113	(1990) Method of Testing for Room Air Diffusion
ASHRAE-02	(1992) HVAC Systems and Equipment (IP Edition)
ASHRAE-03	(1993) Handbook, Fundamentals (IP Edition)

1.2 GENERAL REQUIREMENTS: Section 15003, "General Mechanical Provisions," applies to work specified in this section.

1.3 PERFORMANCE REQUIREMENTS: Air diffusion devices shall be certified as having been tested and rated in accordance with ASHRAE-02, Chapter 17; ASHRAE-03, Chapter 31, and ASHRAE 113, where such certification is required.

1.4 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Equipment and Performance Data shall be submitted for Air-Diffusion Devices consisting of sound data in terms of Noise Criteria (NC) index for the capacity range of the device.

B. Drawings

1. Fabrication Drawings shall be submitted for Air-Diffusion Devices consisting of fabrication and assembly details to be performed in the factory.

2. Installation Drawings shall be submitted for Air-Diffusion Devices in accordance with the paragraph entitled, "Installation," of this section. Drawings shall indicate overall physical features, dimensions, ratings, service requirements, and equipment weights.

C. Schedules: Material, Equipment, and Fixture Lists shall include the manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

D. Samples: Manufacturer's Standard Color Chart shall indicate the manufacturer's standard color selections and finishes for Air-Diffusion Devices.

E. Records of Existing Conditions shall be submitted consisting of the results of Contractor's survey of work area conditions and features of existing structures and facilities within and adjacent to the jobsite. Commencement of work shall constitute acceptance of existing conditions.

PART 2 - PRODUCTS

2.1 AIR-DIFFUSION DEVICE CONSTRUCTION

A. Air-diffusion device construction and mounting shall preclude flutter, rattle, or vibration. Refer to Section 15245, "Vibration Isolation for Air Conditioning Equipment," for vibration isolation considerations. Devices shall have the modifications and accessories necessary for mounting in indicated surface construction.

B. Color selection shall match architectural background.

C. Supply diffusers shall be provided with combination damper and equalizing grid. Dampers shall be extracting-splitter type, except as otherwise indicated.

D. Air-diffusion device volume and pattern adjustments shall be made from the face of the device. Volume adjustments shall be made by removable key

E. Gaskets shall be provided for supply-terminal air devices mounted in finished surfaces.

2.2 TYPES OF AIR-DIFFUSION DEVICES

A. Type CD-1 supply diffuser shall have a square perforated, hinged, face plate, 24" by 24", with opposed blade volume control, white baked enamel exterior finish, and black matte finish on exposed-to-view interior surface.

B. Type CD-2

1. Type DRA supply diffuser shall be round with four or more expanding cones with beaded edges to provide hemispherically diffused discharge air. Cones shall be arranged to provide a minimum of four air paths which simultaneously diffuse air at 20 to 50 feet per minute (fpm) and aspirate room air at 25 to 35 percent of discharge volume.

2. Diffuser finish shall be baked enamel, and shall be constructed of aluminum.

C. Type RG-1 series return air grill shall have a square perforated, hinged, face plate and matching supply diffusers CD-1.

D. Type TR-1 return grilles shall be single deflection type with fixed face bars.

1. Grilles installed in vertical surfaces shall have horizontal face bars set downward at 35 degrees from vertical.

2. Grilles installed in horizontal surfaces shall have face bars straight and parallel to short dimension.

3. Finish shall be baked enamel.

4. Construction shall be aluminum.

5. Integral extended surface to fit into module of lay-in ceiling shall be provided.

E. Type RR-1

1. Type RR shall be return register, single-deflection type, and shall have fixed face bars with opposed-blade dampers.

2. Registers installed in vertical surfaces shall have horizontal face bars set downward at approximately 35 degrees from vertical.

3. Registers installed in horizontal surfaces shall have face bars set straight and parallel to short dimension.

4. Finish shall be baked enamel.

F. Type HF-1 shall have a HEPA filter module 4′ by 2′. The air outlet assembly whall be ceiling mounted and supported by wires from the roof structure.

G. Type HF-2 shall be the same as Type HF-1, except that the outlet assembly shall have a HEPA filter module 2′ by 2′.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment shall be installed as indicated and specified and in accordance with manufacturer's recommendations.

B. Wall-mounted return registers shall be mounted 6 inches above the finished floor.

END OF SECTION

SECTION 15990

TESTING, ADJUSTING AND BALANCING

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

ASSOCIATED AIR BALANCE COUNCIL (AABC)

AABC MN-1	(1989; 5th Ed) National Standards for Testing and Balancing, Heating, Ventilating, and Air Conditioning Systems

AMERICAN SOCIETY OF HEATING, REFRIGERATING, AND AIR CONDITIONING ENGINEERS, INC. (ASHRAE)

ASHRAE-02	(1992) HVAC Systems and Equipment (IP Edition)
ASHRAE-08	(1992) Handbook, Refrigeration (IP Edition)

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B31.5	(1992; Errata 1993) Refrigeration Piping
ASME B40.1	(1991) Gauges - Pressure Indicating Dial Type - Elastic Element

SHEET METAL AND AIR CONDITIONING CONTRACTORS NATIONAL ASSOCIATION, INC. (SMACNA)

SMACNA-07	(1983; 1st Ed) HVAC Systems - Testing, Adjusting and Balancing

1.2 SUBMITTALS: The following shall be submitted in accordance with Section 01300 "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Equipment and Performance Data shall be submitted for instruments and equipment to be used during testing.

B. Reports: Test Reports shall be submitted to the Construction Manager for approval. Six bound copies of the testing, adjusting, and balancing report shall be provided.

C. Certificates of Compliance shall be submitted by the Contractor showing independent laboratory certification of test-apparatus calibration data, dated after the award of the contract.

D. Records of Existing Conditions shall be submitted consisting of the results of Contractor's survey of work area conditions and features of existing structures and facilities within and adjacent to the jobsite. Commencement of work shall constitute acceptance of existing conditions.

1.3 GENERAL REQUIREMENTS: Section 15003, "General Mechanical Provisions," applies to work specified in this section.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 WATER SYSTEM TESTING:

A. General:

1. Prior to acceptance of the work, systems shall be tested in the presence of the Construction Manager.

2. Tests shall be performed prior to insulation of surfaces, painting, and concealment of work. Systems containing repaired defects shall be retested to original criteria for acceptance, except when waived by the Contracting Officer.

3. Tests shall be hydrostatic, unless otherwise specified.Water used for testing shall be potable.

4. The Institute will supply testing water, but the Contractor shall provide for approved disposal of contaminated water.

5. Tests may be pneumatic when freezing conditions may occur and upon prior approval by the Construction Manager. Only oil-free compressed air shall be used for testing.

6. Pneumatic testing shall include swabbing all joints under a test pressure of 5 psig with standard high-film-strength soap solution and observing for bubbles.

7. Contractor may conduct tests for his own purposes, but the acceptance test shall be conducted as specified herein.

8. If the test demonstrates that leakage rate exceeds specified limits, the source(s) of leakage shall be determined, defective materials and workmanship shall be repaired or replaced, and the system shall be retested until specified requirements are met.

9. Other than standard piping flanges, plugs, caps, and valves, only commercially manufactured expandable-elastomer plugs shall be used for sealing off piping for test purposes. Safe test-pressure rating of any plug used shall be not less than two times the actual test pressure being applied.

10. Precautions shall be taken to vent the expansive force of compressed air trapped during high-pressure hydrostatic testing to preclude injury and damage.

11. Construction Manager may require the removal of system components, such as plugs or caps, to ascertain that the water has reached all parts of the system if purging or vent valves are not provided.

12. Piping system components such as valves shall be checked for functional operation under system test pressure. Components that could sustain damage due to test pressure shall be removed from piping systems prior to hydrostatic testing.

13. Leaking gasket joints shall be remade with new gaskets. Leaking copper joints shall be remade with new fittings and new tube ends.

14. Temperature of water used for testing shall not cause condensation on system surfaces.

15. Test media shall not be added to a system during a test for a period specified or to be determined by the Construction Manager.

16. Duration of a test will be determined by the Construction Manager and shall be for a minimum of 2 hours, with a maximum of 24 hours. Test may be terminated by direction of the Construction Manager at any time during this period after it has been determined that the permissible leakage rate has not been exceeded.

17. Test records of piping systems tests shall be prepared and maintained. Records shall show test personnel responsibilities, dates, test gage identification numbers, ambient and test water temperatures, pressure ranges, rate of pressure drop, leakage rates, and other system characteristics.

B. Test Gages shall have a 4-1/2 inch or larger dial, be accurate to plus or minus one-half of 1 percent of full-scale range, and have dial graduations and pointer width compatible with readability and one-half the accuracy extremes. Maximum permissible scale range for a given test shall be such that the pointer shall have a starting position at midpoint of the dial or within the middle third of the scale range. Certification of accuracy and correction table shall bear a date within 90 days prior to use, test gage number, and project number.

C. Test and Acceptance Criteria

1. Aboveground water systems shall be tested at 150 pounds per square inch (psi) and the applied test pressure shall be maintained without further addition of test media for not less than 2 hours. Maximum allowable pressure drop shall be 2 psi, or as approved.

2. Underground rubber-jointed ferrous-pipe water systems shall be tested at 200 psi and the applied test pressure shall be maintained for not less than 2 hours. Where no thrust blocks are to be provided, piping shall be tested at an approved pressure. After satisfactory hydrostatic testing, the piping shall be tested for leakage as follows:

3. Duration of each leakage test shall be not less than 2 hours. During the test, the main shall be subjected to 200 psi pressure, based on the elevation of the lowest section under test and corrected to the elevation of the test gage.

4. Leakage is defined as the additional quantity of water supplied into the laid pipe, or any valved section thereof, that is necessary to maintain the specified leakage test pressure after the pipe has been filled with water and the air expelled.

5. Maximum allowable leakage for the piping installation (gallons per hour) shall be indicated by not more than a 5 percent 1 percent [_____] drop of total system pressure.

6. Hydrostatic tests shall be applied only to piping with concrete thrust blocking that has cured for a minimum of 7 days.

7. Backflow prevention devices in potable water systems and other water system devices shall be tested for proper functioning under conditions normal to their application.

3.2 AIR-HANDLING SYSTEMS TESTING

A. General:

1. Structural integrity and leakage testing of air-handling systems shall be performed by system or by duct mains and branches.

2. Tests shall be performed prior to insulation of surfaces, painting, or concealment of work. Unless waived by the Construction Manager, systems containing repaired defects shall be retested to original criteria for acceptance.

DUCT PRESSURE-VELOCITY CLASSIFICATION

DUCT CLASS	STATIC PRESSURE RATING (INCHES)	PRESSURE	SEAL CLASS	VELOCITY (fpm)
High Pressure	10	Positive	A	2,000 Up
Medium Pressure	6	Positive	A	2,000 Up
Medium Pressure	4	Positive	A	2,000 Up
Medium Pressure	3	Positive/ Negative	A	4,000 Down
Low Pressure	2	Positive/ Negative		2,000 Down
Low Pressure	1	Positive/ Negative		2,000 Down
Low Pressure	1/2	Positive/ Negative		1,500 Down

Seal Class A: All seams, joints, fastener penetrations and connections sealed.

B. Low Pressure Duct Systems

1. Portions of systems shall be inspected and tested to positive or negative pressures, or both, whichever is normal to the portion of system under test, in accordance with the following:

a. There are no visible mechanical defects.

b. There is no audible leakage at any point when area ambient noise is at normal-occupancy level.

c. No leakage is perceptible to the hand, when placed within 6 inches of a joint.

2. Measured total system leakage shall not exceed 1 percent of total system cubic feet per minute (cfm) when tested in accordance with "Leak Tests."

C. Medium/High Pressure Duct Systems: High-velocity, high-pressure duct systems shall be structurally tested at static pressures 50 percent in excess of total fan pressure. Leakage testing shall be at a pressure 25 percent higher than normal operating pressure, and, in dual duct systems at maximum pressure at mixing box, when inlet valve is shut off. System will be acceptable provided:

1. There are no visible mechanical defects.

2. Measured total system leakage does not exceed 1 percent of total system cubic feet per minute (cfm) capacity when tested in accordance with "Leak Test."

3. There is no audible leakage at any point when area ambient noise is at normal-occupancy level.

D. Leak Tests: Test apparatus and procedures shall be similar in all respects to those defined in SMACNA-07. Filtered blower inlet and automatic safety relief device shall be provided to protect system. Accuracy of measurement of leakage flow rate shall be certified to be within 1 percent of total system flow.

1. Test Apparatus shall consist of:

a. A source of high pressure air - a portable rotary blower or tank type vacuum cleaner.

b. A flow measuring device usually an orifice assembly consisting of straightening vanes and an orifice plate mounted in a straight tube with properly located pressure taps. Each orifice assembly shall be accurately calibrated to its own calibration curve. Pressure and flow readings are usually taken with U-tube manometers.

2. Test Procedures

a. Test for audible leaks as follows:

1) Close off and seal openings in the duct section to be tested. Connect the test apparatus to the duct by means of a flexible duct section.

2) Start the blower with its control damper closed (some small blowers popularly used for testing ducts may damage the duct because they can develop pressures up to 25 inches wg.

3) Gradually open the inlet damper until the duct pressure reaches 2 inches wg in excess of designed duct operating pressure. Test pressure is read on manometer No. 1. Note that the pressure is indicated by the difference in level between the two legs of the manometer and not by the distance from zero to the reading on one leg only.

4) Survey joints for audible leaks. Mark each leak and repair after shutting down blower. Do not apply a retest until sealants have set.

b. After all audible leaks have been sealed, the remaining leakage should be measured with the test apparatus orifice section as follows:

1) Start blower and open damper until duct pressure reaches 25 percent in excess of designed duct operating pressure.

2) Read the pressure differential across the orifice on manometer No. 2. Leakage rate in cfm is read directly from the calibration curve. If leakage does not occur, the pressure differential will be zero.

3) Total allowable leakage should not exceed 1 percent of the total system design air flow rate. When partial sections of the duct system are tested, the summation of the leakage for all sections shall not exceed the total allowable leakage.

4) If all audible leaks have been corrected, it is unlikely that the measured leakage will exceed one percent of capacity. If it does, the leaks shall be located by careful listening or feeling along the joint.

5) It should be noted that even though a system may pass the measured leakage test, a concentration of leakage at one point may result in a noisy leak that shall be corrected.

E. Test Report Criteria: A test report shall be provided for each system tested, identified by system or section thereof, and containing leak-test curves for apparatus used and data pertinent to acceptance requirements.

3.3 AIR AND HYDRONIC SYSTEMS TESTING AND ADJUSTMENT

A. General:

1. Operational balancing and adjustment of air-handling and hydronic systems shall be performed under the direction of an independent balancing agency whose field representative is a registered professional engineer. All work shall be done in accordance with ASHRAE-02, AABC MN-1 or SMACNA-07, where applicable, the requirements of the contract documents, and in the presence of the Construction Manager.

2. The Institute reserves the right to require recalibration of any or all test apparatus in accordance with the frequency recommended by the component manufacturer, or when reasonable doubt of accuracy exists.

3. Hydronic systems structural and leakage testing shall be performed in accordance with requirements specified herein under "Water Systems Testing."

4. Air-handling systems structural and leakage testing shall be performed in accordance with requirements specified herein under "Air-Handling System Testing."

5. Components of the various air systems shall be adjusted to operate within the design and operating characteristics published by the equipment manufacturer. The Construction Manager will require the services of an authorized representative of the manufacturer if the Contractor is unable to adjust any equipment.

6. Equipment shall not be operated until properly lubricated and brought into specified service condition.

7. Air- and hydronic-system final adjustments shall be permanently marked to be readily restorable if disturbed.

8. Systems acceptance is predicated upon successful completion of specified work, receipt by the Construction Manager of certified data summarizing the performance of all systems within design intent, and approval thereof. Data shall be arranged by system and identified by apparatus and item, using standard forms, where possible, and supplementing with reasonable facsimiles, where necessary.

B. Air-Handling Systems

1. Balancing, Adjustment, and Acceptance Criteria

a. Final volume conditions for all systems shall be within the following limits:

b. Air-handler Plus 10 percent, minus 0 percent of delivery:design cfm at design temperature

c. Primary air Plus or minus 10 percent of design delivery:cfm at design temperature

2. Balancing and Adjustment, Apparatus and Procedures

a. Balancing and adjustment apparatus and procedures shall be in accordance with ASHRAE-02 and AABC MN-1.

b. Instrumentation shall be provided to record air movement data, motor kilowatt (kW) input, and power factor. If motor identification plate current value is exceeded, the next size larger motor, starter, and wiring (if necessary) shall be provided.

3. Test Reports shall be provided on all systems tested together with test-apparatus data and air-diffusion device flow coefficients, and the following:

a. Air-handling apparatus data

b. Exhaust-fan data

c. Air-diffusion devices data

d. Duct-traverse data for the following:

1) Main supply duct
2) Main exhaust duct
3) Outside air-intake duct
4) Other ducts as indicated

e. Duct zone-traverse data for the following:

1) All zones
2) Air-handling apparatus
3) Air-diffusion devices data
4) Each main duct, exhaust duct, and outside intake data

f. Filter apparatus data, including visual condition, inlet pressure, and differential pressure for each filter installation

g. Coil data, including visual condition, inlet pressure, and differential pressure for each coil installation

h. Pressure at inlet to face zone duct on multizone units

C. Hydronic Systems

1. System Balancing, Adjustment, and Acceptance Criteria: Systems final flow conditions shall be within the following limits:

a. Pump delivery: Plus 10 percent, minus 0 percent of design gallons per minute (gpm) at design temperature

b. Flow-station: Plus or minus 10 percent of design gpm delivery: at design temperature

2. Test Apparatus and Procedures

a. Test apparatus shall consist of devices required for hydronic systems flow measuring and balancing including:

1) Pressure gages and fittings

2) Dry bulb thermometers

3) Wet bulb thermometers

4) Pyrometers

5) Balancing-cock adjustment wrenches

6) Differential-pressure gages or manometers

7) Thermometer wells, where necessary for balancing, but where permanent installation of thermometers is not indicated or required

b. Complete air balance shall have been accomplished before water balance begins.

3. Hydronic Systems Preparation: Hydronic systems shall be prepared in the following manner:

a. Proper installation of valves and balancing devices shall be verified.

b. Valves shall be opened to full-open position, including coil-stop valves, bypass valves, and return-line balancing cocks.

c. Strainer screens shall be removed and cleaned.

d. Water in each system shall be examined to determine that it has been treated.

e. Rotation of pumps shall be checked only after obtaining approval.

f. Expansion tanks shall be checked to determine that they are not air-bound and that system is full of water.

g. Air vents shall be checked at high points to verify proper installation and operation.

h. Temperature controls shall be set so that coils are on full cooling. Automatic bypass valves at coils and liquid chiller should close. Follow the same procedure when balancing heating coils are set on full heating.

i. Water-circulating pumps shall be set to proper gpm delivery.

j. Flow of chilled water through chillers shall be adjusted.

k. Water flow through convertors shall be adjusted.

l. Leaving-water and return-water temperatures through chiller and convertors shall be checked.

m. Water temperature shall be checked at inlet side of cooling and heating coils. Note rise or drop of temperature from source.

n. Next, each coil shall be balanced.

o. Upon completion of flow reading and adjustment of coils, all settings shall be marked and all data recorded.

p. After adjustments to coils have been made, settings at pumps, chiller, and convertors shall be rechecked and readjusted if required.

q. Pressure drop through coils shall be measured at set flow rate on call for full cooling and on full heating.

r. Pressure drop across bypass valve shall be set to match coil full-pressure drop to prevent unbalanced flow conditions when coils are on full bypass.

s. Same procedure on chiller to adjust chiller bypass valves shall be followed.

t. Instrumentation shall be provided to record apparatus motor kW input and power factor. If motor identification plate current capacity and larger starter is exceeded, next-size larger motor and wiring shall be provided, as necessary.

u. Cooling-water flow shall be checked.

4. Operational Test Report shall provide data on systems tested, test apparatus data, and orifice or Venturi data, and shall include:

a. For each cooling element:

1) Inlet water temperature

2) Leaving water temperature

3) Inlet air temperature

4) Leaving air temperature

5) Pressure drop across each element

6) Pressure drop across bypass valve

7) Calculated and measured flow rates through coils and radiation elements

b. For each pump:

1) Balanced-condition suction and discharge pressures

2) Flow rate

3) Mechanical specifications of unit

4) Rated and actual kW input and power factor

c. For each apparatus such as chiller, cooling tower, and converter:

1) Inlet water temperature

2) Leaving water temperature

3) Pressure drop across units

4) Calculated and measured waterflow

5) Mechanical specifications of units

6) Rated and actual kW input and power factor for motors

7) Heating- and cooling-element data

8) Pump data

D. System and Temperature-Control Adjustment

1. Adjustment and Acceptance Criteria: After balance and adjustment operations have been completed, the system shall be tested as a whole to see that components perform as an integral part of the system and that temperature and conditions are evenly controlled. Corrections and adjustment shall be made as necessary to meet the specified design requirements.

2. System Test Report: Test report shall be provided on the system and shall include:

a. Outdoor temperature

b. Room-by-room temperature and humidity conditions (center of cooled area at table top)

c. Calculation for total British thermal units per hour (Btu/hr) cooling required, including time of day and dry bulb outside temperature

d. Calculation for total Btu/hr heating required, including time of day and dry bulb outside temperature

3.4 DRAINAGE AND VENTING SYSTEM TESTING

A. Drainage and venting system piping shall be tested before the fixtures are installed. Soil and waste piping installed underground shall be tested before backfilling. Testing shall be applied to the system in its entirety or in sections. If the entire system is tested, openings in pipes, except the highest opening, shall be tightly closed and the system shall be filled with water to the point of overflow.

B. If the system is tested in sections, each opening, except the highest opening of the section under test, shall be tightly plugged and each section shall be filled and tested with not less than a 10-foot head of water. In testing successive sections, at least the upper 10 feet of the next preceding section shall be tested so that each joint or pipe in the system, except the uppermost 10 feet, has been submitted to a test with not less than a 10-foot head of water. Water shall be kept in the system, or the portion under test, for at least 15 minutes before the inspection starts. System shall be tight at all joints.

END OF SECTION

SECTION 16003

GENERAL ELECTRICAL PROVISIONS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z53.1	(1979) Safety Color Code for Marking Physical Hazards

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 123	(1989a; E1) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

FEDERAL STANDARDS (FED-STD)

FED-STD 595	(Rev B) Colors Used in GovernmentProcurement

FEDERAL SPECIFICATIONS (FS)

FS W-J-800	(Rev E; Am 1) Junction Box:Extension, Junction Box; Cover, Junction Box (Steel, Cadmium, or Zinc-Coated)

INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS (IEEE)

IEEE C2	(1993) National Electrical Safety Code

MILITARY SPECIFICATIONS (MS)

MS MIL-T-704	(Rev J) Treatment and Painting of Material

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1993) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL-05	(1992) Electrical Construction Materials Directory

1.2 INTERPRETATION OF DRAWINGS AND SPECIFICATIONS

A. It is the intent of these specifications and the contract drawings to provide a complete and workable facility.

B. Design drawings are diagrammatic and do not show all offsets, bends, elbows, or other specific elements that may be required for proper installation of the work. Such work shall be verified at the site. Additional bends and offsets, and conduit as required by vertical and horizontal equipment locations or other job conditions, shall be provided to complete the work at no additional cost to the Institute.

C. Except where shown in dimensional detail, the locations of switches, receptacles, lights, motors, outlets, and other equipment shown on plans are approximate. Such items shall be placed to eliminate interference with ducts, piping, and equipment. Exact locations shall be determined in the field. Door swings shall be verified to ensure that light switches are properly located.

D. Equipment sizes indicated are minimum. Before installing any wire or conduit, the Contractor shall obtain the exact equipment requirements and shall install wire, conduit, disconnect switches, motor starters, heaters, circuit breakers, and other items of the correct size for the equipment actually installed. However, wire and conduit sizes shown on the drawings shall be taken as a minimum and shall not be reduced without written approval.

1.4 CODES AND STANDARDS: Equipment design, fabrication, testing, performance, and installation shall, unless shown or specified otherwise, comply with the applicable requirements of NFPA 70 and IEEE C2 to the extent indicated by the references.

1.5 COORDINATION: Installation of the electrical work shall be coordinated with the work of other trades.

1.6 APPROVAL REQUIREMENTS

A. Where materials and equipment are specified to conform to the standards of the Underwriters Laboratories (UL), Inc., the label of, or listing with re-examination, in UL-05 will be acceptable as sufficient evidence that the items conform to the requirements.

B. Where materials or equipment are specified to be constructed or tested in accordance with the standards of NEMA, ANSI, ASTM, or other recognized standards, a manufacturer's certificate of compliance indicating complete compliance of each item with the applicable NEMA, ANSI, ASTM, or other commercial standards specified will be acceptable as proof of compliance.

1.7 PREVENTION OF CORROSION: Metallic materials shall be protected against corrosion. Equipment enclosures shall be given a rust-inhibiting treatment and the standard finish by the manufacturer. Aluminum shall not be used in contact with earth. Dissimilar metals in intimate contact shall be protected by suitable fittings, barrier material, and treatment. Ferrous metals such as anchors, bolts, braces, boxes, bodies, clamps, fittings, guards, nuts, pins, rods, shims, thimbles, washers, and miscellaneous parts not of corrosion-resistant steel or nonferrous materials shall be hot-dip galvanized in accordance with ASTM A 123 for exterior locations and cadmium-plated in conformance with FS W-J-800 for interior locations.

1.8 HAZARDOUS AREA: Electrical work within any hazardous location shall meet the applicable requirements of NFPA 70, Chapter 5, Articles 500 through 517. The following definitions apply:

A. Explosionproof: A receptacle, fixture, device, or equipment enclosure that is designed to withstand explosion of a specified liquid, gas, vapor, or dust within the enclosure and to prevent the ignition of a specified gas, vapor, or dust surrounding the enclosure by sparks, flashes, or explosions of the specified liquid, gas, vapor, or dust that may occur within the enclosure. Enclosure shall be capable of operating at an external temperature that will not ignite a surrounding flammable atmosphere.

B. Hazardous location:An area where ignitable vapors or dust may cause a fire or explosion created by energy emitted from lighting or other electrical equipment or by electrostatic generation.

C. NFPA 70, Article 500-2 lists chemical atmospheres by groups A, B, C, and D. In addition, although not defined as a hazardous material by the NEC, oxygen concentrations (liquid and gaseous) are considered to provide a hazard because of the increased flammability of materials exposed to oxygen. Therefore, oxygen concentrations shall be classified under Group D.

PART 2 - PRODUCTS

2.1 IDENTIFICATION PLATES: Identification plates shall be 3-layer black-white-black, engraved to show white letters on a black background. Letters shall be uppercase. Identification plates 1-1/2 inches high and smaller shall be 1/16-inch thick with engraved lettering 1/8-inch high. Identification plates larger than 1-1/2 inches high shall be 1/8-inch thick with engraved lettering not less than 3/16-inch high. Identification plates having edges of 1-1/2 inches high and larger shall be beveled.

2.2 WARNING SIGNS

A. Each item of electrical equipment operating at 480 volts and above shall be provided with conspicuously located warning signs conforming to the requirements of Occupational Safety and Health Agency (OSHA) standards.

B. Any equipment with externally powered wiring shall be marked with a laminated plastic nameplate having 3/16-inch high white letters on a red background as follows:

DANGER - EXTERNAL VOLTAGE SOURCE

C. Safety color coding for identification of warning signs shall conform to ANSI Z53.1.

2.3 ANCHOR BOLTS: Anchor bolts shall be provided for equipment placed on concrete equipment pads or slabs.

2.4 SEISMIC ANCHORAGE

A. Electrical equipment, except communications, emergency, and standby equipment, shall be anchored to withstand a lateral force of 0.3 times the weight of the equipment.

B. Communications, emergency, and standby equipment shall be anchored to withstand a lateral force of 0.6 times the weight of the equipment.

C. The following standard anchoring should be adequate for equipment not classified as communications, emergency, or standby:

Dry transformers - floor-mounted with four anchor bolts

	BOLT DIAMETER (inches)
Under 150 kVA	3/8
150 to 500 kVA	1/2
Over 500 kVA	5/8

Panels - floor-mounted with four anchor bolts
Each panel - 1/2-inch diameter bolts

2.5 PAINTING: Enclosures of the following listed items shall be cleaned, primed, and factory-painted inside and outside in accordance with MS MIL-T-704.

ITEM	FINISH COLOR
Circuit Breakers	No. 61 gray (FED-STD 595)
Substations	No. 61 gray (FED-STD 595)
Switchgear	No. 61 gray (FED-STD 595)
Transformers	No. 61 gray (FED-STD 595)
Safety Switches	Manufacturer's standard
Panelboards	Manufacturer's standard
Electric Heaters	Manufacturer's standard
Motors	Manufacturer's standard
Limit Switches	Manufacturer's standard
Control Components	Manufacturer's standard

PART 3 - EXECUTION

3.1 INSTALLATION: Installation shall be accomplished by workers skilled in this type of work. Installation shall be made so that there is no degradation of the designed fire ratings of walls, partitions, ceilings, and floors. Except as otherwise indicated, emergency switches and alarms shall be installed in conspicuous locations.

3.2 PAINTING APPLICATION

A. Exposed conduit, supports, fittings, cabinets, pull boxes, and racks, if not factory painted, shall be thoroughly cleaned and painted as specified in Section 09900, "Painting," unless otherwise noted. Work shall be left in a neat and clean condition at final completion of the contract.

B. Emergency equipment, such as fire-alarm boxes, shall be cleaned, primed, and painted red. Color shall conform to FED-STD 595, Color 11105.

3.3 IDENTIFICATION PLATES: Identification plates shall be fastened by means of corrosion-resistant steel or nonferrous metal screws. Hand lettering, marking, or embossed self-adhesive tapes are not acceptable.

3.4 EQUIPMENT PADS: Equipment pads shall be provided where indicated on the drawings and shall be the dimensions shown, or, if not shown, shall conform to the shape of each piece of equipment served with a minimum 3-inch margin around the equipment and supports.

3.5 CUTTING AND PATCHING

A. Contractor shall install his work in such a manner and at such time as will require a minimum of cutting and patching on the building structure.

B. Holes in or through existing masonry walls and floors in exposed locations shall be drilled and smoothed by sanding. Use of a jackhammer will be permitted only where specifically approved.

3.6 DAMAGE TO WORK: Required repairs and replacement of damaged work shall be done as directed by and subject to the approval of the Construction Manager, and at no additional cost to the Institute.

3.7 CLEANING

A. Exposed surfaces of wireways, conduit systems, and equipment that have become covered with dirt, plaster, or other material during handling and construction shall be thoroughly cleaned before such surfaces are prepared for final finish or painting or are enclosed within the building structure.

B. Before final acceptance, electrical equipment, including lighting fixtures and glass, shall be clean and free from dirt, grease, and fingermarks.

END OF SECTION

SECTION 16050

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A117.1	(1986) Buildings and Facilities - Providing Accessibility and Usability for Physically Handicapped People
ANSI Z53.1	(1979) Safety Color Code for Marking Physical Hazards

ELECTRONIC INDUSTRIES ASSOCIATION (EIA)

EIA 480	(1981) Toggle Switches

NATIONAL ELECTRICAL MANUFACTURER'S ASSOCIATION (NEMA)

NEMA 250	(1991) Enclosures for Electric Equipment (1000 Volts Maximum)
NEMA FB 1	(1988) Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies
NEMA KS 1	(1990) Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
NEMA OS 1	(1989) Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports
NEMA PB 1	(1990) Panelboards
NEMA RN 1	(1989) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA VE 1	(1991) Metallic Cable Tray Systems
NEMA WD 1	(1983; Rev 1989) General Requirements for Wiring Devices
NEMA WD 6	(1988) Wiring Devices - Dimensional Requirements

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1993) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 1	(1985; 8th Ed; Jan 3, 1992) UL Standard for Safety - Flexible Metal Conduit

UL 1242	(1983; 1st Ed, June 26, 1991) UL Standard for Safety - Intermediate Metal Conduit
UL 489	(1991; 8th Ed; May 1, 1992; Bulletin Feb 11, 1992; Bulletin Mar 16, 1992) UL Standard for Safety Molded-Case Circuit Breakers and Circuit-Breaker Enclosures
UL 506	(1989; 10th Ed) UL Standard for Specialty Transformers
UL 6	(1993) UL Standard for Safety - Rigid Metal Conduit
UL 797	(1983; 5th Ed; July 8, 1991) UL Standard for Safety - Electrical Metallic Tubing
UL 870	(1991; 6th Ed) UL Standard for Safety Wireways, Auxiliary Gutters, and Associated Fittings

1.2 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Manufacturer's Catalog Data shall be submitted for the following items:

Conduit, Raceway and Fittings
Wire and Cable
Splices and Connectors
Switches
Receptacles
Outlets, Outlet Boxes, and Pull Boxes
Circuit Breakers
Panelboards
Lamps and Lighting Fixtures
Dry-Type Distribution Transformers
Spare Parts

B. Instructions: Manufacturer's Instructions shall be submitted including special provisions required to install equipment components and system packages. Special notices shall detail impedances, hazards and safety precautions.

C. Schedules: Material, Equipment, and Fixture Lists shall be submitted for the following items showing manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site.

Conduit, Raceway and Fittings
Wire and Cable
Splices and Connectors
Switches
Receptacles
Outlets, Outlet Boxes, and Pull Boxes
Circuit Breakers
Panelboards
Lamps and Lighting Fixtures
Dry-Type Distribution Transformers

1.3 PREVENTION OF CORROSION: Metallic materials shall be protected against corrosion. Equipment enclosures shall have the standard finish by the manufacturer. Aluminum shall not be used in contact with earth and, where connected to dissimilar metal, shall be protected by approved fittings and treatment. Ferrous metals such as but not limited to, anchors, bolts, braces, boxes, bodies, clamps, fittings, guards, nuts, pins, rods, shims, thimbles, washers, and miscellaneous parts not of corrosion-resistant steel shall be hot-dip galvanized except where other equivalent protective treatment is specifically approved in writing.

PART 2 - PRODUCTS

2.1 MATERIALS: Materials and equipment to be provided shall be the standard cataloged products of manufacturers regularly engaged in the manufacture of the products.

A. Rigid Steel Conduit shall be in accordance with UL 6 and shall be galvanized by the hot-dip process. Where underground and in corrosive areas, rigid steel conduit shall be polyvinylchloride (PVC) coated in accordance with NEMA RN 1 or shall be painted with bitumastic.

1. Fittings for rigid steel conduit shall be threaded.

2. Gaskets shall be solid. Conduit fittings with blank covers shall have gaskets, except in clean, dry areas or at the lowest point of a conduit run where drainage is required.

3. Covers shall have captive screws and shall be accessible after the work has been completed.

B. Electrical Metallic Tubing (EMT) shall be in accordance with UL 797 and shall be zinc coated steel. Couplings and connectors shall be zinc-coated, raintight, gland compression type fittings with insulation throat. Crimp, spring, or setscrew type fittings shall not be acceptable.

C. Flexible Metallic Conduit shall be in accordance with UL 1 and shall be galvanized steel.

1. Fittings for flexible metallic conduit shall be specifically designed for such conduit.

2. Liquidtight flexible metallic conduit shall be provided with a protective jacket of PVC extruded over a flexible interlocked galvanized steel core to protect wiring against moisture, oil, chemicals, and corrosion.

3. Fittings for liquidtight flexible metallic conduit shall be specifically designed for such conduit.

D. Intermediate Metal Conduit shall be in accordance with UL 1242 and shall be galvanized.

E. Rigid Nonmetallic Conduit shall be in accordance with NEMA TC 13 and shall be PVC with wall thickness not less than Schedule 40.

F. Wireways and Auxiliary Gutters shall be a minimum 4- by 4-inch trade size conforming to UL 870.

G. Surface Raceways and Assemblies and multi-outlet assemblies shall conform to NFPA 70. Receptacles shall conform to NEMA WD 1, Type 5-20R.

H. Cable Trays shall be ladder type conforming to NEMA VE 1.

2.2 WIRE AND CABLE

A. Conductors installed in conduit shall be copper 600-volt type THWN or THW.All conductors AWG No. 8 and larger, shall be stranded. All conductors smaller than AWG No. 8 shall be solid.

B. Flexible cable shall be Type SO and shall contain a grounding conductor with green insulation.

C. Conductors installed in plenums shall be marked plenum rated.

2.3 SPLICES AND CONNECTORS

A. Splices in AWG No. 8 and smaller shall be made with approved insulated electrical type indentor crimp-type connectors and compression tools or wirenuts.

B. Splices in AWG No. 6 and larger shall be made with [indentor crimp-type connectors and compression tools] [bolted clamp-type connectors]. Joints shall be wrapped with an insulating tape that has an insulation and temperature rating equivalent to that of the conductor insulation.

2.4 SWITCHES

A. Safety Switches: shall be in accordance with NEMA KS 1, and shall be the heavy-duty type with enclosure, voltage, current rating, number of poles, and fusing as indicated. Switch construction shall be such that, with the switch handle in the "ON" position, the cover or door cannot be opened. Cover release device shall be coinproof and shall be so constructed that an external tool must be used to open the cover. Provisions shall be made to lock the handle in the "OFF" position, but the switch shall not be capable of being locked in the "ON" position.

1. Switches shall be of the quick-make, quick-break type. Terminal lugs shall be approved for use with copper conductors.

2. Safety color coding for identification of safety switches shall conform to ANSI Z53.1.

B. Toggle Switches shall be in accordance with EIA 480, and shall control incandescent, HID, and fluorescent lighting fixtures and shall be of the heavy duty, general purpose, noninterchangeable flush-type.

1. Toggle switches shall be commercial grade toggle type, single -pole, [three] [four]-way two-position devices rated 20 amperes at 277 volts, 60 hertz alternating current (ac) only.

2. All toggle switches shall be products of the same manufacturer.

2.5 RECEPTACLES: Receptacles shall be commercial grade, 20A, 125 VAC, 2-pole, 3-wire duplex conforming to NEMA WD 6, NEMA 5-20R.

2.6 OUTLETS, OUTLET BOXES, AND PULL BOXES: Outlet boxes for use with conduit systems shall be in accordance with NEMA FB 1 and NEMA OS 1 and shall be not less than 1-1/2 inches deep. Pull and junction boxes shall be furnished with screw-fastened covers.

2.7 PANELBOARDS: Lighting and receptacle branch circuit panelboards shall be the circuit-breaker type in accordance with NEMA PB 1. Circuit breakers shall be bolted to the bus. Plug-in circuit breakers shall not be acceptable. Buses shall be copper of the rating indicated, with main lugs or main circuit breaker as indicated. Panelboards for use on grounded ac systems shall be provided with a full-capacity isolated neutral bus and a separate grounding bus bonded to the panelboard enclosure. Panelboard enclosures shall be NEMA 250, Type 1, in accordance with NEMA PB 1. Enclosure fronts shall have latchable hinged doors. Interior panelboards shall be flush mounted type.

2.8 CIRCUIT BREAKERS: Circuit-breaker interrupting rating shall be not less than those indicated and in no event less than 10,000 amperes root-mean-square (rms) symmetrical at 208 volts, respectively. Multipole circuit breakers shall be the common-trip type with a single handle. Molded case circuit breakers shall be bolt-on type conforming to UL 489.

2.9 LAMPS AND LIGHTING FIXTURES

A. Manufacturers and catalog numbers shown are indicative of the general type desired and are not intended to restrict the selection to fixtures of any particular manufacturer. Fixtures with the same salient features and equivalent light distribution and brightness characteristics, of equal finish and quality, will be acceptable. Lamps of the proper type and wattage shall be provided for each fixture.

B. Ballasts shall be high power factor and be energy efficient. Ballasts shall have a Class P terminal protective device for 277-volt operation as indicated and shall be rapid-start fluorescent. Ballasts shall be "A" sound rated. Fluorescent lamps shall be T-8 reduced wattage type.

C. High intensity discharge (HID) lighting fixtures shall have prewired integral ballasts and cast aluminum housings complete with protective and optical lenses suitable for installation in dry locations as indicated. Fixtures and lamps shall be provided.

2.10 DRY-TYPE DISTRIBUTION TRANSFORMERS: General purpose dry-type transformers with windings 600 volts or less shall be two-winding, 60 hertz, self-cooled in accordance with UL 506. Windings shall have a minimum of two 2-1/2-percent taps above and below nominal voltage.

PART 3 - EXECUTION

3.1 CONDUITS, RACEWAYS AND FITTINGS

A. General:

1. Conduit runs between outlet and outlet, between fitting and fitting, or between outlet and fitting shall contain not more than the equivalent of three 90-degree bends, including those bends located immediately at the outlet or fitting.

2. Crushed or deformed conduit shall not be installed. Trapped conduit runs shall be avoided where possible. Care shall be taken to prevent the lodgment of foreign material in the conduit, boxes, fittings, and equipment during the course of construction. Clogged conduit shall be cleared of obstructions or shall be replaced. Boxes shall be free of debris and shall be cleaned with vacuum after installation.

B. Rigid Steel Conduit

1. Field-made bends and offsets shall be made with approved hickey or conduit bending machine. Conduit elbows larger than 2-1/2 inches shall be long radius.

2. Conduit stubbed-up through concrete floors for connections to free-standing equipment with the exception of motor-control centers, cubicles, and other such items of equipment, shall be provided with a flush coupling when the floor slab is of sufficient thickness. Otherwise, a floor box shall be provided and set flush with the finished floor. Conduits installed for future use shall be terminated with a coupling and plug set flush with the floor.

C. Electrical Metallic Tubing (EMT) shall be grounded in accordance with NFPA 70, using pressure grounding connectors especially designed for EMT.

D. Flexible Metallic Conduit

1. Flexible metallic conduit shall be used to connect recessed fixtures from outlet boxes in ceilings, transformers, and other approved assemblies.

2. Bonding wires shall be used in flexible conduit as specified in NFPA 70, for all circuits. Flexible conduit shall not be considered a ground conductor.

3. Electrical connections to vibration-isolated equipment shall be made with liquid-tight flexible metallic conduit.

4. Liquidtight flexible metallic conduit shall be used in wet and oily locations and to complete the connection to motor-driven equipment.

E. Intermediate Conduit: Field-made bends and offsets shall be made with approved hickey or conduit bending machine. Intermediate metal conduit shall be used only for indoor installations.

F. Rigid Nonmetallic Conduit

1. Rigid PVC conduit shall be direct buried.

2. A green insulated copper grounding conductor shall be in conduit with conductors and shall be solidly connected to ground at each end. Grounding wires shall be sized in accordance with NFPA 70.

G. Wireway and Auxiliary Gutter

1. Straight sections and fittings shall be bolted together to provide a rigid, mechanical connection and electrical continuity. Dead ends of wireways and auxiliary gutters shall be closed.Unused conduit openings shall be plugged.

2. Wireways for overhead distribution and control circuits shall be supported at maximum 5 -foot intervals.

3. Auxiliary gutters used to supplement wiring spaces for equipment not contained in a single enclosure shall contain no switches, overcurrent devices, appliances, or apparatus and shall be not more than 20 -feet long.

H. Surface Raceways and Assemblies: Surface raceways shall be mounted plumb and level, with the base and cover secured. Minimum circuit run shall be three-wire with one wire designated as ground.

I. Cable Trays shall be supported from ceiling hangers, equipment bays, or floor or wall supports. Cable trays may be mounted on equipment racks. Support shall be provided when the free end extends beyond 3 feet. Maximum support spacing shall be 10 feet. Cable trays shall be bonded at splices.

3.2 WIRING:

A. Feeder and branch circuit conductors shall be color coded as follows:

120/208 - 240 V AC circuits:	Black:	A phase
	Red:	B phase
	Blue:	C phase
277/480 V AC circuits:	Brown:	A phase
	Orange:	B phase
	Yellow:	C phase
480 V AC circuits:	Brown:	A phase
	Orange:	B phase
	Yellow:	C phase
4.16 KV AC, 13.8KV AC	Black:	A phase
34.5 KV AC circuits:	Red:	B phase
	Blue:	C phase
DC circuits:	Red:	positive
	Black:	negative

Equipment Grounds[Green] [Green with Yellow Stripe] [Bare]

B. Conductors up to and including AWG No. 2 shall be manufactured with colored insulating materials. Conductors larger than No. 2 shall have ends identified with color plastic tape in outlet, pull, or junction boxes.

C. Splices shall be in accordance with the NFPA 70. Conductor identification shall be provided within each enclosure where a tap, splice, or termination is made and at the equipment terminal of each conductor. Terminal and conductor identification shall match as indicated.

D. Where several feeders pass through a common pullbox, the feeders shall be tagged to clearly indicate the electrical characteristics, circuit number, and panel designation.

3.3 SAFETY SWITCHES: Switches shall be securely fastened to the supporting structure or wall, utilizing a minimum of four 1/4-inch bolts. Sheet metal screws and small machine screws shall not be used for mounting. Switches shall not be mounted in an inaccessible location or where the passageway to the switch may become obstructed. Mounting height shall be 5 feet above floor level, when possible.

3.4 WIRING DEVICES

A. Wall Switches and Receptacles shall be so installed that when device plates are applied, the plates will be aligned vertically to within 1/16 inch.

B. Ground terminal of each common flush-mounted receptacle shall be bonded to the outlet box with an approved green bonding jumper when used with dry wall type construction.

C. Isolated ground receptacles shall be installed in accordance with the intent shown on the drawings.

D. Device Plates for switches that are not within sight of the loads controlled shall be suitably engraved with a description of the loads.

1. Device plates and receptacle cover plates for receptacles other than 125-volt, single-phase, duplex, convenience outlets shall be suitably marked, showing the circuit number, voltage, frequency, phasing, and amperage available at the receptacle. Required marking shall consist of a self-adhesive label having 1/4 -inch embossed letters.

2. Device plates for convenience outlets shall be similarly marked indicating the supply panel and circuit number.

3.5 BOXES AND FITTINGS

A. Pullboxes shall be furnished and installed where necessary in the conduit system to facilitate conductor installation. Conduit runs longer than 100 feet or with more than three right-angle bends shall have a pullbox installed at a convenient intermediate location.

B. Boxes and enclosures shall be securely mounted to the building structure or walls with supporting facilities independent of the conduit entering or leaving the boxes.

C. Mounting height of wall-mounted outlet and switch boxes, measured between the bottom of the box and the finished floor, shall be in accordance with ANSI A117.1 and as follows:

LOCATION	MOUNTING HEIGHT
Receptacles in offices	18 inches
Receptacles in corridors	18 inches
Receptacles in shops & laboratories	48 inches
Receptacles for clocks	90 inches
Receptacles in rest rooms	48 inches
Switches for light control	48 inches
Thermostats	60 inches

3.6 LAMPS AND LIGHTING FIXTURES: New lamps of the proper type and wattage shall be installed in each fixture. Fixtures and supports shall be securely fastened to structural members and shall be installed parallel and perpendicular to major axes of structures.

3.7 PANELBOARDS: Panelboards shall be securely mounted so that the top operating handle does not exceed 72 -inches above the finished floor. Directory card information shall be complete and legible.

3.8 DRY-TYPE DISTRIBUTION TRANSFORMERS: Dry-type transformers shall be connected with flexible metallic conduit. All dry-type transformers shall be mounted on vibration isolators in accordance with Section 15245, "Vibration Isolation for Air Conditioning Systems."

3.9 IDENTIFICATION PLATES AND WARNINGS:

A. Identification plates shall be furnished for lighting and power panelboards, motor control centers, all line voltage heating and ventilating control panels, fire detector and sprinkler alarms, door bells, pilot lights, disconnect switches, manual starting switches, and magnetic starters. Process control devices and pilot lights shall have identification plates.

B. Identification plates shall be furnished for all line voltage enclosed circuit breakers, identifying the equipment served, voltage, phase(s) and power source. Circuits 480 volts and above shall have conspicuously located warning signs in accordance with OSHA requirements.

3.10 PAINTING: Exposed conduit, supports, fittings, cabinets, pull boxes, and racks shall be thoroughly cleaned and painted as specified in Section 09900, "Painting."

3.11 FIELD TESTING

A. After completion of the installation and splicing, joints, and terminations, and prior to energizing the conductors, wire and cable shall be given continuity and insulation tests before the conductors are energized.

B. Insulation tests on circuits with conductor sizes AWG No. 2 and larger, shall be conducted using a 1,000-volt insulation resistance test set. Readings shall be taken after 1 minute or until the reading is constant for 15 seconds. Resistance between phase conductors and ground shall be not less than 25 megohms.

C. Phase-rotation tests shall be conducted on three-phase circuits using a phase-rotation indicating instrument. Phase rotation of electrical connections to connected equipment shall be A, B, C left to right, or top to bottom, front to back, facing the equipment.

D. Final acceptance will depend upon the satisfactory performance of equipment. No conductor shall be energized until the installation has been approved.

END OF SECTION

SECTION 16400

MOTORS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

FEDERAL SPECIFICATIONS (FS)

FS L-P-387	(Rev A; Am 1, Int Am 2) Plastic Sheet, Laminated, Thermosetting (for Designation Plates)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1	(1993) Industrial Controls and Systems
NEMA ICS 2	(1993) Industrial Control Devices, Controllers and Assemblies
NEMA ICS 3	(1993) Industrial Systems
NEMA ICS 6	(1993) Enclosures for Industrial Control and Systems
NEMA MG 1	(1993) Motors and Generators
NEMA MG 10	(1983; R 1988) Energy Management Guide for Selection and Use of Polyphase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1993) National Electrical Code
NFPA 101	(1994) Safety to Life from Fire in Buildings and Structures

UNDERWRITERS LABORATORIES (UL)

UL 508	(1993) Industrial Control Equipment
UL 845	(1994) Motor Control Centers
UL 1004	(1994) Electric Motors

1.2 GENERAL

A. Rules: The installation shall conform to the requirements of NFPA 70 and NFPA 101, unless more stringent requirements are indicated herein or shown.

B. Coordination: The drawings indicate the extent and the general location and arrangement of equipment, conduit, and wiring. The Contractor shall become familiar with all details of the work and verify all dimensions in the field so that the outlets and equipment shall be properly located and readily accessible. Equipment and materials shall be located to avoid interference with mechanical or structural features. If any conflicts occur necessitating departures from the drawings, details of and reasons for departures shall be submitted and approved prior to implementing any change.

C. Special Environments

1. Weatherproof Locations: Wiring, fixtures, and equipment in designated locations shall conform to NFPA 70 requirements for installation in damp or wet locations.

D. Standard Products: Material and equipment shall be a standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

E. Identification Nameplates

1. Major items of electrical equipment and major components shall be permanently marked with an identification name to identify the equipment by type or function and specific unit number as indicated. Designation of motors shall coincide with their designation in the motor control center or panel. Unless otherwise specified, all identification nameplates shall be made of laminated plastic in accordance with FS L-P-387 with black outer layers and a white core. Edges shall be chamfered. Plates shall be fastened with black-finished round-head drive screws, except motors, or approved nonadhesive metal fasteners. When the nameplate is to be installed on an irregular-shaped object, the Contractor shall devise an approved support suitable for the application and ensure the proper installation of the supports and nameplates. In all instances, the nameplate shall be installed in a conspicuous location. At the option of the Contractor, the equipment manufacturer's standard embossed nameplate material with black paint-filled letters may be furnished in lieu of laminated plastic. The front of each panelboard, motor control center, switchgear, and switchboard shall have a nameplate to indicate the phase letter, corresponding color and arrangement of the phase conductors. The following equipment, as a minimum, shall be provided with identification nameplates:

Minimum 1/4 Inch High Letters	Minimum 1/8 Inch High Letters
Starters	Control Power Transformers
Safety Switches	Control Devices
Motor Control Centers	Instrument Transformers
Equipment Enclosures	
Motors	

2. Each panel, section, or unit in motor control centers shall be provided with a nameplate in addition to nameplates listed above, which shall be provided for individual compartments in the respective assembly, including nameplates which identify "future," "spare," and "dedicated" or "equipped spaces."

F. As Built Drawings: Following the project completion or turnover, within 30 days the Contractor shall furnish 2 sets of as built drawings to the Construction Manager.

1.4 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Reports

1. Materials and Equipment

a. The label or listing of the Underwriters Laboratories, Inc., shall be accepted as evidence that the materials or equipment conform to the applicable standards of that agency. In lieu of this label or listing, a statement from a nationally recognized, adequately equipped testing agency indicating that the items have been tested in accordance with required procedures and that the materials and equipment comply with all contract requirements will be accepted. However, materials and equipment installed in hazardous locations must bear the UL label unless the data submitted from other testing agency is specifically approved in writing by the Construction Manager. Materials and equipment shall be approved based on the manufacturer's published data.

b. For other than equipment and materials specified to conform to UL publications, a manufacturer's statement indicating complete compliance with the applicable Federal Specification, or standard of the American Society for Testing and Materials, National Electrical Manufacturers Association, or other commercial standard, is acceptable.

1.4 WORKMANSHIP: Materials and equipment shall be installed in accordance with recommendations of the manufacturer and as shown.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT: Materials and equipment shall conform to the respective publications and other requirements specified below. Materials and equipment not listed below shall be as specified elsewhere in this section.

A. Motors, AC, Fractional and Integral: Motors, ac, fractional and integral horsepower 500 Hp and smaller shall conform to NEMA MG 1 and UL 1004 for motors and NEMA MG 10 for energy management selection of polyphase motors.

1. Rating: The kilowatt (horsepower) rating of motors should be limited to no more than 125 percent of the maximum load being served unless a NEMA standard size does not fall within this range. In this case, the next larger NEMA standard motor size should be used.

2. Motor Efficiencies: Permanently wired polyphase motors of 1 hp or more shall meet the minimum full-load efficiencies as indicated in the following table, and as specified in this specification. Motors of 1 hp or more with open, dripproof or totally enclosed fan cooled enclosures shall be high efficiency type. Motors provided as an integral part of motor driven equipment are excluded from this requirement if a minimum seasonal or overall efficiency requirement is indicated for that equipment by the provisions of another section.

Minimum Motor Efficiencies

HP	Std. Efficiency	High Efficiency
1	77.0	85.5
1.5	78.5	85.5
2	78.5	85.5
3	78.5	88.5
5	82.5	88.5
7.5	84.0	90.0
10	85.5	90.0
15	85.5	91.0
20	87.5	92.0
25	88.5	92.0
30	88.5	92.0

40	88.5	92.0
50	89.0	92.5
60	89.0	92.5
75	89.0	95.5
100	90.0	93.5
125	91.0	94.5
150	91.0	94.5
200	91.0	94.5
250	91.0	94.5
300	91.0	94.5
350	91.0	94.5
400	91.0	94.5
500	91.0	94.5

2.1.2 Motor Controls and Motor Control Centers: NEMA ICS 1, NEMA ICS 2, NEMA ICS 3 and NEMA ICS 6, and UL 508 and UL 845.

PART 3 - EXECUTION

3.1 MOTORS: Motors shall be as specified in Paragraph MATERIALS AND EQUIPMENT for motors, ac, fractional and integral horsepower 500 Hp and smaller, whether or not motors are separately provided or included in equipment assemblies specified in other sections of these specifications. Each motor shall conform to the HP and voltage ratings indicated, and shall have a service-factor and other characteristics that are essential to the proper application and performance of the motors under conditions shown or specified. Three-phase motors for use on 3-phase 208-volt systems shall have a nameplate rating of 200 volts. Unless otherwise specified, all motors shall have open frames, and continuous-duty classification based on a 40-degree C ambient temperature reference. Polyphase motors shall be induction squirrel-cage type, having normal-starting-torque and low-starting-current characteristics, unless other characteristics are specified in other sections of these specifications or shown on contract drawings. The actual horsepower ratings and other motor requirements necessary for the applications shall be as indicated. When electrically driven equipment furnished under other sections of these specifications materially differs from the design, the Contractor shall make the necessary adjustments to the wiring, disconnect devices and branch-circuit protection to accommodate the equipment actually installed.

3.2 MOTOR CONTROL: Each motor or group of motors requiring a single control and not controlled from a motor-control center shall be provided under other sections of these specifications with a suitable controller and devices that will perform the functions as specified for the respective motors. Each motor of 1/8 hp or larger shall be provided with thermal-overload protection. Polyphase motors shall have overload protection in each ungrounded conductor. The overload-protection device shall be provided either integral with the motor or controller, or shall be mounted in a separate enclosure. Unless otherwise specified, the protective device shall be of the manually reset type. Single- or double-pole tumbler switches specifically designed for alternating-current operation only may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating. Automatic control devices such as thermostats, float or pressure switches may control the starting and stopping of motors directly, provided the devices used are designed for that purpose and have an adequate horsepower rating. When the automatic-control device does not have such a rating, a magnetic starter shall be used, with the automatic-control device actuating the pilot-control circuit. When combination manual- and automatic-control is specified and the automatic-control device operates the motor directly, a double-throw, three-position tumbler or rotary switch shall be provided for the manual control; when the automatic-control device actuates the pilot control circuit of a magnetic starter, the latter shall be provided with a three-position selector switch marked HAND-OFF-AUTOMATIC. Connections to the selector switch shall be such that only the normal automatic regulatory control devices will be bypassed when the switch is in the Manual position; all safety control devices, such as low- or high-pressure cutouts, high-temperature cutouts, and motor-overload protective devices, shall be connected in the motor-control circuit in both the Manual and the Automatic positions of the selector switch. Control circuit connections to any HAND-OFF-AUTOMATIC switch or to more than one automatic regulatory control device shall be made in accordance with wiring diagram approved by the Construction Manager unless such diagram is included on the drawings. All controls shall be 120 volts unless otherwise indicated.

A. Motor Control Centers: Control centers shall be indoor type and shall contain combination starters and other equipment as indicated. Control centers shall be NEMA ICS 2, Class A, Type B. Each control center shall be mounted on floor sills or mounting channels. Each circuit shall have a suitable metal or laminated plastic nameplate with white cut letters. Combination starters shall be provided with circuit breakers. Motor control centers shall be provided with a full-length ground bus bar.

B. Contacts in miscellaneous control devices such as float switches, pressure switches, and auxiliary relays shall have current and voltage ratings in accordance with NEMA ICS 2 for rating designation B300.

C. Safety Controls for boilers shall be connected to a 2-wire, 120 volt grounded circuit supplied from the associated boiler-equipment circuit. Where the boiler circuit is more than 120 volts to ground, safety controls shall be energized through a two-winding transformer having its 120 volt secondary winding grounded. Overcurrent protection shall be provided in the ungrounded secondary conductor and shall be sized for the load encountered.

3.3 MOTOR-DISCONNECT MEANS: Each motor shall be provided with a disconnecting means when required by NFPA 70 even though not indicated. For single-phase motors, a single-or double-pole toggle switch, rated only for alternating current, will be acceptable for capacities less than 30 amperes, provided the ampere rating of the switch is at least 125 percent of the motor rating. Switches shall disconnect all ungrounded conductors.

3.4 EQUIPMENT CONNECTIONS: All wiring not furnished and installed under other sections of the specifications for the connection of electrical equipment as indicated on the drawings shall be furnished and installed under this section of the specifications. Flexible conduits 6 feet or less in length shall be provided to all electrical equipment subject to periodic removal, vibration, or movement and for all motors. All motors shall be provided with separate grounding conductors. Liquid-tight conduits shall be used in damp or wet locations.

A. Motors and Motor Control: Control equipment furnished under this section of the specifications, and shown on the drawings, shall be connected under this section of the specifications unless shown or specified otherwise. Except as otherwise specifically noted, automatic-control wiring, signaling, and protective devices are not included in this section of the specifications, but shall be furnished and installed under other sections of the specifications. Control wiring not shown on the drawings shall be furnished under the other sections of the specifications.

3.5 PAINTING AND FINISHING: Field-applied paint on exposed surfaces shall be provided under Section 09900 PAINTING, GENERAL.

3.6 REPAIR OF EXISTING WORK: The work shall be carefully laid out in advance, and where cutting, channeling, chasing, or drilling of floors, walls, partitions, ceiling, or other surfaces is necessary for the proper installation, support, or anchorage of the conduit, raceways, or other electrical work, this work shall be carefully done, and any damage to building, piping, or equipment shall be repaired by skilled mechanics of the trades involved, at no additional cost to the Institute.

3.7 TESTS: After the interior-wiring-system installation is completed, and at such time as the Construction Manager may direct, the Contractor shall conduct an operating test for approval. The equipment shall be demonstrated to operate in accordance with the requirements of this specification. The test shall be performed in the presence of the Construction Manager. The Contractor shall furnish all instruments and personnel required for the tests, and the Contractor shall furnish the necessary electric power. No part of the electrical distribution system shall be energized prior to the resistance testing of that systems ground rods and submission of test results to the Construction Manager. Test reports shall indicate the location of the rod and the resistance and the soil conditions at the time the test was performed.

END OF SECTION

SECTION 16450

TRANSFORMERS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.11	(1987) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV (0.6 kV NSV through 69 kV NSV)
ANSI C57.12.13	(1982) Conformance Requirements for Liquid-Filled Transformers Used in Unit Installations, Including Unit Substations
ANSI C57.12.27	(1982) Conformance Requirements for Liquid-Filled Distribution Transformers Used in Pad-Mounted Installations, Including Unit Substations
ANSI C57.12.50	(1981; R 1989) Ventilated Dry-Type Distribution Transformers, 1 to 500 kVA, Single-Phase, and 15 to 500 kVA, Three-Phase, with High-Voltage 601 to 34 500 Volts, Low-Voltage 120 to 600 Volts
ANSI C57.12.70	(1978; R 1993) Terminal Markings and Connections for Distribution and Power Transformers

FEDERAL SPECIFICATIONS (FS)

FS L-P-387	(Rev A; Am 1, Int Am 2) Plastic Sheet, Laminated, Thermosetting (for Designation Plastes)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C57.12.00	(1993) IEEE Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.01	(1989) Dry-Type Distribution and Power Transformers Including Those With Solid Cast and/or Resin - Encapsulated Windings
IEEE C57.12.80	(1978; R 1992) Terminology for Power and Distribution Transformers

IEEE C57.12.90	(1993) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers
IEEE C57.12.91	(1979) Test Code for Dry-Type Distribution and Power Transformers
IEEE C57.13	(1993) Instrument Transformers
IEEE C57.94	(1982; R 1987) Installation, Application, Operation and Maintenance of Dry-Type General Purpose Distribution and Power Transformers
IEEE C57.98	(1993) Guide for Transformer Impulse Tests
IEEE C57.100	(1986) Test Procedure for Thermal Evaluation of Oil-Immersed Distribution Transformers
IEEE C57.105	(1978; R 1987) Transformers Connections in Three-Phase Distribution Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ST 20	(1992) Dry-Type Transformers for General Applications

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1993) National Electrical Code
NFPA 101	(1994) Safety to Life from Fire in Buildings and Structures

UNDERWRITERS LABORATORIES (UL)

UL 506	(1994; Rev Jul 1994) Specialty Transformers
UL 1561	(1994) Dry-Type General Purpose and Power Transformers

1.2 GENERAL

A. Rules: The installation shall conform to the requirements of NFPA 70 and NFPA 101, unless more stringent requirements are indicated herein or shown.

B. Coordination: The drawings indicate the extent and the general location and arrangement of equipment. The Contractor shall become familiar with all details of the work and verify all dimensions in the field so that the outlets and equipment shall be properly located and readily accessible. If any conflicts occur necessitating departures from the drawings, details of and reasons for departures shall be submitted and approved prior to implementing any change.

C. Special Environments

1. Weatherproof Locations: Wiring, fixtures, and equipment in designated locations shall conform to NFPA 70 requirements for installation in damp or wet locations.

D. Standard Products: Material and equipment shall be a standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

E. Identification Nameplates: Major items of electrical equipment and major components shall be permanently marked with an identification name to identify the equipment by type or function and specific unit number as indicated. Designation of motors shall coincide with their designation in the motor control center or panel. Unless otherwise specified, all identification nameplates shall be made of laminated plastic in accordance with FS L-P-387 with black outer layers and a white core. Edges shall be chamfered. Plates shall be fastened with black-finished round-head drive screws, except motors, or approved nonadhesive metal fasteners. When the nameplate is to be installed on an irregular-shaped object, the Contractor shall devise an approved support suitable for the application and ensure the proper installation of the supports and nameplates. In all instances, the nameplate shall be installed in a conspicuous location. At the option of the Contractor, the equipment manufacturer's standard embossed nameplate material with black paint-filled letters may be furnished in lieu of laminated plastic. The front of each panelboard, motor control center, switchgear, and switchboard shall have a nameplate to indicate the phase letter, corresponding color and arrangement of the phase conductors. The following equipment, as a minimum, shall be provided with identification nameplates:

Minimum 1/4 Inch High Letters	Minimum 1/8 Inch High Letters
Transformers	Control Power Transformers
Equipment Enclosures	Control Devices
	Instrument Transformers

1. Each panel, section, or unit in motor control centers, switchgear or similar assemblies shall be provided with a nameplate in addition to nameplates listed above, which shall be provided for individual compartments in the respective assembly, including nameplates which identify "future," "spare," and "dedicated" or "equipped spaces."

F. As Built Drawings: Following the project completion or turnover, within 30 days the Contractor shall furnish 2 sets of as built drawings to the Construction Manager.

1.3 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Reports of Materials and Equipment: The label or listing of the Underwriters Laboratories, Inc., shall be accepted as evidence that the materials or equipment conform to the applicable standards of that agency. In lieu of this label or listing, a statement from a nationally recognized, adequately equipped testing agency indicating that the items have been tested in accordance with required procedures and that the materials and equipment comply with all contract requirements will be accepted. However, materials and equipment installed in hazardous locations must bear the UL label unless the data submitted from other testing agency is specifically approved in writing by the Construction Manager.

1.4 WORKMANSHIP: Materials and equipment shall be installed in accordance with recommendations of the manufacturer and as shown.

PART 2 - PRODUCTS

2.1 CONVENTIONAL DRY-TYPE TRANSFORMERS

A. Transformers shall comply with applicable requirements of IEEE C57.12.01, ANSI C57.12.10, IEEE C57.12.80, IEEE C57.12.91, IEEE C57.94, IEEE C57.98, IEEE C57.105 and UL 1561 in addition to the specific standards referenced below.

1. Distribution: Ventilated, 1 to 500 kVA, single-phase, and 15 to 500 kVA, three-phase with high-voltage 601 to 34500 volts, low-voltage 120-600 volts: ANSI C57.12.50.

2. Power: Ventilated, 501 kVA and larger, three-phase with high-voltage 601 to 34500 volts, low-voltage 208Y/120 to 4160 volts: ANSI C57.12.51.

3. Power: Sealed, 501 kVA and larger, three-phase with high-voltage 601 to 34500 volts, low-voltage 208Y/120 to 4160 volts: ANSI C57.12.52.

4. Specialty or General Applications: NEMA ST 20 and UL 506 unless otherwise shown or specified.

5. Instrument: ANSI C12.11 and IEEE C57.13 with current ratio or voltage ratings shown or specified.

2.2 LIQUID FILLED AND LIQUID IMMERSED: Transformers shall comply with applicable requirements of IEEE C57.12.00, ANSI C57.12.10, ANSI C57.12.13, ANSI C57.12.27, ANSI C57.12.70, IEEE C57.12.80, IEEE C57.12.90, IEEE C57.98, IEEE C57.100, and IEEE C57.105, including transformers having mineral oil, silicone or high molecular weight hydrocarbon dielectrics to be installed in an interior vault as shown.

PART 3 - EXECUTION

3.1 TRANSFORMERS:

A. Only single- and three-phase transformers having two windings per phase will be approved. Full-capacity standard NEMA taps shall be provided in the primary windings of transformers having a primary rating in excess of 600 volts. Three-phase transformers shall be connected only in a delta-wye or wye-delta configuration, as indicated except isolation transformers having a one-to-one turns ratio. "T" connections may be used for transformers rated at 15 kVA or below. The insulation on transformer windings may be the manufacturer's standard for transformers rated for operation in a 40-degree Celsius ambient temperature unless a higher-temperature insulation is shown, specified or required by the application indicated. Dual kVA ratings requires that transformers be equipped for forced-air cooling. Forced-air-cooling shall include the fans and control circuits necessary to energize the fans when the self-cooling temperature rating is attained, and to de-energize the fans when the self-cooling temperature rating is reached following operation at a higher operating temperature. Transformers rated above 300 kVA shall be equipped with features to permit the future addition of cooling fans, control circuit devices and wiring. The basic impulse level (BIL) of individual transformers shall be as stated in the following paragraphs. The conventional dry-type transformer shown located within 5 feet of the exterior wall shall be provided in a weatherproof enclosure. Transformers to be located within the building may be provided in the manufacturer's standard, ventilated indoor enclosure designed for use in a 40-degree Celsius ambient temperature, unless otherwise specified or shown. The average sound level in decibels (dB) of transformers shall not exceed the following dB level for the applicable kVA rating range listed:

kVA RANGE	dB SOUND LEVEL
1-50	40
51-150	45
151-300	48
301-500	50
501-700	52
501 & above	54

B. Conventional Dry-Type Transformers: Transformers having the primary or higher-voltage winding rated at 600 volts or less and a secondary or lower-voltage winding rated at 240 volts or less may be manufacturer's standard ventilated or enclosed, self-cooled type of transformer unless otherwise shown, specified or required for proper and safe application. Transformers shown with primary ratings in excess of 600 volts shall have the NEMA 220-degree C insulation and shall be rated for a temperature rise of 80 degrees C above ambient. Similarly, transformers having primary windings rated at 480 volts or less and a kVA rating of 150 or larger shall have Class H insulation and be suitable for an 80-degree C temperature rise above ambient. The percent voltage impedance for the transformer shown to supply all facility power demands shall be 5.75 as required to limit the available fault current to less than the ampere-interrupting-capacity of the equipment supplied through the power supply transformer shown. These distribution transformers shall have a basic impulse level (BIL) rating not less than the ANSI standard BIL rating for the mineral-oil insulated type of transformer having the same voltage classification or rating as the dry-type of transformer proposed for installation not less than [95] [110] [125] kV for the distribution voltage shown to supply the facility power demands.

C. Liquid-Insulated Transformers: Transformers may be the mineral-oil insulated, silicone, or the high-molecular-weight-hydrocarbon (HMWH) type. Each of these liquid-insulated or dielectric types of transformers shall be installed in the fire-resistant vault shown, which will be equipped with fire detection, suppression and associated control circuits. These types of transformers shall have the VA and voltage ratings shown, and shall be provided with pressure-relief devices and relays required for safe application in an interior environment. The type or types of transformer proposed for supplying the peak power demands of the facility shall be suitable for operation in an ambient temperature of 40 degrees Celsius without exceeding a temperature rise of 80-degrees Celsius under full-load operation. The type or types of transformer proposed shall have a percent voltage impedance as indicated on the drawings. The basic impulse level (BIL) rating of primary transformer windings shall comply with the ANSI standard requirement for the mineral-oil insulated type of transformer having a voltage rating the same as the voltage rating of the distribution voltage shown to supply the facility power transformer.

3.2 TESTS: After the interior-wiring-system installation is completed, and at such time as the Construction Manager may direct, the Contractor shall conduct an operating test for approval. The equipment shall be demonstrated to operate in accordance with the requirements of this specification. Continuity test shall be conducted on the telephone wiring system. No part of the electrical distribution system shall be energized prior to the resistance testing of that systems ground rods.

END OF SECTION

SECTION 16455

SECONDARY GROUNDING

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B 3	(1990) Standard Specification for Soft or Annealed Copper Wire

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8	(1989) Specification for Filler Metals for Brazing

INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS (IEEE)

IEEE Std 81	(1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

MILITARY STANDARDS (MIL-STD)

MIL-STD 889	(Rev B, Notice 2) Dissimilar Metals

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1993) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 467	(1984; 6th Ed; Nov 14, 1986) UL Standard for Safety Grounding and Bonding Equipment

1.2 GENERAL REQUIREMENTS: Section 16003, "General Electrical Provisions," applies to work specified in this section. Section 05055, "Welding Steel Construction," applies to work specified in this section.

1.3 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data

1. Equipment and Performance Data shall be submitted for the following items including use life, system functional flows, safety features, and mechanical automated details.

Grounding Rods
Ground Wires
Connectors and Fasteners
Bonding Materials
Accessories

2. Manufacturer's Catalog Data shall be submitted for the following items:

Grounding Rods
Ground Wires
Connectors and Fasteners
Bonding Materials
Accessories

B. Drawings

1. As-Built Drawings shall indicate the location of ground rods, mats, grids, building ground bus, supplementary grounding electrodes, steel building columns, and other metal structures connected to the grounding system.

2. Location of each ground rod and ground-rod assembly and other grounding electrodes shall be identified by letter in alphabetical order and keyed to the record of ground-resistance tests.

C. Manufacturer's Instructions shall be submitted for the Grounding Systems including special provisions required to install equipment components and system packages. Special notices shall detail impedances, hazards and safety precautions.

D. Schedules: Material, Equipment, and Fixture Lists shall be submitted for Grounding Systems including manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

E. Test Reports shall be submitted for the following tests on grounding systems in accordance with the paragraph entitled, "Field Tests," of this section. Report shall include certified record of ground-resistance tests on each driven ground rod, ground rod assembly, and other grounding electrodes. Record shall include the number of rods driven and their depth at each location to meet the required resistance-to-ground measurements specified. A statement shall be included describing the condition of the soil at the time of measurement.

Bond Resistance Tests
Grounding Resistance Tests
Ground Isolation Tests
Continuity Isolation Tests

PART 2 - PRODUCTS

2.1 GROUND RODS

A. Ground rods shall conform to the requirements of UL 467.

B. Ground rods shall be copper-clad steel rods not less than 5/8 inch in diameter and not less than 10-feet long per section. Ground rods shall be clean and smooth and have a cone-shaped point on the first section and shall be die-stamped near the top with the name or trademark of the manufacturer and the length of the rod in feet.

2.2 GROUND WIRES

A. Ground wires shall be in accordance with Section 16150, "Standard Wiring Systems."

B. Ground and bond wires for substations, main panels and distribution points, and ground rod connections shall be annealed bare copper conforming to ASTM B 3, stranded, with 98 percent conductivity. Wire size shall be in accordance with the grounding requirements of NFPA 70.

C. Ground wires for equipment receptacles and for noncurrent carrying hardware, installed in conduit shall be soft drawn copper, in accordance with ASTM B 3, stranded, with green insulation. Wire size shall be as noted.

2.3 CONNECTORS AND FASTENERS

A. Grounding and bonding fasteners and connectors shall conform to the requirements of UL 467, and Section 16150, "Standard Wiring Systems."

B. Grounding and bonding fasteners shall be copper for interior use and bronze for exterior use.

C. Equipment bonding straps and jumpers shall be copper and shall have a cross-sectional area of not less than No. 6 AWG. Bonding straps and jumpers for shock-mounted devices with movable joints shall be made of [flat] [tinned-copper] woven-wire braid wire.]

PART 3 - EXECUTION

3.1 BONDING AND GROUNDING: Bonding and grounding requirements shall be in accordance with NFPA 70.

3.2 GROUNDING ELECTRODES

A. Grounding electrodes shall include ground rods installed expressly for grounding systems.

B. Minimum ground rod section length shall be 10 feet. Sections shall be threaded together and exothermically fusion welded.

C. Ground rods exposed to view shall be driven so that the top of the rod is 4 inches above grade.

D. Ground rods in ground wells shall be driven so that the top of the rod is not less than 6 inches below finished grade.

3.3 GROUND GRIDS

A. Ground grids shall consist of a series of ground rods installed with interconnecting grounding conductors between ground rods. Ground rods shall be spaced as noted.

B. Ground grid shall be buried not less than 18 inches below the finish grade. Grounding conductors shall be not less than No. 1/0 AWG and shall be exothermically fusion welded together at crossover points and to ground rods.

3.4 BUILDING GROUNDS

A. Steel framework of the building shall be grounded with a driven ground rod at the base of every corner column and intermediate exterior columns at distances not greater than 100-feet apart. Grounding conductor shall be electrically connected to each ground rod and to each identified steel column and shall extend around the perimeter of the building as indicated on the drawings. Grounding-conductor loop around the perimeter of the building shall be not less than No. 1/0 AWG. Tap connections from the ground loop to the building steel shall be not less than No. 1/0 AWG.

B. Building ground shall be buried not less than 18 inches below grade and 5 feet from the building foundation. Interconnecting grounding conductor between ground grid and building grounds shall be not less than No. 1/0 AWG.

3.5 EQUIPMENT GROUNDING

A. Metallic raceway systems shall have electrical continuity with equipment individually and directly connected to the building ground, independent of the raceway system.

B. Enclosures for panelboards shall be individually and directly connected to the building ground. Grounding conductor shall be not less than No. 1/0 AWG and shall be connected from the building ground to a copper ground-bus terminal strip located in each panelboard.

C. Polarized receptacles, lighting fixtures, and equipment enclosures shall be grounded with an identified (green color) insulated conductor, not smaller than No. 12 AWG, connected to the branch circuit ground-bus terminal strip. Ground-bus terminal strip in each panelboard enclosure shall be isolated and independent of the system neutral terminal strip.

D. Indoor substations, transformers, switchboard frames, motors, generators, frames and tracks of cranes, and other miscellaneous equipment shall be individually and directly connected and grounded to the building ground. Current-carrying capacity of the grounding conductor shall be the same as the current-carrying capacity of the power conductors for circuits utilizing power lines size No. 2 AWG and smaller. For circuits with power wiring larger than No. 2 AWG, the grounding conductor shall be in accordance with NFPA 70, except that the grounding conductor shall be not smaller than No. 2 AWG.

E. Noncurrent carrying metallic parts of electrical equipment, including metallic cable sheaths, conduit, raceways, and electrical structural members, shall be bonded together and connected to the ground grid or ground connection rods.

F. Isolated ground systems shall be installed for power (facility) and instrumentation (technical). Each system shall be independently connected to the building counterpoise as shown.

G. Isolated ground systems shall consist of unspliced ground wires in individual PVC conduit runs to the building counterpoise. Welding and epoxying shall conform to Section 16150, "Standard Wiring Systems."

3.6 GROUNDING CONNECTIONS

A. Ground connections shall be bonded connections in accordance with paragraph entitled, "Bonding."

B. Ground connections that are buried or in inaccessible locations shall be welded.

C. Connections in accessible locations shall be bolted. Connections to steel building columns in accessible locations shall be exothermically fusion-welded to the structure.

D. Ground connection surfaces shall be cleaned and degreased and foreign matter removed. Clad material shall not be penetrated in the cleaning process. Connection shall be made between like metals where possible. Where dissimilar metals are welded, brazed, or clamped, the weld kit manufacturer's instructions shall be followed. Connections between dissimilar metals shall not produce galvanic action.

3.7 BONDING

A. Type of Bonds: Bonding of metal surfaces shall be accomplished by welding or clamping.

1. Welding

a. Welding shall be by the exothermic process. Welding procedure shall include the proper mold and powder charge and shall conform to the manufacturer's recommendations.

b. Welding processes shall be of the exothermic fusion type that will make a connection without corroding or loosening. Process shall join all strands and shall not cause the parts to be damaged or weakened. Completed connection or joint shall be equal or larger in size than the conductors joined and shall have the same current-carrying capacity as the largest conductor. Buried ground exothermic welded connections shall be painted with a bitumastic paint.

2. Clamping: In external locations, clamping shall be used only where a disconnect type of connection is required. Connection device may utilize threaded fasteners. Device shall be constructed such that positive contact pressure shall be maintained at all times. Machine bolts with tooth-type lockwashers shall be used.

B. Cleaning of Bonding Surfaces: Surfaces that comprise the bond shall be thoroughly cleaned before joining. An appropriate abrasive shall be applied with a gentle and uniform pressure to ensure a smooth and uniform surface. Excessive metal shall not be removed from the surface. Clad metals shall be cleaned in such a manner that the cladding material is not penetrated by the cleaning process. Bare metal shall then be cleaned with an appropriate solvent to remove any grease, oil, dirt, corrosion preventives, and other contaminants. Cleaned area shall be bonded within one hour after cleaning. Joint shall be sealed and the exposed surfaces refinished within two hours to prevent oxidation. When additional time is required, a corrosion preventive compound shall be applied until the area can be refinished.

C. Bonding Straps and Jumpers

1. Jumpers shall be installed such that the vibration by the shock-mounted device shall not change its electrical characteristics.

2. Bonds shall be welded for outdoor locations unless a disconnect type of connection is required. When a disconnect is required, clamping with bolts shall be used. A tooth-type lockwasher shall be inserted between the strap and metallic member for each bolt.

3. Straps shall be bonded directly to the basic structure and shall not penetrate any adjacent parts. Straps shall be installed in an area that is accessible for maintenance.

4. Single straps shall be used for the bonds and shall be installed such that they will not restrict movement of structural members. Two or more straps shall not be connected in series.

5. Straps shall be installed such that they will not weaken structural members to which they are attached.

D. Equipment and Enclosure Bonding: Each metallic enclosure and all electrical equipment shall be bonded to appropriate ground. At least one copper connection shall be made from the system ground point to one or more enclosures in the area such that all enclosures and equipment provide a low-impedance path to ground when properly bonded together.

E. Bonding of Conduit and Raceway Systems:

1. Metal conduit, fittings, junction boxes, outlet boxes, armored and metal sheathed cable, and other raceways shall be bonded as listed below. Care shall be taken to ensure adequate electrical contact at the joints and terminations.

2. Rigid Metal Conduit and Terminations

a. Threaded connections must be wrench-tight and the unexposed internal and external threads shall be treated with a corrosion-inhibiting compound. Conduits entering boxes and enclosures shall be bonded to the box with locknuts and grounding-type bushings. Locknuts that gouge into the metal box when tightened are not acceptable.

b. Conduit systems that are interrupted by intentional PVC dielectric links shall be bonded separately on either side of the link. Dielectric link shall not be jumpered.

3. Flexible Metal Conduit shall have an integral grounding conductor.

F. Cable Tray Bonding: Cable tray sections shall be bonded together. Cable tray sections in tandem assembly shall be considered as having electrical continuity when these sections are joined with the appropriate bolts. Bond straps shall be installed across expansion joints. Cable trays shall be bonded to the building ground system.

G. Protection of Finished Bonds: Finished bonds shall be protected by painting to match the original finish after the bond is made, when painted tray is used.

3.8 FIELD TESTS: The following tests shall be performed by the Contractor in the presence of the Construction Manager.

A. Bond Resistance: Resistance of any bond connection shall not exceed 0.5 milliohm. Bonds that exceed this resistance shall be reworked by the Contractor at no additional cost to the Institute.

B. Grounding Resistance Tests:

1. Grounding systems shall be tested for ground resistance. Total resistance from any point on the ground network to the building counterpoise shall not exceed 50 milliohms using a 500 VAC megohmeter.

2. Ground resistance and counterpoise tests shall be made during dry weather, and no sooner than 48 hours after rainfall. Tests shall be conducted using the ratio method that measures the ratio of the resistance to earth of an auxiliary test electrode to the series resistance of the electrode under test and a second auxiliary electrode. Measurements shall be performed in accordance with IEEE Std 81.

3. Indicating instrument shall be self-contained and shall include a direct-current generator, synchronized current and potential reversers, crossed-current and potential coils, direct-reading ohmmeter, series resistors, and range-selector switch. Direct-reading ohmmeter shall be calibrated for ranges of 0 to 20 ohms and 0 to 200 ohms.

4. Auxiliary grounding electrodes shall be placed in accordance with instrument manufacturer's recommendations but not less than 50 feet apart, in accordance with IEEE Std 81.

C. Ground Isolation Test: Ground systems shall be tested for isolation from other ground systems.

D. Continuity Isolation Test: Continuity test shall be performed on all power receptacles to ensure that the ground terminals are properly grounded to the facility ground system.

END OF SECTION

SECTION 16470

PANELBOARDS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

ELECTRONIC INDUSTRIES ASSOCIATION (EIA)

EIA 416	(1974; R 1981) Fittings, Radio Interface
EIA 46	(1987) Test Procedure for Resistance to Soldering (Vapor Phase Technique) for Surface Mount Devices

FEDERAL STANDARDS (FED-STD)

FED-STD 595	(Rev B) Colors Used in Government Procurement

INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS (IEEE)

IEEE Std 474	(1973; R 1982) Fixed and Variable Attenuators, dc to 40 GHz Including Trial-Use Sections on Insertion-Loss Repeatability and Characteristic Insertion Loss of a Noninsertable Two-Port

MILITARY HANDBOOK (MIL-HDBK)

MIL-HDBK 232	(Rev A) Red/Black Engineering Installation Guidelines

NATIONAL ELECTRICAL MANUFACTURER'S ASSOCIATION (NEMA)

NEMA 250	(1991) Enclosures for Electric Equipment (1000 Volts Maximum)
NEMA AB 1	(1986; Rev 1 - Jan 1989) Molded Case Circuit Breakers and Molded Case Switches
NEMA PB 1	(1990) Panelboards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1993) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 67	(1988; 10th Ed; Rev thru Jun 27, 1990; Errata Aug 21, 1990) Panelboards

1.2 GENERAL REQUIREMENTS: Section 16003, "General Electrical Provisions," applies to work specified in this section.

1.3 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Manufacturer's Catalog Data shall be submitted for the following items:

Panelboards
Directory Card and Holder
Filtered Panelboard

B. Drawings

1. Detail Drawings shall be submitted for the Panelboards consisting of fabrication and assembly drawings for all parts of the work in sufficient detail to enable the Construction Manager to check conformity with the requirements of the contract documents. Drawings shall include details of bus layout.

2. Outline Drawings for Panelboards shall indicate overall physical features, dimensions, ratings, service requirements, and weights of equipment.

C. Instructions: Manufacturer's Instructions shall be submitted for Panelboards including special provisions required to install equipment components and system packages. Special notices shall detail impedances, hazards and safety precautions.

D. Reports: Test Reports shall be submitted for the following tests in accordance with the paragraph entitled, "Site Testing," of this section. Panelboards shall not be energized until the recorded test data have been submitted to and approved by the Construction Manager.

Continuity Tests
Insulation Tests

E. Samples: Keys shall then be properly tagged and delivered to the Construction Manager.

PART 2 - PRODUCTS

2.1 PANELBOARDS

A. Power-distribution panelboards and lighting and appliance branch-circuit panelboards shall be totally enclosed in a steel cabinet, dead-front circuit breaker type with copper buses, surface- or flush-mounted as indicated. Panelboards shall conform to NEMA PB 1 and NEMA AB 1.

B. Branch circuit panels shall have buses fabricated for bolt-on type circuit breakers.

C. An outer door or cover, hinged on one side, shall be provided on surface-mounted panelboards to provide gutter space access.

D. Voltage and current rating, number of phases, and number of wires shall be as indicated. Four-wire distribution panelboards and lighting and appliance branch-circuit panelboards shall be provided with an isolated full-capacity neutral bus. Panelboards shall be rated for maximum 120/208-volt, three-phase and/or 277/480-volt, three-phase, 60-hertz current.

E. Three-phase, 4-wire and single-phase, 3-wire distribution lighting and branch circuit panelboards shall be provided with an isolated full-capacity bus providing spaces for single-pole circuit breakers/switches and spaces indicated as spare.

F. Panelboards shall be provided with a separate grounding bus bonded to the enclosure, unless the panel is to have an isolated ground as indicated on the drawings. Grounding bus shall be a solid bus bar of rectangular cross section equipped with binding screws for the connection of equipment, or circuit grounding conductors.

G. Each panelboard, as a complete unit, shall have a short-circuit current rating equal to or greater than the integrated equipment rating shown on the panelboard schedule or as indicated.

H. Panelboards and main lugs or main breaker shall have current ratings as shown on the panelboard schedule.

I. Panels, as indicated, shall be equipped with open system protocol compatible with communications and control devices.

J. Bus bar connections to the branch circuit breakers shall be the "distributed phase" or "phase sequence" type. Single-phase, three-wire panelboard busing shall be such that when any two adjacent single-pole breakers are connected to opposite polarities, two-pole breakers can be installed in any location. Three-phase, four-wire busing shall be such that when any three adjacent single-pole breakers are individually connected to each of the three different phases, two- or three-pole breakers can be installed at any location. Current-carrying parts of the bus assembly shall be plated. Mains ratings shall be as shown.

K. Mechanical lugs furnished with panelboards shall be copper or copper alloys of sizes suitable for the conductors indicated to be connected thereto.

L. Boxes shall have the manufacturer's standard knockouts and shall be galvanized code-gage sheet steel. Fronts shall be of code-gage sheet steel furnished with hinged doors with adjustable trim clamps for securing the fronts to the boxes.

M. Panelboard box shall be galvanized code-gage sheet steel without knockouts. Entire panelboard front shall be hinged on one side with a piano hinge for the full height and shall also have captive screws opposite the hinged side. Where panelboards are installed flush with the walls, the installation details shall be such that the hinged front can be opened without damage to the adjacent wall surfaces. Color of the finished coat of trim and front shall be the gray finish as specified.

N. Panelboard enclosures shall be NEMA 250, Type 1. Enclosures shall be provided with hinged fronts and corrosion-resistant steel pin-tumbler cylinder locks. Locks shall be keyed alike, and two keys shall be provided for each enclosure.

O. Panelboards shall be finished with fast drying enamel. Finish color shall be No. 61 gray conforming to FED-STD 595.

2.2 CIRCUIT BREAKERS

A. Circuit breakers shall be the molded-case type as specified in Section 16475, "Overcurrent Protective Devices". Frame and trip ratings shall be as indicated.

B. Interrupting rating of circuit breakers shall be as indicated. If not shown, the interrupting rating for circuit breakers in 120/208-volt panelboards shall be not less than 10,000 amperes rms symmetrical, and that for breakers in 277/480-volt panelboards shall be not less than 25,000 amperes rms symmetrical.

C. Circuit breakers shall be bolt-on type. Plug-in type shall not be acceptable.

D. Shunt trips shall be provided where indicated.

E. In branch circuit panelboards, branch circuit breakers feeding convenience outlets shall have sensitive instantaneous trip settings of not more than 10 times the trip rating of the breaker to prevent repeated arcing shorts resulting from frayed appliance cords. Single-pole 15- and 20-ampere circuit breakers shall be UL listed as "Switching Breakers" at 120 volts ac and 277 volts ac as applicable for each panelboard. UL Class A (5-milliampere sensitivity) ground fault circuit protection shall be provided on 120-volt ac branch circuit as indicated. This protection shall be an integral part of the branch circuit breaker that also provides overload and short-circuit protection for branch circuit wiring. Tripping of a branch circuit breaker containing ground fault circuit interruption shall not disturb the feeder circuit to the panelboard. A single-pole circuit breaker with integral ground fault circuit interruption shall require no more panelboard branch circuit space than a conventional single pole circuit breaker.

F. Connections to the bus shall be bolt-on type.

G. When multiple wires per phase are specified, the circuit breakers shall be furnished with connectors made to accommodate multiple wires.

H. Circuit breaker spaces called out on the drawings shall be complete with mounting hardware to permit ready installation of the circuit breakers.

I. Circuit breakers that function under the open system protocol shall be as indicated.

2.3 DIRECTORY CARD AND HOLDER: A directory card shall be mounted on the inside of hinged fronts and doors under 0.030-inch thick minimum plastic in a metal frame, with spaces for circuit numbers, outlets controlled, and room numbers. Directory card shall identify each branch circuit with its respective and numbered circuit breaker.

2.4 FILTERED PANELBOARDS

A. General

1. Panelboards shall be designed for the distribution, control, and protection of electrical circuits, providing filtering and shielding performance and, when specified, shall conform to applicable portions of MIL-HDBK 232.

2. Panelboard cabinet shall be 12-gage steel minimum, with corrosion-resistant finish and four external mounting brackets welded to the case. Front door and trim shall be of code gage steel, with gray finish, equipped with directory, holder, adjustable trim clamps, hinges, self-latching catch, tumbler lock and key and shall bear the UL label. A red diagonal strip shall be provided across the outside surface of door and trim.

B. RF Shielding: Circuit breaker and filter compartments shall be completely radio-frequency (rf) shielded and shall comply with specified shielding requirements with front door open. Case seams shall be continuous inert gas welded. Removable circuit breaker actuator faceplate and the filter compartment cover shall be fitted with corrosion-resistant rf gasketing material and be installed in place with suitable fasteners having a maximum spacing of 3 inches on center. Rf filter units shall be mounted to the internal shield wall with similar rf gasketing to ensure rf shielding integrity.

C. Circuit Breaker Actuators: Circuit breaker operating mechanisms shall be designed to maintain rf shielding effectiveness without limit to time or number of operations.

D. Terminals: Filter terminals shall be of high-temperature alumina ceramic, continuously brazed to filter case. Soft solder shall not be used. Ceramic terminal shall incorporate a permanently attached flexible lead, with a suitable electric lug. Incoming service connections shall be made to the filter lead at a UL-approved, flame-retardant standoff insulator, mounted in the filter compartment.

E. Attenuation: Each filter unit shall provide a minimum insertion loss of 100 dB over the frequency range of 14 kilohertz (kHz) to 10 gigahertz (GHz) , measured in accordance with IEEE Std 474. Full rated load insertion loss of 100 dB in the frequency range 14 kHz to 20 megahertz (MHz), to 14 kHz shall be measured by a laboratory approved by the Construction Manager.

F. Current: Each filter unit shall be capable of carrying its full rated current continuously without heat rise exceeding 122 degrees F above ambient temperature. Each filter shall be capable of withstanding a 100-percent overload for 30 seconds without damage.

G. Voltage: Each filter unit shall be capable of continuous operation at its full rated voltage and withstanding an initial voltage test of twice its rated voltage without damage.

H. Circuit Breakers shall be rated minimum 10,000 amperes asymmetrical ac interrupting capacity, 5,000 amperes dc, and shall be in accordance with NEMA AB 1.

I. RF Filters

1. RF filter units shall be designed to suppress and reduce the amplitude of undesired rf energy conducted by power service lines. Rf filter units shall be designed in compliance with the applicable requirements of EIA 416.

2. Filter cases shall be made of steel, 16-gage minimum, corrosion-resistant finish with a blue lacquer over zinc chromate primer. Conductive grounding surfaces shall be either plated or made of corrosion-resistant steel. Hermetic seams shall be continuous inert gas welded; no soft solder shall be used. Internal components shall be firmly mounted to withstand applicable shock and vibration test requirements without damage.

3. Fluid impregnant shall conform to UL nonflammable classification. Internal components shall be fully impregnated and intimately immersed in the fluid to obtain the full benefit of cooling by convection flow through the liquid medium to filter case. Filter case shall be completely filled with the fluid impregnant.

J. Filter Discharge Unit: A filter discharge unit for three-filtered circuits shall be installed on the panelboard. Unit shall meet applicable requirements of EIA 46, and shall be installed in accordance with NFPA 70.

2.5 FACTORY TESTING: Complete panelboards shall be tested in accordance with UL 67.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Panelboards shall be installed as indicated and in accordance with the manufacturer's instructions. Panels shall be fully aligned and mounted so that the height of the top operating handle will not exceed 72-inches above the finished floor.

B. Directory-card information shall be typewritten in capital letters to indicate outlets controlled and final room numbers served by each circuit and shall be mounted in holders behind protective covering.

3.2 SITE TESTING

A. Each panelboard enclosure key shall be shown to operate the enclosure locks in the presence of the Construction Manager.

B. Panelboards shall be given continuity and insulation tests after the installation has been completed and before the panelboard is energized.

C. Test equipment, labor, and personnel shall be provided by the Contractor as required to perform the tests as specified. Continuity tests shall be conducted using a dc device with audible signal.

D. Insulation tests on 480-volt panelboards shall be conducted using a 1,000-volt insulation-resistance test set. Readings shall be recorded every minute until three equal and consecutive readings have been obtained. Resistance between phase conductors and between phase conductors and ground shall be not less than 50 megohms.

E. Insulation tests on panelboards rated 300 volts or less shall be conducted using a 500-volt minimum insulation-resistance test set. Readings shall be recorded after 1 minute and until the reading is constant for 15 seconds. Resistance between phase conductors and between phase conductors and ground shall be not less than 25 megohms.

F. Test data shall be recorded and shall include the location and identification of panelboards and megohm readings versus time and local weather conditions.

END OF SECTION

SECTION 16480

MOTOR CONTROL

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

NATIONAL ELECTRICAL MANUFACTURER'S ASSOCIATION (NEMA)

NEMA ICS 2	(1988) Industrial Control Devices, Controllers and Assemblies

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1993) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 845	(1988; 3rd Ed; Aug 1, 1989) UL Standard for Safety Motor Control Centers

1.2 GENERAL REQUIREMENTS:Section 16003, "General Electrical Provisions," applies to work specified in this section.

1.3 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Manufacturer's Catalog Data shall be submitted for the following items:

Motor-Control Centers
Motor Control Units
Accessories

B. Drawings

1. Connection Drawings shall be submitted showing the relations and connections of the following items by showing the general physical layout of all controls, the interconnection of one system (or portion of system) with another, and internal tubing, wiring, and other devices.

Control Devices
Protective Devices

2. Installation Drawings shall be submitted for the following items in accordance with the paragraph entitled, "Installation," of this section.

Control Devices
Protective Devices

C. Instructions: Manufacturer's Instructions shall be submitted for the following including special provisions required to install equipment components and system packages. Special notices shall detail impedances, hazards and safety precautions.

Control Devices
Protective Devices

D. Certificates of Compliance shall be submitted for Circuit Tests on similar motor-control or motor-circuit protector (MCP) units under actual conditions may be submitted in lieu of factory tests on the actual units provided.

1.4 SHIPPING: Motor control centers longer than 8 feet shall be shipped in coordinated subassemblies for field connection. Maximum shipping length shall be as approved.

PART 2 - PRODUCTS

2.1 EQUIPMENT: Motor-control centers shall conform to NEMA ICS 2, UL 845 and NFPA 70.

2.2 CONFIGURATION: Motor-control centers shall be NEMA ICS 2, Class I, Type B, totally enclosed, free-standing, dead-front distribution type with one or more vertical sections in which combination motor-control units, and associated control equipment units are group-mounted in an integrated assembly.

2.3 CONSTRUCTION

A. Motor-control centers shall be accessible from the front only..

B. Provisions shall be made for leveling the entire assembled motor-control center sections and bolting them together so that they form a contiguous structural enclosure.

C. Motor-control centers shall contain electrical interlocks, unit control terminal blocks, master control terminal blocks, unit wiring to terminal blocks and unit interconnections, and power connection terminal blocks as required.

D. Covers for motor-control centers shall be fabricated from cold-rolled carbon-steel sheets of commercial quality with stretcher-level flatness. Vertical sections shall be reinforced to form a rigid structure.

E. Lifting angles shall be 7 gage, and shall be provided on the top of each section, and shall extend the entire width of the section, and shall be capable of supporting the entire weight of the motor-control center section without distortion. Base channels shall be provided with holes to facilitate floor mounting and leveling.

F. Design of the motor-control centers shall allow addition of sections with the same height and width without major modifications. Top cover shall not sag or be deformed.

G. Top and sides shall have removable covers secured with bolts or fasteners. Access doors to motor-control drawout units, wiring channels, and the protective cover of the main horizontal bus shall provide dead front construction.

H. Horizontal wiring channels shall be provided in the top and bottom of motor-control centers for wiring between vertical sections. Wiring channels shall extend the entire length of the motor-control center and shall allow space for duct and conduit entrances. Vertical wiring channels shall be provided in each vertical section for side wiring to individual motor-control units. Vertical wiring channels shall extend the entire length of each vertical section. Covers of motor-control units and vertical wiring channels shall be side-hinged to the vertical section and fastened in the closed position with captive bolts, screws, or latches.

Horizontal wiring channel covers shall be removable and fastened in place with captive bolts or screws. A removable steel-plate barrier shall be provided at the top of each vertical structure to isolate the main horizontal bus from the horizontal wireway.

I. Horizontal bus structure shall extend the entire length of the motor-control center and shall be tinned copper with a continuous rating as indicated on the single-line diagram.

J. All vertical sections shall be completely bused (300-ampere rating)and electrically interconnected with silver-plated solid copper busbars to accommodate plug-in starter units with main horizontal and vertical buses uniformly positioned and phase sequenced. Main horizontal buses shall be readily accessible for connection of future vertical sections at either end.

K. Vertical sections shall have a width not less than 20 inches.

L. Buses shall be supported and braced to withstand the short-circuit currents indicated. Contact surfaces of main buses shall be silver plated and bolted together to ensure conductivity.

M. Main incoming lug compartments shall be provided.

N. A continuous rigid silver-plated copper ground bus shall extend through the bottom of the entire assembly and shall ground the stationary structure and equipment. Ground bus shall be capable of carrying the rated short-circuit current available in the motor-control center.

O. After fabrication, steel surfaces of motor-control centers shall be cleaned and phosphatized prior to the application of paint. External and internal surfaces shall be finished with baked enamel or a fast air-drying enamel. Color of internal and external finishes shall be the manufacturer's standard. Nonpainted parts shall be phosphatized or cadmium plated.

2.4 COMBINATION MOTOR-CONTROL UNITS

A. Combination motor-control units for the control and protection of single-and three-phase, 60-hertz squirrel-cage induction motors with branch-circuit disconnection and protective devices shall include magnetic motor-controllers, molded-case circuit breakers, or motor circuit protectors in compartmentalized draw-out unit construction with fused control-power transformers, selector switches, pushbuttons, and indicating lights, as indicated. Motor control and protective devices shall conform to the requirements of Section 16475, "Overcurrent Protective Devices."

B. Unit spaces in vertical sections shall be provided with guide rails for the support and alignment of motor-control draw-out units. Plug-in units shall be interchangeable.

C. Draw-out unit shall be provided with spring-loaded, silver-plated, plug-in stabs for connection to the main bus on the line side of the motor-control unit and fixed terminal blocks for the load-side connections. Wiring shall be accessible from the front. No wiring shall extend into the bus compartment. Unit control wiring terminal blocks shall be the split type, allowing unit removal without disturbing outgoing control wires.

D. Motor-control units shall be provided with a single separate hinged door interlocked with its associated disconnecting device to prevent access to draw-out units when the circuit breaker contacts are closed and the operating handle is in the "ON" position. Doors shall swing open a minimum of 110 degrees. An interlock release shall be provided, however, to defeat the interlocking mechanism and permit access to the draw-out unit using a simple hand tool.

E. Doors shall be provided with openings for the operating handle of molded-case circuit breakers, thermal-overload relay reset buttons, indicating lights, selector switches, and pushbuttons as required.

F. Disconnect switch overload reset button, selector switches, and any indicating lights and pushbuttons shall be operable with the compartment door closed. The ON-OFF position of the main disconnect method shall be clearly indicated with the door closed.

G. Feeder tap units shall include externally operable molded-case circuit breakers in combination motor-control unit enclosures for the protection of nonmotor loads or remotely located magnetic motor-controllers. Not more than two molded-case circuit breakers shall be contained in feeder tap units.

H. Compartments for future combination motor-control units shall be complete with hardware, buses, and hinged doors ready to receive future draw-out units. Compartments for spare combination motor-control units shall be complete with buses, hinged doors, and draw-out units but without terminal connections. Spare spaces shall be complete with buses and screwed-on front cover plates.

I. Combination motor-control units shall be identified with identification plates affixed to the front hinged door or cover plate of each compartment. Identification plate shall identify the connected load.

PART 3 - EXECUTION

3.1 INSTALLATION: Complete assembly shall be electrically and mechanically connected and assembled from coordinated subassemblies shipped in complete sections from the manufacturer. Installation shall be aligned, leveled, and secured to the supporting construction in accordance with the manufacturer's recommendations.

3.2 FIELD TESTING

A. Motor-control centers shall be subjected to continuity and insulation tests after the installation has been completed and before the motor-control centers are energized.

B. Contractor shall provide test equipment, labor, and personnel to perform the tests required. Continuity tests shall be conducted using a dc device with audible signal.

C. Motor-control centers shall be completely isolated from extraneous electrical connections. Substation feeder breakers, circuit breakers in switchboards, and other disconnecting devices shall be used to isolate the motor-control center under test.

D. Insulation tests on 480-volt motor-control centers shall be conducted using a 1,000-volt insulation-resistance test set. Readings shall be recorded every minute until three equal and consecutive readings are obtained. Resistance between phase conductors and between phase conductors and ground shall be not less than 50 megohms.

E. Phase-rotation tests shall be conducted on all three-phase circuits using a phase-rotation indicating instrument. Phase rotation of electrical connections to motors and other connected equipment shall be clockwise.

F. Test data shall be recorded and shall include location, weather conditions, and identification of motor-control centers and megohm readings versus time.

G. Final acceptance shall depend upon the satisfactory performance of the motor-control centers under test. No motor-control center shall be energized until recorded test data have been approved by the Construction Manager.

END OF SECTION

SECTION 16500

LAMPS AND LIGHTING

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C82.1	(1985; C82.1a; C82.1b; C82.1c; R 1992) Ballasts for Fluorescent Lamps
ANSI C82.4	(1992) Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps (Multiple-Supply Type)

CODE OF FEDERAL REGULATIONS (CFR)

47 CFR 18	Rules and Regulations:Industrial, Scientific, and Medical Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41	(1991) Surge Voltages in Low-Voltage AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA LE 4	(1987) Recessed Luminaires, Ceiling Compatibility

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1993) National Electrical Code
NFPA 101	(1994) Safety to Life from Fire in Buildings and Structures

UNDERWRITERS LABORATORIES (UL)

UL-03	(1993; Supple) Electrical Construction Materials Directory
UL 542	(1994) Lampholders, Starters, and Starter Holders for Fluorescent Lamps
UL 924	(1990; Rev thru Aug 1994) Emergency Lighting and Power Equipment
UL 935	(1993; Rev thru Apr 1994) Fluorescent-Lamp Ballasts
UL 1029	(1994; Rev Apr 1994) High-Intensity-Discharge Lamp Ballasts

UL 1570	(1988; Rev thru Jul 1994) Fluorescent Lighting Fixtures
UL 1571	(1991; Rev thru Nov 1994) Incandescent Lighting Fixtures
UL 1572	(1991; Rev thru Nov 1994) High Intensity Discharge Lighting Fixtures

1.2 GENERAL

A. Rules: The installation shall conform to the requirements of NFPA 70 and NFPA 101, unless more stringent requirements are indicated herein or shown.

B. Coordination: The drawings indicate the extent and the general location and arrangement of equipment, conduit, and wiring. The Contractor shall become familiar with all details of the work and verify all dimensions in the field. Lighting fixtures, outlets, and other equipment and materials shall be located to avoid interference with mechanical or structural features; otherwise, lighting fixtures shall be symmetrically located according to the room arrangement when uniform illumination is required, or asymmetrically located to suit conditions fixed by design and shown. Lighting fixtures shall not be supported from sheet metal roof decks. If any conflicts occur necessitating departures from the drawings, details of and reasons for departures shall be submitted and approved prior to implementing any change.

C. Special Environments

1. Weatherproof Locations: Wiring, fixtures, and equipment in designated locations shall conform to NFPA 70 requirements for installation in damp or wet locations.

D. Standard Products: Material and equipment shall be a standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

E. As Built Drawings: Following the project completion or turnover, within 30 days the Contractor shall furnish 2 sets of as built drawings to the Construction Manager.

1.4 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Reports, Materials and Equipment: The label or listing of the Underwriters Laboratories, Inc., shall be accepted as evidence that the materials or equipment conform to the applicable standards of that agency. In lieu of this label or listing, a statement from a nationally recognized, adequately equipped testing agency indicating that the items have been tested in accordance with required procedures and that the materials and equipment comply with all contract requirements will be accepted. However, materials and equipment installed in hazardous locations must bear the UL label unless the data submitted from other testing agency is specifically approved in writing by the Construction Manager.

1.4 WORKMANSHIP: Materials and equipment shall be installed in accordance with recommendations of the manufacturer and as shown.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Fixtures to be installed shall be as shown on drawings, including ballasts, lampholders, lamps, starters and starter holders, and shall conform to industry standards specified below.

B. Fixture, Auxiliary or Emergency: UL 924.

C. Fluorescent

1. Fixture: NEMA LE 4 for ceiling compatibility of recessed fixtures and UL 1570. Fixtures shall be plainly marked for proper lamp and ballast type to identify lamp diameter, wattage, color and start type. Markings shall be readily visible to service personnel, but not visible from normal viewing angles.

2. Ballasts:

a. Magnetic Ballast, Energy-Saving, High Power Factor, Class P, Automatic-Resetting Type, approved for the application by the Certified Ballast Manufacturers:ANSI C82.1 and UL 935. Two-lamp ballasts shall be used for each pair of lamps within a fixture or within continuous mounted fixtures. Single-lamp ballasts shall be used for individually mounted single-lamp fixtures and where an odd single-lamp fixture occurs at the end of a continuous group. Magnetic fluorescent lamp ballasts shall have a Ballast Efficacy Factor (BEF) not less than shown in the following Table:

MAGNETIC FLUORESCENT BALLAST EFFICACY FACTORS*
Design starting temperature above 40 degrees F, with 60 Hz input frequency

NUMBER OF LAMPS	LAMP TYPE INPUT	NOMINAL OPERATIONAL VOLTAGE	MAX. LAMP OPERATING CURRENT	MIN. BALLAST EFFICACY FACTOR
1	4 ft rapid start	120 or 277	less than 1000 m amp	1.805
2	4 ft rapid start	120	less than 1000 m amp	1.060
2	4 ft rapid start	277	less than 1000 m amp	1.050

* For ballasts not specifically designed for use with dimming controls

The BEF is calculated using the formula:
BEF = Ballast Factor (in percent) / Power Input
where Power Input = Total Wattage of Combined Lamps and Ballasts.

b. Electronic Ballast.Electronic ballasts shall consist of a rectifier, high frequency inverter, and power control and regulation circuitry. The ballasts shall be UL listed, Class P, with a Class A sound rating and shall contain no PCBs. Ballasts shall meet 47 CFR 18 for electromagnetic interference and shall not interfere with the operation of other electrical equipment. Design shall withstand line transients per IEEE C62.41, Category A. Unless otherwise indicated, the minimum number of ballasts shall be used to serve each individual fixture, using one, two, three or four lamp ballasts. A single ballast may be used to serve multiple fixtures if they are continuous mounted, factory manufactured for that installation with an integral wireway and are identically controlled.

1) Light output regulation shall be plus or minus 10 percent.

2) Voltage input regulation shall be plus or minus 10 percent.

3) Lamp current crest factor shall be no more than 1.7.

4) Ballast factor shall be not less than 85 percent nor more than 100 percent, unless otherwise indicated.

5) A 60 Hz filter shall be provided. Flicker shall be no more than 15 percent with any lamp suitable for the ballast.

6) Ballast case temperature shall not exceed 25 degree celsius rise above 40 degree celsius ambient, when tested in accordance with UL 935.

7) Input current third harmonic shall not exceed 32 percent total harmonic distortion or 27.5 percent of the third triplens.

8) Power factor shall not be less than 0.9.

9) Ballasts shall operate at a frequency of 20 KHz or more.

10) Operating filament voltage shall be 2.5 to 4.5 volts.

11) Warranty. Three year full warranty including a $10 labor allowance.

12) Ballast Efficacy Factor (BEF) shall be in accordance with the following Table. Ballasts and lamps shall be matching rapid start or instant start as indicated on the following Table. If 32W-F32-T8 lamps and ballasts are used, they must be either all rapid start or all instant start.

ELECTRONIC FLUORESCENT BALLAST EFFICACY FACTORS*

LAMP TYPE	TYPE OF STARTER & LAMP	NOMINAL OPERATIONAL INPUT VOLTAGE	NUMBER OF LAMPS	MIN. BALLAST EFFICACY FACTOR
40W F40 T12	rapid start	120 or 277 V	1	2.3
			2	1.2
			3	0.8
			4	0.6

34W F40 T12	rapid start	120 or 277 V	1	2.6
			2	1.3
			3	1.0
			4	0.7
40W F40 T10	rapid start	120 or 277 V	1	2.2
			2	1.1
			3	0.8
32W F32 T8 instant start	rapid or	120 or 277 V	1	2.4
			2	1.4
			3	1.0
			4	0.8

*For ballasts not specifically designed for use with dimming controls

The BEF is calculated using the formula:
BEF = Ballast Factor (in percent) / Power Input
where Power Input = Total Wattage of Combined Lamps and Ballasts

13) The total harmonic current distortion shall be less than 10 percent.

c. Lampholders, Starters, and Starter Holders:UL 542.

4. High-Intensity-Discharge

a. Fixture: NEMA LE 4 for ceiling compatibility of recessed fixtures and UL 1572.

b. Ballasts: ANSI C82.4 for multiple supply types and UL 1029.

PART 3 - EXECUTION

3.1 WIRING METHODS:

A. Unless otherwise indicated, wiring shall consist of insulated conductors installed in rigid zinc-coated steel conduit, electrical metallic tubing, or intermediate metal conduit. Metallic-armored cables may be installed in areas permitted by NFPA 70.

B. Sizes shall be not less than indicated.Branch-circuit conductors shall be not smaller than No. 12 AWG. Conductors for branch circuits of 120 volts more than 100 feet long and of 277 volts more than 230 feet long, from panel to load center, shall be no smaller than No.10 AWG.

3.2 LAMPS AND LIGHTING FIXTURES: Ballasted fixtures shall have ballasts which are compatible with the specific type and rating of lamps indicated and shall comply with the applicable provisions of the publications referenced.

A. Lamps of the type, wattage, and voltage rating indicated shall be delivered to the project in the original cartons and installed in the fixtures just prior to the completion of the project.

1. Incandescent lamps shall be for 125-volt operation unless otherwise indicated.

2. Fluorescent lamps for magnetic ballasts shall have standard cool-white color characteristics and shall be of a type that will not require starter switches. Lamps shall be of

the rapid-start type unless otherwise shown or approved. Fluorescent lamps for electronic ballasts shall be as indicated.

3. High-Intensity-Discharge lamps shall be the metal halide type unless otherwise indicated, shown, or approved.

B. Fixtures shall be as shown on the drawings. Fixtures of similar designs and equivalent energy efficiency, light-distribution and brightness characteristics, and of equal finish and quality will be acceptable if approved. In suspended acoustical ceilings with fluorescent fixtures, the fluorescent emergency light fixtures shall be furnished with self-contained battery packs.

1. Accessories such as straps, mounting plates, nipples, or brackets shall be provided for proper installation. Open type fluorescent fixtures with exposed lamps shall have a wire-basket type guard.

2. Suspended fixtures shall be provided with swivel hangers in order to ensure a plumb installation. Pendants, rods or chains 4 feet or longer, excluding fixture, shall be braced to limit swinging. Bracing shall be 3 directional, 120 degrees apart. Single-unit suspended fluorescent fixtures shall have twin-stem hangers. Multiple-unit or continuous-row fluorescent units shall have a tubing or stem for wiring at one point, and a tubing or rod suspension provided for each length of chassis including one at each end. Maximum distance between adjacent tubing or stems shall be 10 feet. Rods shall be of not less than 3/16 inch diameter. Flexible raceway shall be installed to each fixture from an overhead junction box. Fixture to fixture wiring installation is allowed only when fixtures are installed end to end in a continuous run.

3. Ceiling fixtures shall be coordinated with and suitable for installation in, on, or from the suspended ceiling provided under other sections of these specifications. Installation and support of fixtures shall be in accordance with the NFPA 70 and manufacturer's recommendations. Where seismic requirements are specified herein, fixtures shall be supported as shown or specified. Recessed fixtures shall have adjustable fittings to permit alignment with ceiling panels. Recessed fixtures installed in fire-resistive type of suspended ceiling construction shall have the same fire rating as the ceiling or shall be provided with fireproofing boxes having materials of the same fire rating as the ceiling panels, in conformance with UL-03. Surface-mounted fixtures shall be suitable for fastening to the structural support for ceiling panels.

4. Sockets of industrial, strip, and other open type fluorescent fixtures shall be of the type requiring a forced movement along the longitudinal axis of the lamp for insertion and removal of the lamp.

C. Emergency Light Sets shall conform to UL 924 with the number of heads as indicated. Sets shall be permanently connected to the wiring system by conductors installed in short lengths of flexible conduit.

3.3 REPAIR OF EXISTING WORK: The work shall be laid out in advance, and where cutting, channeling, chasing, or drilling of floors, walls, partitions, ceiling, or other surfaces is necessary for the proper installation, support, or anchorage of the conduit, raceways, or other electrical work, damage to building, piping, or equipment shall be repaired by mechanics of the trades involved, at no additional cost to the Institute.

3.4 TESTS: After the interior-wiring-system installation is completed, and at such time as the Construction Manager may direct, the Contractor shall conduct an operating test for approval. The equipment shall be demonstrated to operate in accordance with the requirements of this specification.

END OF SECTION

SECTION 16535

EMERGENCY LIGHTING

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101	(1991) Code for Safety to Life from Fire in Buildings and Structures
NFPA 70	(1993) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 924	(1990; 7th Ed; Rev Nov 24, 1993) UL Standard for Safety Emergency Lighting and Power Equipment

1.2 GENERAL REQUIREMENTS: Section 16003, "General Electrical Provisions," applies to work specified in this section.

1.3 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Manufacturer's Catalog Data shall be submitted for the following items:

Emergency Lighting Egress Units
Emergency Fluorescent Lighting
Accessories

B. Drawings: Installation Drawings shall be submitted for the Emergency Lighting Systems indicating location of installed fixture.

C. Schedules: Material, Equipment, and Fixture Lists shall be submitted showing manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site.

D. Reports: Test Reports shall be submitted showing results of System Operational Tests for emergency lighting systems.

E. Certificates of Compliance shall be submitted for the following showing conformance with the referenced standards contained in this section.

Emergency Lighting Egress Units
Emergency Fluorescent Lighting
Accessories

PART 2 - PRODUCTS

2.1 PRODUCT STANDARDS: Emergency lighting units shall conform to UL 924 and NFPA 101. Emergency lighting units shall be furnished completely assembled with wiring and mounting devices and ready for installation at the locations indicated. Fixtures shall be equipped with lamps.

2.2 EMERGENCY LIGHTING EGRESS UNITS

A. Emergency lighting units shall be complete self-contained units with batteries, battery charger, one or more local or remote lamp heads with lamps, under-voltage relay, indicator lights, on/off switch, and test switch, in accordance with UL 924 for Type I (emergency light set), Class I (rechargeable storage-battery-powered unit), as indicated.

B. Batteries shall be rated not less than 6 volts.

C. Battery charger shall include a dry-type full-wave rectifier with two charging rates, one to automatically maintain the battery in a fully charged state under normal conditions and the other to automatically recharge the battery to a fully charged state within 12 hours after continuous discharge of 1-1/2 hours through the connected lampload.

D. Batteries shall have capacity and rating to supply the lamp load with maintained 87.5 85-percent power, minimum, for 1.5 hours, or the battery-lamp combination shall maintain 60 -percent, minimum, illumination. Batteries shall be maintenance-free lead acid nickel-cadmium type. Minimum normal life shall be 10 years.

E. Unit enclosure shall be fabricated from sheet steel not less than 18 gage. Cover shall provide access to the battery and battery-charger compartments and shall have a full-length piano hinge and a latching device. Component parts within the enclosure shall be protected from dust, moisture, and corrosive fumes from the battery. Interior and exterior surfaces of enclosure shall be coated with a corrosion-resistant gray baked-enamel finish.

F. Lampheads shall be mounted on the top of the unit enclosure except where otherwise indicated and shall be fully adjustable in the horizontal and vertical planes. The lamphead mounting assembly shall be metallic construction with nickel chromium plating. Exterior housing of the lamp shall be formed from nickel cadmium-plated sheet steel.

G. Lamps shall be the sealed-beam or halogen type rated not less than 12 watts at the specified dc voltage.

H. An amber "ready-for-use on alternating current" indicating light, a red "recharging on alternating current" indicating light, and a momentary-contact pushbutton test switch shall be mounted on the cover of the unit enclosure. The amber indicating light shall indicate, when illuminated, that the unit is electrically connected to the normal ac supply source and that the battery is fully charged. The red indicating light shall indicate, when illuminated, that the battery is being recharged. The momentary-contact pushbutton test switch shall transfer unit from normal supply to battery supply and shall test operation of equipment under simulated ac source power failure.

I. The under-voltage relay shall be the self-clearing type and shall automatically connect the lampload to the battery supply upon failure of the alternating current supply. An on-off toggle switch shall be mounted inside the unit enclosure to disconnect the battery from the lampload when the unit is taken out of service for maintenance purposes. The relay shall energize when the ac supply falls to 70 percent of normal voltage.

J. Emergency lighting units shall be provided with angle steel mounting shelves. The mounting shelf and screen shall be coated with a corrosion-resistant finish in accordance with manufacturer's standard practice.

K. Emergency lighting units shall be suitable for operation on the 120 Vac supply circuit to which they are to be electrically connected.

2.3 EMERGENCY FLUORESCENT LIGHTING: Each unit shall have an automatic power failure device, test switch, pilot light, and fully automatic high/low trickle charger in a self-contained solid-state, temperature-compensated power-pack. The battery shall be gelled-electrolyte type with capacity as required to supply power to provide a minimum of 600 lumens using a 35-watt rapid start lamp. The battery shall be sealed and maintenance-free for a period of not less than 10 years under normal operating conditions.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Emergency lighting unit shall be permanently fixed in place and shall have wiring to each unit installed in accordance with NFPA 70. The branch circuit feeding the unit equipment shall be the same panel bus or branch circuit as that serving the normal lighting in the area and shall be connected ahead of area switches. Emergency lighting fixtures that are remotely connected to the emergency lighting unit shall have circuit wiring kept independent of all other wiring and equipment and shall not enter the same conduit, cable, box, or cabinet with other wiring unless the fixture is supplied from two sources.

B. Mounting heights of emergency lighting units and remote lamps shall be a minimum of 7 -feet above the finished floor.

3.2 FIELD TESTING: Emergency lighting units shall be demonstrated to operate satisfactorily in the presence of the Construction Manager.

END OF SECTION

SECTION 16536

EXIT LIGHTING

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101	(1991) Code for Safety to Life from Fire in Buildings and Structures

UNDERWRITERS LABORATORIES (UL)

UL 924	(1990; 7th Ed; Rev Nov 24, 1993) UL Standard for Safety Emergency Lighting and Power Equipment

1.2 GENERAL REQUIREMENTS: Section 16003, "General Electrical Provisions," applies to work specified in this section.

1.3 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Manufacturer's Catalog Data shall be submitted for the following items:

Exit Lighting Units
Accessories

B. Drawings:

1. Installation Drawings shall be submitted for Exit Lighting Systems in accordance with the paragraph entitled, "Installation," of this section.

2. Outline Drawings shall be submitted for Exit Lighting Systems indicating overall physical features, dimensions, ratings, service requirements, and weights of equipment.

C. Schedules: Material, Equipment, and Fixture Lists shall be submitted for the following showing manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site.

Exit Lighting Units
Installation Equipment
Accessories

D. Reports: Test Reports shall be submitted showing results of Operational Tests of exit lighting systems.

PART 2 - PRODUCTS

2.1 PRODUCT STANDARDS

A. Emergency exit lighting fixtures shall conform to UL 924, NFPA 101, and as specified.

B. Exit lighting fixtures shall be furnished completely assembled with wiring and mounting devices and ready for installation at the locations indicated. Ceiling-mounted fixtures shall be designed to be supported independent of the ceiling. Fixtures shall be equipped with lamps.

2.2 EMERGENCY POWER LOSS EXIT LIGHTING MASTER POWER UNITS: Each self-contained master unit shall have an automatic power failure device, test switch, pilot light, and fully automatic high/low solid-state trickle charger in a self-contained power pack. Battery shall be the sealed-wet type and shall be maintenance-free for a period of not less than 5-years under normal operating conditions. Normal operation shall be with 277-volts.

2.3. LIGHT EMITTING DIODES (LEDs) EXIT LIGHTING REMOTE (SLAVE) FIXTURES: Exit remote (slave) lighting fixtures shall include vinyl coated aluminum housing with brushed aluminum finish with frames, battery charger, batteries, green light emitting diodes (LEDs) and mounting brackets. Fixtures shall be single faced. Mounting plates shall be suitable for securing the fixture to a 4-inch outlet box. Minimum operating time of the master battery system shall be four hours for single faced fixtures. Brightness shall not be less than ten (10) candlepower. All components shall have a five year warranty.

2.6 SELF LUMINOUS EXIT SIGNS

A. General:

1. All units shall be internally illuminated non-electric (light source is independent of electrical power and is generated by the action of tritium gas on a phosphorescent material).

2. All self luminous signs shall be in accordance with UL 924, OSHA 1910, Section 37, Part (G), Subparts (6) and (7), and NFPA 101, Section 5-10.3.3. All signs shall be licensed by the United States Nuclear Regulatory Commission or its successor. Integrity and performance shall be guaranteed for 20 years of normal use.

B. Enclosure: The assembled tamperproof enclosure shall be of 1/8 inch high impact ABS plastic 0.20 inch thickness metal, framed with 0.50 inch thick extruded aluminum.

1. Each sign shall bear a permanently attached metal nameplate bearing the Manufacturer's Name and Address and Date of Manufacture (in addition to information required by listed authorities.

C. Face: Each face of the sign shall be a non-colored translucent panel covered by an opaque 1/8 inch red ABS plastic stencil bearing the word "EXIT" in 6 by 3/4 inch letters and including a universal directional arrow which indicates the direction of the exit (left, right or both ways).

D. Illumination of the sign shall be by means of sealed glass tubes, internally phosphor coated and filled with tritium gas. Tubes shall be securely bonded to the enclosure and cushioned against mechanical shock. Luminous areas shall have a minimum initial brightness of 0.15 footlamberts and a guaranteed minimum brightness after 20 years of 0.080 footlamberts.

E. Mounting Accessories: Each sign shall be supplied with tamperproof hardware for wall mounting. Edge on for double face, flat for single face or double face for ceiling mount.

PART 3 - EXECUTION

3.1 INSTALLATION: Fixtures shall be connected to the main panel bus through overcurrent protection. Emergency lighting panel shall be used where available.

3.2 FIELD TESTING: Exit lighting shall be demonstrated to operate satisfactorily in the presence of the Construction Manager.

END OF SECTION

SECTION 16670

LIGHTNING PROTECTION SYSTEMS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this section to the extent referenced:

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C135.30	(1979) Galvanized Ferrous Ground Rods for Overhead or Underground Line Construction

FEDERAL SPECIFICATIONS (FS)

FS W-R-550	(Rev A; Notice 1) Rods, Ground (With Attachments)
FS W-S-610	(Rev E) Splice Connectors

NATIONAL ELECTRICAL MANUFACTURER'S ASSOCIATION (NEMA)

NEMA LA 1	(1986) Surge Arresters

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1993) National Electrical Code
NFPA 780	(1989) Lightning Protection Code

UNDERWRITERS LABORATORIES (UL)

UL 467	(1984; 6th Ed; Nov 14, 1986) UL Standard for Safety Grounding and Bonding Equipment
UL 96	(1985; 3rd Ed; Dec 5, 1988) UL Standard for Safety Lightning Protection Components
UL 96A	(1982; 9th Ed; Jul 6, 1990) UL Standard for Safety Installation Requirements for Lightning Protection Systems, Ninth Edition

1.2 GENERAL REQUIREMENTS: Section 16003, "General Electrical Provisions," applies to work specified in this section.

1.3 SUBMITTALS: The following shall be submitted in accordance with Section 01300, "Submittals," in sufficient detail to show full compliance with the specification:

A. Data: Manufacturer's Catalog Data shall be submitted for the following items:

Air Terminals
Main and Secondary Conductors
Ground Rods
Clamp-Type Connectors

Lightning Protection Components
Hardware Items
Appurtenances

B. Drawings

1. Fabrication Drawings shall be submitted for the following items consisting of fabrication and assembly details to be performed in the factory.

Air Terminals
Main and Secondary Conductors
Ground Rods
Clamp-Type Connectors
Lightening Protection Components
Hardware Items
Appurtenances

2. Installation Drawings shall be submitted for the Lightening Protection Systems in accordance with the paragraph entitled, "Installation," of this section. Drawings shall indicate overall physical features, dimensions, ratings, service requirements, and weights of equipment.

C. Schedules: Material, Equipment, and Fixture Lists shall be submitted for the following items including manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

Air Terminals
Main and Secondary Conductors
Ground Rods
Clamp-Type Connectors
Lightening Protection Components
Hardware Items
Appurtenances

D. Certificates of Compliance shall be submitted showing compliance with UL requirements for "Master Label" ratings.

PART 2 - PRODUCTS

2.1 MATERIALS: Lightning protection equipment, appurtenances, and hardware shall conform to NFPA 70, NFPA 780, and UL 96.

2.2 DISSIMILAR METALS

A. No combination of materials shall be used that forms an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture unless moisture is permanently excluded from the junction of such metals.

B. Where unusual conditions exist which would cause corrosion of conductors, conductors with protective coatings or oversize conductors shall be used. Where a mechanical hazard is involved, the conductor size shall be increased to compensate for the hazard or the conductors shall be protected by covering them with molding or tubing made of wood or nonmagnetic material. When metallic conduit or tubing is used, the conductor shall be electrically connected to conduit at both ends.

2.3 AIR TERMINALS

A. Air terminals shall be in accordance with UL 96 and NFPA 780, except Class II terminals shall be used for Class I and Class II applications.

B. Air terminal tips on buildings shall be a minimum of 1-1/2 feet above the ridge, ventilator or perimeter.

C. Air terminals shall be 1/2-inch diameter nickel-tipped solid copper with length and location as indicated. Ground wires shall be fastened by threaded bolts to a bronze connector with a male threaded stud on which the female threaded air-terminal shaft shall be mounted.

D. Air terminals shall be not less than 18-inches high, tapered to a point. Air terminals more than 18-inches high shall be supported by a suitable brace with guide(s) not less than one-half the height of the air terminal.

2.4 MAIN AND SECONDARY CONDUCTORS

A. Conductors shall be in accordance with NFPA 780 and UL 96 for Class I, Class II, or Class II modified materials as applicable and shall be copper

B. Weight of copper conductors shall be not less than 187.5 pounds per thousand feet, and the size of any wire of this cable shall be not less than No. 17. Copper tube or solid-section conductors of copper shall weigh not less than 187.5 pounds per thousand feet, and no tube wall shall be less than No. 20. Thickness of any copper ribbon or strip shall be not less than No. 16. Copper conductors used for counterpoise shall be not smaller than No. 1/0.

2.5 GROUND RODS

A. Rods made of copper-clad or galvanized ferrous metal shall conform to UL 467.

B. Ground rods shall be not less than 5/8 inch in diameter and 10 feet in length. Ten-foot~ threaded section rods shall be utilized to make up the length of rod required.

2.6 CLAMP-TYPE CONNECTORS: Clamp connectors for splicing conductors shall conform to UL 96, Class 2 noninsulated, style and size as required for the installation. Connectors shall be of corrosion-resistant material and shall afford protection against electroysis.

2.7 LIGHTNING PROTECTION COMPONENTS: Lightning protection components, such as bonding plates, air terminal supports, clips, and fasteners shall conform to UL 96, classes as applicable.

PART 3 - EXECUTION

3.1 INSTALLATION" Installation shall conform to NFPA 70, NEMA LA 1, NFPA 780, and UL 96A.

3.2 INTEGRAL SYSTEM

A. General: Lightning protection system shall consist of air terminals, roof conductors, down conductors, ground connections, and grounds, electrically interconnected to form the shortest distance to ground without passing through any nonconducting parts of the structure. All conductors on the structures shall be exposed except where conductors are in protective sleeves exposed on the outside walls. Secondary conductors shall interconnect with grounded metallic parts within the building. Interconnections made within side-flash distances shall be at or above the level of the grounded metallic parts.

B. Air Terminal Design: Air terminal design and support shall be in accordance with UL 96 and NFPA 780. Terminals shall be rigidly connected to, and made electrically continuous with, roof conductors by means of pressure connectors or crimped joints of T-shaped malleable metal and connected to the air terminal by a dowel or threaded fitting. Air terminals at the ends of the structure shall be set not more than 2 feet from the ends of the ridge or edges and corners of roofs. Spacing of air terminals 2 feet in height on ridges, parapets, and around the perimeter of buildings with flat roofs shall not exceed 25 feet. In specific instances where it is necessary to exceed this spacing, the specified height of air terminals shall be increased not less than 2 inches for each foot of increase over 25 feet. On large, flat or gently sloping roofs, as defined in NFPA 780, air terminals shall be placed at points of the intersection of imaginary lines dividing the surface into rectangles having sides not exceeding 50 feet in length. Air terminals shall be secured against overturning either by attachment to the object to be protected or by means of a substantial tripod or other braces permanently and rigidly attached to the building or structure. Metal projections and metal parts of buildings, smokestacks, and other metal objects that do not contain hazardous materials, need not be provided with air terminals. These metal objects shall be bonded to the lightning conductor through a metal conductor of the same unit weight per length as the main conductor.

C. Roof Conductors shall be connected directly to the roof or ridge roll. Sharp bends or turns in conductors shall be avoided. Necessary turns shall have a radius of not less than 8 inches. Conductors shall preserve a downward or horizontal course and shall be rigidly fastened every 4 feet along the roof and down the building to ground. All connections shall be electrically continuous. Roof conductors shall be coursed along the contours of flat roofs, ridges, and edges; and where necessary, over flat surfaces, in such a way as to join each air terminal to all the rest. Roof conductors surrounding decks, flat surfaces, and flat roofs shall be connected to form a closed loop.

D. Down Conductors

1. Down conductors shall be electrically continuous from air terminals and roof conductors to grounding electrodes. Down conductors shall be coursed over extreme outer portions of the building, such as corners, with consideration given to the location of ground connections and air terminals.

2. Each building or structure shall have not less than two down conductors located as widely separated as practicable, at diagonally opposite corners.

3. On rectangular structures having gable, hip, or gambrel roofs more than 110 feet long, there shall be at least one additional down conductor for each additional 50 feet of length or fraction thereof.

4. On rectangular structures having French, flat, or sawtooth roofs exceeding 300 feet in perimeter, there shall be at least one additional down conductor for each 100 feet of perimeter or fraction thereof.

5. On an L- or T-shaped structure, there shall be at least one additional down conductor; on an H-shaped structure, at least two additional down conductors; and on a wing-built structure, at least one additional down conductor for each wing.

6. On irregularly shaped structures, the total number of down conductors shall be sufficient to make the average distance between them along the perimeter not greater than 100 feet.

7. On structures exceeding 50 feet in height, there shall be at least one additional down conductor for each additional 60 feet of height or fraction thereof, except that this application will not cause down conductors to be placed about the perimeter of the structure at intervals of less than 50 feet.

8. Additional down conductors shall be installed when necessary to avoid "dead ends" or branch conductors exceeding 16 feet in length, ending at air terminals.

9. Down conductors shall be equally and symmetrically spaced about the perimeter of the structure. Down conductors shall be protected where necessary, to prevent mechanical injury to the conductor.

E. Interconnection of Metallic Parts: Metal doors, windows, and gutters shall be connected directly to the grounds or down conductors using not smaller than No. 6 copper conductor, or equivalent. Conductors placed where there is probability of unusual wear, mechanical injury, or corrosion shall be of greater electrical capacity than would normally be used, or shall be protected. Ground connection to metal doors and windows shall be by means of mechanical ties under pressure.

F. Ground Connections comprising continuations of down conductors from the structure to the grounding electrode shall securely connect the down conductor and ground in a manner to ensure electrical continuity between the two. All down conductor connections shall be of the clamp type. There shall be a ground connection for each down conductor. Metal water pipes and other large underground metallic objects shall be bonded together with all grounding mediums. Ground connections shall be protected from mechanical injury. In making ground connections, advantage shall be taken of all permanently moist places where practicable, although such places shall be avoided if the area is wet with waste water that contains chemical substances, especially those corrosive to metal.

G. Grounding Electrodes

1. A grounding electrode shall be provided for each down conductor located as shown. A driven ground shall extend into the earth for a distance of not less than 10 feet. Ground rods shall be set not less than 5 feet nor more than 10 feet, from the structure. Complete installation shall have a total resistance to ground of not more than 10 ohms (if a counterpoise is not used).

2. Ground rod resistance shall be measured with the ground under test isolated and under normal dry weather conditions, not less than 48 hours after rainfall.

3. Ground connections below grade shall be painted with a coat of bituminous mastic.

4. When two of any three ground rods, driven not less than 10 feet into the ground, a minimum of 10 feet, apart, and equally spaced around the perimeter, give a combined value exceeding 50 ohms immediately after driving, a counterpoise shall be used. A counterpoise, where required, shall be of No. 1/0 copper cable or equivalent material having suitable resistance to corrosion and shall be laid around the perimeter of the structure in a trench not less than 2 feet deep at a distance not less than 5 feet nor more than 10 feet

from the nearest point of the structure. All connections between ground connectors and grounds or counterpoise, and between counterpoise and grounds shall be electrically continuous. Where so indicated, an alternate method for grounding electrodes in shallow soil shall be provided by digging trenches radially from the building. Lower ends of the down conductors (or their equivalent in the form of metal strips or wires) shall then be buried in the trenches.

3.4 STEEL-FRAME, STEEL NON-INSULATED PANEL BUILDINGS: Steel framework shall be made electrically continuous by bolting the steel frame. Air terminals shall be connected to the structural steel framework at the ridge. Short runs of conductors shall be used as necessary to join air terminals to the metal framework so that proper placing of air terminals is maintained. Separate down conductors from air terminals to ground connections are not required. Where a water system enters the building, the structural steel framework and the water system shall be connected at the point of entrance by a ground connector. Connections to pipes shall be by means of ground clamps with lugs. Connections to structural framework shall be by means of nut and bolt. All connections between columns and ground connections shall be made at the bottom of the steel columns. Ground connections to grounds or counterpoise shall be run from not less than one-half of all the columns distributed equally around the perimeter of the structure. When no water system enters the structure, ground connections shall be run from all steel columns distributed equally around the perimeter of the structure. Metal doors, windows, gutters, and similar metal installations shall be bonded to the steel work of the building. A grounding electrode shall be provided for each ground connection.

3.5 RAMPS: Lightning protection for covered ramps (connecting passageways) shall conform to the requirements for lightning protection systems for buildings of similar construction contained in this section. A down conductor and a driven ground shall be placed at one of the corners where the ramp connects to each building or structure. This down conductor and driven ground shall be connected to the counterpoise or nearest ground connection of the building or structure. Where buildings or structures and connecting ramps are clad with metal, the metal of the buildings or structures and metal of the ramp shall be connected in a manner to ensure electrical continuity, in order to avoid a flash-over or spark due to a difference in potential.

3.6 IGLOO-TYPE BEAM TUBE ENCLOSURE: Reinforcing steel in reinforced-concrete, igloo-type structures shall be made electrically continuous. Electrical continuity may be provided by clipping or brazing, unless a specific method is noted on the drawings. Air terminals and roof conductors shall be securely connected to, and made electrically continuous with, the reinforcing steel. Air terminals shall extend vertically at least 2 feet above the top of the front wall and the highest point on the ventilator. Down conductors and grounding electrodes shall be provided at diagonally opposite corners of the beam tube enclosure and shall be connected together. Steel door frames shall be made electrically continuous with the reinforcing steel. Steel doors shall be connected to steel frames by means of a flexible copper strap or cable unless the steel hinges make the door and frame electrically continuous.

3.7 TANKS AND TOWERS: Metal tanks and towers shall be made electrically continuous. Electrical continuity may be provided by bolting metal and tying or clipping reinforcing bars, unless otherwise noted. Air terminals and down conductors shall be required except on bolted, riveted, or welded 3/16-inch minimum, steel plate tanks. Ground connections and grounding electrodes are not required on metal tanks that are electrically continuous with a metallic underground pipe system. On other structures, two ground connections shall be provided approximately 180 degrees apart, at the base of the structure. Where buried metal pipes enter the tank or tower, one ground connection shall be connected to them, approximately 1 foot below finished grade. Metal guy wires on tanks and towers shall be grounded. Metal guy wires or cables attached to steel anchor rods set in earth will be considered as grounded. Metal guy wires or cables set in concrete or attached to buildings or nonconducting supports shall be grounded to a ground rod driven full length into the ground.

3.8 STACKS

A. General:

1. Metal guy wires for stacks shall be grounded. Metal guy wires or cables attached to steel anchor rods set in the earth will be considered as sufficiently well grounded.

2. Metal guy wires or cables attached to anchor rods set in concrete or attached to buildings or nonconducting supports shall be grounded to a ground rod driven full length into the ground.

B. Metal Stacks: Metal smokestacks shall be electrically continuous and be grounded. Where the construction of the foundation is not such as to provide 10 ohms maximum to ground, the stack shall be grounded to two ground rods driven full length into the earth. Ground rods shall be located approximately 180 degrees apart and shall be set not less than 3 feet not more than 8 feet from the nearest point of the stack foundation.

3.9 INTERCONNECTION OF METAL BODIES: Metal bodies of conductance shall be protected if not within the zone of protection of an air terminal. All metal bodies of conductance having an area of 400 square inches or greater or a volume of 1000 cubic inches or greater shall be bonded to the lightning protection system using main size conductors and a bonding plate having a surface contact area of not less than 3 square inches. Metal bodies of inductance shall be bonded at their closest point to the lightning protection system using secondary bonding conductors and fittings. A metal body that exceeds 5 feet in any dimension, that is situated wholly within a building, and that does not at any point come within 6 feet of a lightning conductor or metal connected thereto shall be independently grounded.

3.10 FENCES:

A. Metal fences that are electrically continuous with metal posts extending at least 2 feet into the ground require no additional grounding. Other fences shall be grounded on each side of every gate. Fences shall be grounded by means of ground rods every 1000 to 1500 feet of length when fences are located in isolated places, and every 500 to 750 feet when in proximity 100 feet or less to public roads, highways, and buildings. Where the fence consists of wooden posts and horizontal metal strands only, down conductors consisting of AWG No. 8 copper wire or equivalent shall be run from the ground rod the full height of the fence and fastened to each wire, so as to be electrically continuous. Connection to ground shall be made from the post where it is of metal and is electrically continuous with the fencing. All metal fences shall be grounded at or near points crossed by overhead lines in excess of 600 volts and at distances not exceeding 150 feet on each side of line crossings.

B. Fences shall be grounded at corner posts, end posts, and gate posts, using removable ground clamps on the fence posts and split-bolt connectors suitable for dissimilar metals on the fence fabric and barbed wire. Gates shall be bonded to the adjacent fence post utilizing flexible copper grounding braid with sufficient slack to permit 180-degree opening of the gate.

Flexible copper ground braid shall have an ampacity equivalent to that of the fence ground wire.

C. Grounding connections shall be exothermic-fusion-welded, except where bolted connections are indicated on the contract drawings.

3.11 SEPARATELY MOUNTED SHIELDING SYSTEM

A. Mast Type: Mast-type protection shall consist of a pole, which, when of a nonconducting material, shall be provided with an air terminal mounted to the top, extending not less than 2 feet nor more than 5 feet above the top of the pole and a down conductor run down the side of the pole will act as a down conductor, and an air terminal need not be provided. Where resistance of the pole to ground is 10 ohms or less, additional grounding is unnecessary. Where resistance exceeds 10 ohms, additional grounding shall be provided, and the ground connection shall be fastened to the metal pole and the ground. When a ground rod is necessary, the rod shall be driven approximately 6 feet from the base of the pole. When resistance to ground of this rod is more than 10 ohms, an additional ground rod shall be driven not closer than 10 feet to the first rod. When resistance of the system to ground is still greater than 10 ohms when the two ground rods are connected together, a counterpoise, consisting of approximately 30 feet of No. AWG 1/0 copper cable buried in a trench not less than 2 feet deep in the form of a circle or square around the base of the pole, shall be provided. When a counterpoise is used, the entire system resistance requirement of 10 ohms or less need not be met. Grounding system at the base of the pole shall be interconnected with any grounding system provided for the protected structure.

B. Overhead Ground-Wire Type: Overhead ground-wire type of protection shall consist of two or more poles electrically connected to each other by overhead conductors. Where the poles are made of a nonconducting material an air terminal shall be mounted to the top of each pole and shall extend not less than 2 nor more than 5 feet above the top of the pole. Down conductors shall be run down the side of the pole, or a guy wire may be used as a conductor. When the guy wire is used, the guy wire and the overhead ground wire shall be dead-ended at the pole. Overhead ground wires and the guy wires shall then be connected to each other by a separate cable using standard cable clamps in such manner that the discharge will not be reversed at any point. Guy wires used as down conductors shall be grounded by means of separate ground rods with cable connections clamped to the lower end of guy wire. Resistance to ground shall not exceed 10 ohms. Where metal poles are used, air terminals are not required and if resistance of the poles to ground is 10 ohms or less, additional grounding is unnecessary. Where the resistance to ground exceeds 10 ohms, additional grounding shall be provided and the ground connection shall be fastened to the metal pole and the ground. Height of the poles shall be sufficient to provide a clearance of not less than 6 feet from the base of each pole. When the resistance to ground of this rod is more than 10 ohms, an additional ground rod shall be driven not closer than 10 feet from the first rod. When the resistance of the entire system to ground is still greater than 10 ohms, a counterpoise consisting of at least 50 feet of No. 1/0 copper cable buried in a trench not less than 2 feet deep shall be provided. When a counterpoise is used, the entire system resistance requirement of 10 ohms or less need not be met.

3.12 SYSTEM RATING: Lightning-protection systems conforming to the installation requirements of UL 96A shall be qualified for a UL "Master Label" rating. Installed lightning-protection system shall be inspected and approved by a certified UL inspector.

END OF SECTION