SECTION 15050
BASIC MECHANICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.01 WORK INCLUDED

A. The work described in this Section and/or indicated on the Drawings shall include the furnishing of all materials, equipment, appurtenances, accessories, connections, labor, etc., required and/or necessary to completely install, clean, inspect, adjust, test, balance and leave in safe and proper operating condition all mechanical systems.

B. Prior to the ordering or purchase of any equipment or materials or the layout or installation of any work, the Contractor shall visit and examine the site and shall examine and understand the work shown on the Drawings and described in these Specifications. If any work involves existing equipment, ductwork, piping, buildings, etc., the Contractor shall first verify model numbers, electrical characteristics, sizes, dimensions, etc., to be compatible with the work shown on the Drawings.

C. Throughout the course of the Project, the Contractor shall schedule and coordinate work with the Engineer and other trades to optimize space utilization and avoid conflict or interference with the work of other trades, structural elements, doors, windows, lights, conduit and other equipment or systems.

D. Unless otherwise shown on the Electrical Drawings, the mechanical work shall include the following items. These items shall conform with the requirements of Division 16.

1. All motors, motor starters, disconnect switches, relays and other controls and control wiring necessary for the proper operation of all mechanical equipment shall be furnished and installed under Division 15 and as specified under Division 16. Power wiring to mechanical equipment and 120-volt source for control power shall be provided as a part of the electrical work.

2. All controls and control wiring for HVAC equipment shall be provided and installed under Division 15. Where control power is not available in the vicinity of mechanical equipment, a transformer shall be furnished and installed to convert power voltage to control voltage. The transformer may be an integral part of the starter.

3. Starters complete with "hand-off-automatic" switches, with running indication lights in an approved enclosure, shall be furnished and installed for mechanical equipment automatically started and stopped, or otherwise controlled by thermostats, timers, or other devices under Division 15 and as specified under Division 16. Starters for all manually controlled equipment shall include start-stop pushbuttons with running indication lights in an approved enclosure.

4. Starters shall be of the reduced voltage part winding type for all equipment with motors 50 HP and larger as shown on the Drawings or specified in Division 16.

5. Disconnect switches shall be provided for mechanical equipment in accordance with the National Electrical Code. Coordinate type (fused or not), fuse ratings, enclosure type and installation with equipment nameplate, NEC, NEMA and Sections 16050 and 16440 requirements.

E. All electrical items provided under Division 15 of the Specifications shall be provided in accordance with applicable sections of Division 16. Enclosures shall be the same NEMA type as specified in Division 16 or on the Electrical Drawings.

F. The Contractor shall be responsible for the satisfactory and complete execution of all work included. The Contractor shall produce complete finished operating systems and provide all incidental items required as part of the work, regardless of whether such item is particularly specified or indicated.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

B. Drawings and Specifications

1. The Drawings are diagrammatic and, unless specifically dimensioned, are intended to show only the general arrangement of equipment and accessories, and the general routing of piping, ductwork, etc. The Drawings do not specifically show every fitting, offset, contour, etc., required to accomplish the intended work or to avoid every interference that may be encountered. It shall be the responsibility of the Contractor to arrange all work to fit within the allowed space without modifying any building structure or property, and to make readily accessible all equipment and accessories requiring servicing or maintenance.
2. Should any changes be deemed necessary by the Contractor in items shown on the Contract Drawings, the Contractor shall submit shop drawings, descriptions, and the reason for the proposed changes to the Engineer for approval.
3. Exceptions and inconsistencies in Drawings and Specifications shall be brought to the Engineer's attention before Bids are submitted.
4. Titles of Sections and Articles in these Specifications are introduced merely for convenience and are not to be construed as complete segregation of tabulation of the various units of material and/or work.

C. Operation and Maintenance Instructions: Operation and maintenance instructions shall be provided in accordance with the requirements of the General Conditions of the Contract Documents. The Contractor shall instruct the City's personnel during the adjustment and testing period. The Contractor shall also, in the presence of the Engineer, demonstrate the complete operation of each and every piece of apparatus.

D. Permits and Inspections

1. Obtain and pay for, as part of the mechanical work, all permits, fees, licenses, taxes, assessments, etc. necessary for performing the work outlined in the Contract Documents.
2. All applicable certificates of inspection shall be delivered to the Owner at the completion of the work.

1.03 QUALITY ASSURANCE

A. The manufacturer shall provide written certification to the Engineer that all equipment furnished complies with all applicable requirements of these Specifications.

B. Codes and Standards

1. All mechanical work shall be performed in accordance with all applicable codes, ordinances, rules and regulations of local, state, federal or other authorities having jurisdiction. As a minimum, this shall include:
   a. International Building Code, 2006 Edition
   b. International Fire Code, 2006 Edition
   c. International Plumbing Code, 2006 Edition
   d. International Mechanical Code, 2006 Edition
   e. International Fuel Gas Code, 2006 Edition
   f. National Electrical Code, 2011 Edition
   g. International Energy Conservation Code, 2009 Edition
   h. Rules and Regulations of the Safety Fire Commissioner for the State Minimum Fire Safety Standards (NFPA)
   i. Unless otherwise specified on the Drawings, the latest edition of all codes, including state and local amendments as adopted by the Board of Community Affairs or ordinances, shall be followed. Where code or other requirements exceed the provisions shown on the Contract Documents, the Contractor shall notify the Engineer. Where provisions of the Contract Documents exceed code or other requirements, the Work shall be performed in accordance with the Contract Documents.
2. All equipment, products and materials used in mechanical work shall be listed by Underwriter's Laboratories, ARI or AMCA as appropriate.
3. The Contractor shall schedule all required tests and inspections with a minimum of 72 hours prior notice to the Engineer.

C. Allowable Tolerances: Equipment shall be readily adaptable for installation and operation in the structures shown on the Drawings. No responsibility for alteration of a planned structure to accommodate other types of equipment will be assumed by the City. Equipment, which requires alteration of the structures, will be considered only if the Contractor assumes all responsibility for making and coordinating all necessary alterations. All such alterations shall be made at the Contractor's expense.

1.04 QUALITY STANDARDS

A. All materials shall be furnished by manufacturers fully experienced, reputable and qualified in the manufacture of the particular material to be furnished. All material shall be designed, constructed and installed in accordance with standard practices and methods and shall comply with these Specifications as applicable.

B. The manufacturer shall provide written certification to the Engineer that all equipment furnished complies with all applicable requirements of these Specifications.

1.05 TRANSPORTATION AND DELIVERY

A. As part of the mechanical work, the Contractor shall provide and pay for all transportation, delivery and storage required for all equipment and materials.

B. The Contractor shall closely coordinate the ordering and delivery of all mechanical equipment with other trades to assure that equipment will be delivered in time to be installed in the building without requiring special or temporary access or building modifications. Certain equipment may have to be installed prior to the erection of the building walls or roofs.

1.06 STORAGE AND PROTECTION

A. Equipment and materials shall be properly stored to protect against vandalism, theft, the elements and other harm or damage. Any equipment or materials received in a damaged condition, or damaged after receipt, shall not be installed. Only new undamaged equipment in first-class operating condition shall be installed.

B. Provide protection covers, skids, plugs or caps to protect equipment and materials stored or otherwise exposed during construction.

1.07 WARRANTY

A. All mechanical work described in the Contract Documents shall be warranted in accordance with the General Conditions of the Contract Documents.

B. This warranty shall apply to all equipment, materials and workmanship.

C. During the warranty period, all defects in mechanical systems shall be corrected in an acceptable manner, consistent with the quality of materials and workmanship of original construction, at no expense to the City.

PART 2 - PRODUCTS

2.01 MATERIALS AND CONSTRUCTION

A. General

1. All equipment, materials, accessories, etc. used as part of the mechanical work shall be new, of the best grade and quality and of current production, unless specified otherwise. Equipment not specified in the Contract Documents shall be suitable for the intended use and shall be subject to approval by the Engineer.
2. All equipment, products and materials shall be free of defects and shall be constructed to operate in a safe manner without excessive noise, vibration, leakage or wear.
3. Electric motors shall be as specified in Section 16150, Electric Motors, unless otherwise specified.

B. Piping: See appropriate sections of Division 15 for Specifications on various piping systems.

C. Valves: See appropriate sections of Division 15 for Specifications for general stipulations on valve installation.

D. Unions

1. Provide and install unions between each item of equipment and the valve controlling and/or the various piping connections to it.
   a. Steel Pipe: Unions 2-1/2-inches and smaller shall have ground joints. Unions 3-inches and larger shall have flanged unions.
   b. PVC Pipe: Unions 2-inches and smaller shall be threaded and have Buna O-rings. Unions 2-1/2-inches and larger shall be flanged.

E. Equipment Bases: Each piece of equipment, which is motor driven shall be furnished with an approved base, which shall be in addition to the foundation. Each base shall be furnished integral with the equipment or apparatus, or shall be furnished as a separate item, designed to accommodate the equipment or apparatus. Submit shop drawings for all foundations and supports for review.

F. Dielectric Isolation

1. Wherever dissimilar metals are used in piping systems, this connection shall be made with dielectric isolators. The dielectric isolators shall be so designed that non-ferrous piping materials shall be isolated by the use of Teflon or nylon isolating materials made up in the form of screwed type unions or insulating gaskets and bolt sleeves and washers for standard flanged connection. All dielectric isolators shall be selected for the pressure and contents of the system involved.
2. Dielectric isolators shall be Watts, Epco, Crane or Maloney.

G. Anchor Bolts

1. All anchor bolts shall be ANSI type 316 stainless steel and must conform to requirements of Section 01600 and the material articles in the appropriate Sections in which they are used.
2. All anchor bolts are to be supplied by the manufacturer or fabricator of the specific material or equipment to be installed.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General

1. All equipment, materials, accessories, etc. used as part of the mechanical work shall be installed according to the manufacturer's recommendations and in accordance with the best practice and standards for the work.
2. All work shall be performed by competent personnel satisfactory to the Engineer. All work requiring particular skill shall be performed by persons that have had special training and past experience in that line of work.

B. Equipment Support

1. Major equipment supports (concrete foundations, framed structural openings, etc.) shall be furnished and installed under other Divisions of the Contract Documents as shown on the Drawings. The mechanical work shall include, however, the furnishing and installation of

all miscellaneous equipment supports, housekeeping pads, structural members, rods, clamps and hangers required to provide adequate support of all mechanical equipment.

2. Unless otherwise shown on the Drawings, all mechanical equipment, piping and accessories shall be installed level, square and plumb.

C. Pipe and Ductwork Penetrations

1. Sleeves or wall pipes shall be installed in all masonry or concrete walls, floors, roofs, etc. for pipe and ductwork penetrations. See Section 15060 for pipe sleeve material requirements. Sleeves for ductwork shall be 20 gauge galvanized steel. Sleeves shall be sized to provide a minimum of ¼-inch clearance between the sleeve and pipe or duct. For insulated pipes or ducts, the clearance shall be ¼-inch between the sleeve and the insulation.

2. As far as possible, all pipe and ductwork penetrations shall be made at the time of masonry or concrete construction. Where drilling is required, only core drills shall be used. Star drills shall not be used.

D. Welding

1. All welded pipe joints shall be made by the fusion welding process, employing a metallic arc or gas welding process.

2. All welding operations shall conform to the latest recommendations of the American Welding Society or to the applicable provisions of the Code for Pressure Piping. The Contractor shall pay for all electrical energy and/or gas used in welding.

E. Cutting and Patching: Where cutting or patching becomes necessary to permit the installation of any work or should it become necessary to repair any defects that may appear in patching, the Contractor shall make the necessary repair at no cost to the Owner.

F. Large Apparatus and Equipment: All large apparatus and equipment which is specified or shown to be furnished or installed under this Contract, and which may be too large to be moved into its final position through the normal building openings planned, shall be placed by the Contractor in its approximate final position before any obstructing structure is installed. All apparatus shall be cribbed up from the floor and cared for as specified under Paragraph 1.06 or as directed by the Engineer.

G. Cross Connection and Interconnections

1. No plumbing fixture, device or piping shall be installed which will provide a cross connection or interconnection between a distributing supply for drinking or domestic purposes and a polluted supply, such as drainage system or a soil or waste pipe which will permit or make possible the backflow of sewage, polluted water or waste into the water supply system.

2. The Contractor shall verify location of all existing utilities and make all connections to existing facilities as required.

H. Thermal Expansion of Piping

1. The Contractor shall furnish and install all devices required to permit the expansion and contraction of all work installed by the Contractor, particularly in water supply and

circulating systems. In the main water and circulating lines, Contractor shall employ expansion joints where required or directed by the Engineer. Swing joints, turns, expansion loops or long offsets shall be provided wherever shown on the Drawings or wherever necessary to allow for the expansion of piping within the building. Broken pipes or fittings broken due to rigid connections must be removed and replaced at the Contractor's expense.

2. Anchor all lines having expansion joints so that expansion and contraction effect is equally distributed. Verify exact locations of anchors with the Engineer prior to making installation. The lines having expansion joints shall be accurately guided on both sides of each joint. These guides shall consist of saddles and "U" clamps properly arranged and supported. Submit complete details for approval.

3. In installing expansion members exercise care to preserve proper pitch on lines. Furnish and install all special fittings, connectors, etc., as required.

3.02 SURFACE PREPARATION, SHOP AND FIELD PAINTING

A. Unless otherwise specified herein or shown on the Drawings, general painting of mechanical equipment shall be in accordance with Section 09900, Painting.

B. Touch-up painting of mechanical equipment shall be part of the mechanical work. All equipment and materials that are painted or coated by the manufacturer shall be touched-up prior to completion to conceal any and all scratches or other finish irregularities and to maintain the integrity of the paint or coating. All painting and coating shall match the original and shall conform to the requirements detailed in other sections of these specifications.

C. All roof-mounted equipment shall be painted with an exterior paint of a type and color as specified in Section 09900, Painting. The painting shall not impair the performance of the equipment in any manner.

3.03 INSPECTION AND TESTING

A. The mechanical work shall include all materials and labor required to properly test and balance all mechanical systems as required by codes and as described herein.

B. Concealed, underground and insulated piping shall be tested in place before concealing, burying or covering. Tests shall be conducted in the presence of the Engineer or designated representative. Equipment, materials and instruments required for tests shall be furnished without incurring additions to the Contract. The Contractor shall schedule all required tests and inspections with a minimum of 72 hours prior notice to the Engineer.

C. Unless otherwise specified herein, all mechanical piping shall be tested as required by Code to 1-1/2 times the rated system pressure or 100 psig, whichever is greater. Care shall be taken to isolate all equipment not suitable for this test pressure by installing pipe caps or blank flanges at the equipment connections. All valves and fittings shall be tested under pressure.

D. Unless more stringent requirements are specified herein, the following procedures shall be used for pressure testing building mechanical piping gravity-drained piping systems. Soil, waste and vent piping shall be tested with water before installing fixtures. Water test shall be applied to the system either in its entirety or in sections. If the test is applied to the entire system, all openings in the piping shall be closed except to highest opening, and the system shall be filled with water to the point of overflow. If the system is tested in sections, each opening except the highest

opening of the section under test shall be plugged and each section shall be filled with water and tested with at least a 10 foot head of water. Each joint or pipe in the building except the uppermost 10 feet of the system shall be submitted to a test with at least a 10 foot head of water. The water shall be kept in the system, or in the portion under test, for at least 1 hour before the inspection starts; no substantial drop in the water level will be acceptable.

E. The services of an independent testing and balancing agency shall be used to balance the air and water distribution systems.

3.04 CLEANING

A. At all times, the premises shall be kept reasonably clean and free of undue amounts of waste, trash and debris by periodic cleaning and removal. After completion, all foreign material, trash and other debris shall be removed from the site.

B. After all equipment has been installed, and prior to testing and balancing, all equipment, piping, ductwork, etc. shall be thoroughly cleaned both inside and out.

C. All air moving equipment operated during construction shall have filters in place and changed regularly so as to be clean.

D. After testing and balancing and just prior to Engineer review and acceptance, all systems shall be finally cleaned and shall be left ready for use. Air filters shall be new and piping strainers shall be clean.

E. All water piping shall be cleaned and disinfected in accordance with Section 15060 of these Specifications.

END OF SECTION 15050

SECTION 15060
PIPING AND APPURTENANCES

PART 1 - GENERAL

1.01 SCOPE

A. The work covered by this Section includes furnishing all labor, tools, equipment, transportation, labor, supervision, and incidentals required to furnish, store, install, clean, and test, complete piping systems including all fittings, sleeves, supports, unions, and accessories, as specified herein and/or shown on the Drawings. The materials to be used for piping systems are listed by service in the Piping Schedule included on the Process Drawings.

B. Contract Drawings show only functional features and some of the required external connections. They do not show all components required for a complete installation nor exact dimensions particular to any specific material. Contractor shall supply all parts, devices and equipment necessary to meet the requirements of the Contract Documents and shall make all dimensional adjustments particular to the material being furnished. All costs associated with such changes and adjustments shall be considered as being included in the price bid for the Work shown and specified.

C. Related work specified elsewhere:

1. Section 02200 - Earthwork
2. Section 02730 – Sewers, Storm Drains and Accessories
3. Division 3 – Concrete
4. Section 05120 – Structural Steel
5. Section 05500 – Miscellaneous Metals
6. Section 09900 - Painting .
7. Section 15100 - Valves and Appurtenances.
8. Buried ductile iron pipe for gravity sewer is specified under Section 02730.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

1. Manufacturer's certification.
2. Manufacturer's data.
3. Pipe support calculations.
4. Piping layouts, schedules, shop fabrication drawings, specifications, catalog cuts and other data necessary to show conformance of the complete piping systems to these Specifications.

5. Drawings showing dimensions, fittings, locations of equipment, valves, all piping supports, anchors, expansion joints, mechanical couplings and all other piping appurtenances, joint locations and details, types and locations of supports, coordination with all other work and existing conditions, and all other pertinent technical specifications for the piping systems to be furnished.

6. Shop fabrication drawings shall show alloys, diameters, pipe wall thicknesses, flanges and other joint preparation details, dimensions, fittings and other appurtenances to be supplied.

7. Welding procedures and qualification reports in accordance with Section 05120.

B. Prior to its incorporation into the work, the Contractor shall submit to the Engineer written evidence that the pipe furnished under this Specification is in conformance with the material and mechanical requirements specified herein. Certified copies of independent laboratory test results or mill test results from the pipe supplier may be considered evidence of compliance provided such tests are performed in accordance with the appropriate ASTM testing standards by experienced, competent personnel. In case of doubt as to the accuracy or adequacy of mill tests, the Engineer may require that the Contractor furnish test results from an independent testing laboratory on samples of pipe materials.

1.03 QUALITY ASSURANCE

A. Reference Standards: Comply with all Federal and State laws or ordinances, as well as all applicable codes, standards, regulations and/or regulatory agency requirements including the partial listing below:

1. American National Standards Institute (ANSI).

2. American Society for Testing Materials (ASTM).

3. American Water Works Association (AWWA)

1.04 QUALITY STANDARDS

A. All such work shall be done by competent workmen in a thorough workmanlike manner according to the best practice and in compliance with all codes and applicable regulations, with proper provisions for uncoupling, draining, expansion and contraction.

B. See applicable sections of Part 2 - Products for Manufacturer quality standards.

1.05 STORAGE AND PROTECTION

A. All piping and tubing and accessories shall be stored above ground fully supported so as not to bend or deflect excessively under their own weight. Piping shall be stored with slope so as to be free draining.

1.06 WARRANTY

A. Provide a warranty against defective equipment and workmanship in accordance with the requirements of the General Conditions of the Contract Documents.

PART 2 - PRODUCTS

2.01 MATERIALS

A. General: No broken, cracked, deformed, imperfectly coated or otherwise damaged or defective pipe or fittings shall be used. All such materials shall be removed from the site.

B. Stainless Steel Pipe and Fittings – 3-inch and Smaller:

1. Material: Unless otherwise indicated, stainless steel pipe shall be in accordance with ASTM A 312 - Seamless and Welded Austenitic Stainless Steel Pipe, Type 316, seamless, Schedule 40, with welded fittings for sizes up to and including 3inches and welded fittings or flanged fittings for sizes larger than 3-inches.

2. Joints : Where indicated stainless steel pipes 3- inches and smaller shall have welded joints with socket-welding fittings, butt-welding fittings, or socket welding flanges. Stainless steel flanges shall have stainless steel bolts and nuts. Where indicated, stainless steel pipe shall have grooved ends for shouldered couplings, except that no pipe with less than Schedule 40 wall thickness shall be grooved. Where indicated, stainless steel pipe shall have plain ends for sleeve-type couplings.

3. Fittings:
   a. Socket-Welding Fittings: 3,000 lbs. type 316 forged stainless steel fittings conforming to ASTM A 82 / A 182M and ASME B 16.11.
   b. Butt-Welding Fittings: Wrought stainless steel butt-welding fittings conforming to ASTM A 403 - Wrought Austenitic Stainless Steel Piping Fittings, and ASME B 16.9 - Factory-Made Wrought Steel Butt-Welding Fittings, Type 316.
   c. Grooved Fittings: Wrought stainless steel grooved fittings conforming to ASTM A 403 and ASME B 16.9, with grooving conforming to AWWA C606 - Grooved and Shouldered Joints, Type 316.
   d. Flanged Fittings: Type 316 stainless steel flanged fittings and flanges conforming to ASME B 16.5 - Pipe Flanges and Flanged Fittings.

C. Polyvinyl Chloride Pipe and Fittings (PVC Pressure Piping):

1. Polyvinyl Chloride Pipe less than 4 inch diameter nominal pipe size shall be of unplasticized compounds suitable for use with chemicals and sewage, as shown on the Drawings and as specified and shall bear the seal of approval to this effect from an accredited testing laboratory. Pipe shall conform to the requirements of ASTM D1784 and D1785, Schedule 80, Type 1, Grade 1, or class 12454-B. Potable water pipe 4 inch through 12 inch shall be rated for Potable Water service and meet the requirements of ANSI / AWWA.C900 class 250 psi.

2. Fittings for pipe less than 4 inch diameter nominal pipe size shall conform to the requirements of ASTM Designation D2467, Class 12454-B for socket type and ASTM Designation D2464 for threaded type. Potable water pipe fittings for pipe 4 –nch through 12 inch shall be ductile iron mechanical joint bell fittings and or ductile iron slip bell fittings for use with AWWA C900 pipe and have a pressure rating of at least 250 psi.

3. Compounds for pipe and fittings shall conform to the requirements of ASTM Designation D1784, Class 12454-B.

4. Joints shall be the solvent-welded socket, bell and spigot, or flanged type. Flanges, where shown, shall be 150-pound, and shall be of the same material as the pipe. Bell and spigot pipe shall meet the requirements for potable water pipe.

5. Bolts for use with PVC flanges shall be as follows:

With Flat Ring Gaskets	Carbon steel, ASTM A307, Grade B square head bolts and ASTM A563, Grade A heavy hex head nuts
With Full Face Gaskets or in Submerged, Corrosive, or Buried Service	Type 316 stainless steel, ASTM A193, Grade B8M hex head bolts and ASTM A194, Grade 8M hex head nuts

   a. Gaskets shall be EPDM or Viton, full-faced, and 1/8 – inch thick, minimum.

   b. All socket connections shall be joined with PVC solvent cement conforming to ASTM D2564. Manufacturer and viscosity shall be as recommended by the pipe and fitting manufacturer to assure compatibility. Provide adequate ventilation when working with pipe joint solvent cement.

   c. Provide magnetic tracer tape for all buried PVC piping.

D. Chlorinated Polyvinyl Chloride Pipe

1. CPVC pipe shall be in accordance with ASTM F 441 - Chlorinated Poly Vinyl Chloride (CPVC), Plastic Pipe, Schedules 40, and 80, from all new compounds, meeting the requirements of Class 23447 per ASTM D 1784 - Rigid Poly Vinyl Chloride Compounds and Chlorinated Poly Vinyl Chloride Compounds. CPVC pipes shall be Schedule 80 pipe unless otherwise indicated. All materials in shall be compatible with raw sewage and various forms of hydrogen sulfide present in raw sewage.

2. Pipe joints shall be solvent-welded with solvent cement in accordance with ASTM F 493 - Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings, and with primer in accordance with ASTM F 656 - Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings. Flanged joints shall be made with solvent-welded CPVC flanges, drilled to ASME B 16.5 - Pipe Flanges and Flanged Fittings, Class 150, unless otherwise indicated. All materials in shall be compatible with raw sewage and various forms of hydrogen sulfide present in raw sewage.

3. Solvent-Welded Fittings: Solvent-welded fittings shall be Schedule 80 CPVC fittings in accordance with ASTM F 439 - Socket-Type Chlorinated Poly Vinyl Chloride (CPVC) Plastic Pipe Fittings, Schedule 80. All materials in shall be compatible with raw sewage and various forms of hydrogen sulfide present in raw sewage.

4. Flanged Fittings: Flanged fittings shall be fabricated Schedule 80 CPVC fittings with 150 lb. flanges to ASME B 16.5. Gaskets shall be ANSI 150 lb. full face, 1/8-inch thick Neoprene for water or wastewater service. Gasket material for chemicals shall be suitable for the chemical service.

5. Bolts for use with CPVC flanges shall be as specified for PVC flanges in paragraph 2.01.C.

E. Ductile Iron Pipe:

1. Unless otherwise specified elsewhere, ductile iron pipe shall have a minimum wall thickness in accordance with Pressure Class 350, except for sizes 14 inches and larger, which shall

have a minimum wall thickness in accordance with Pressure Class 250. All ductile iron pipe supplied shall conform to the requirements of ANSI/AWWA Specifications C150/A21.50-81 and C151/A21.51-1981.

2. Fittings in pipe lines shall conform to the requirements of ANSI/AWWA C110/A21.10-82, Pressure Class 350 for 12 inch and smaller and Pressure Class 250 for 14 inch and larger sizes.

3. Exposed ductile iron piping shall be coated/painted externally per the requirements of Section 09900 – Painting and lined internally as specified on the Pipe Schedule.

4. Exposed joints shall be flanged or restrained mechanical joints unless otherwise shown on the Drawings. Buried joints shall be restrained, push-on or mechanical joints as specified on the drawings or schedule and shall conform to the following requirements:

Flanged	ANSI/AWWA C110 & ANSI B16.1, faced and drilled 125-pound ANSI Standard
Mechanical Joint	ANSI/AWWA C110, ANSI/AWWA C111 and ANSI/AWWA C151
Grooved Joint	ANSI AWWA C606 and ANSI/AWWA C151
Push-On	ANSI/AWWA C110, ANSI/AWWA C111 and ANSI/AWWA C151, equal to American Cast Iron Pipe Company, or U.S. Pipe and Foundry Tyton joint

5. Restraining of joints shall be as recommended in the Ductile Iron Pipe Research Association (DIPRA) Handbook of Cast Iron Pipe.

6. Mechanical joints with retainer glands are not acceptable.

7. Flanges shall be ductile iron, threaded, rated for 250 psi working pressure, and conform to ANSI A21.15/AWWA C115 and ANSI 125-pound drilling.

8. Bolts, studs, washers and nuts for flanges and mechanical joints shall be Type 316 stainless steel conforming to the requirements of ASTM A193/320 Grade B8 and ASTM A194 and shall meet the requirements of Section 05500 – Miscellaneous Metals.

9. Gaskets for mechanical or push-on joints shall be rubber, conforming to ANSI A21.11, AWWA C111. Gaskets for flanged joints shall be 1/8-inch thick, cloth-inserted rubber conforming to applicable parts of ANSI B16.21 and AWWA C207. Gasket material shall be free from corrosive alkali or acid ingredients and suitable for use in sewage or potable water lines. Gaskets shall be full-face type for 125-pound FF flanges. Gaskets for grooved joints shall be molded conforming to the requirements of ANSI/AWWA C606.

10. Interior Lining: Ductile iron pipe and fittings shall be lined with ceramic epoxy when specified in the Pipe Schedule. Ceramic epoxy lining shall be as specified below:
    a. All ductile iron pipe and fittings shall be delivered to the application facility without asphalt, cement lining or any other lining on the interior surface.
    b. Linings shall cover all exposed surfaces of pipe and fittings subject to contact with sewer liquid or gas. The lining of the pipe barrel shall extend from spigot end through the socket to the edge of the gasket sealing area or recess for pipe using push-on gaskets, and to the edge of the gasket seat for mechanical joints. The lining shall also cover the exterior of the spigot end from the end of the pipe to beyond the gasket sealing area. The lining in fittings shall cover the interior surfaces including the socket

areas as defined above. Lining shall not be used on the face of flanges. All linings shall be hermetically sealed at the ends.

c. Lining Materials: The lining material shall be amine cured novalac epoxy containing at least 20% by volume of ceramic quartz pigment epoxy formulated for corrosion control with the following minimum requirements:

i) A permeability rating of 0.0 perms when measured by ASTM E 96, Procedure A. Duration of test shall be 30 days.

ii) A direct impact resistance of 125 inch-pounds with no cracking when measured by ASTM D 2794.

iii) The ability to build at least 50 mils dry in one coat.

iv) The material shall be recoatable with itself for at least seven days with no additional surface preparation when exposed to direct summer sun and a temperature of 90 degrees F.

v) The material shall contain at least 20 percent by volume of ceramic quartz pigment.

vi) A test and service history demonstrating the ability of the material to withstand the service expected.

vii) Possess a minimum solids volume content of 88 percent, + one percent.

viii) Possess a maximum drying time to allow recoating as follows: 50 degrees F - 72 hours; 75 degrees F - 18 hours; 90 degrees F - 8 hours. If recoating cannot be accomplished within seven days, a light brush blast shall be performed to improve intercoat adhesion.

ix) ASTM B-117 salt Spray (scribed panel) result equal to 0.0 undercutting after 2-years.

x) ASTM G-95 Cathodic Disbondment 1.5 volts @ 77 °F result equal to no more than 0.5 mm undercutting after 30 days.

xi) Immersion test rating using ASTM D-714-87 shall be equal to or better than the following:

a) 20% Sulphuric acid – No effect after two years

b) 140° F 25% Sodium Hydroxide – No effect after two years

c) 160° F Distilled Water - No effect after two years

d) 120° F Tap Water (scribed panel) – No undercutting after two years, no effects.

xii) The lining material shall be Protecto 401 Ceramic Epoxy or Equal

d. Application

i) Lining shall be applied by a certified firm with a successful history of applying ceramic epoxy lining to the interior of ductile iron pipes and fittings.

ii) Lined pipe and fittings shall be handled only from outside of the pipe and fittings. No forks, chains, hooks, straps, etc. shall be placed inside the pipe for lifting, positioning or laying. Pipes shall not be dropped or unloaded by rolling. Pipes shall not be allowed to strike sharp objects while swinging or being offloaded. Pipes shall be handled strictly in conformance with lining manufacturers' recommendations.

iii) Lining of pipe barrel and fittings shall be 40 mils nominal thickness; minimum lining thickness shall be 30 mils. Lining thickness for exterior of spigot and interior of socket shall be 8 to 10 mils.

iv) The lining shall be applied using a centrifugal lance applicator by applicators certified by the lining manufacturer. The workers shall be experienced and competent in the surface preparation, application and inspection of the lining to be applied. The compound shall not be applied when the substrate temperature is below 40 degrees F or in adverse atmospheric conditions which will cause detrimental blistering, pin-holing or porosity of the film.

e. All pipe and fitting linings shall be tested for pinholes in accordance with ASTM G 62, Method B and shall be holiday free.

f. All pipe linings shall be checked for thickness using a magnetic film thickness gauge.

g. Each pipe joint and fitting shall be marked with the date of application of the lining system and with the numerical sequence of application of that date.

h. Touch up repairs shall be in accordance with manufacturer's recommendation

F. Steel Pipe and Fittings

1. Steel pipe supplied shall be schedule 40 carbon steel, black, electric fusion welded or seamless conforming to the requirements of ASTM A 53, Grade B, with beveled ends. Pipe joints shall be butt-welded or flanged, as specified herein. Tees shall be ANSI B16.4 welding tees.

2. Butt-welded flanges shall be carbon steel, to match pipe wall thickness. Fittings shall be seamless conforming to ASTM A234 and ANSI B16.9. Use long radius elbow unless otherwise noted.

3. Flanges shall be 150 lb. forged steel, conforming to ASTM A181 and ANSI B16.5. Carbon steel, ASTM A 307, Grade A hex head bolts ASTM A 563, Grade A hex head nuts shall be used. Gaskets shall be 1/16-inch thick neoprene, full-face type.

G. Copper and Copper Alloy Pipe, Tubing, and Fittings

1. Copper tubing shall be seamless, and conform to, ASTM B88 (Type K and L).

2. Fittings shall be commercially pure wrought copper, socket joint, and conforming to ASTM B75 and ANSI Bl6.22.

3. The solder used shall be 95-5 wire solder conforming to ASTM B32, Grade 95 TA. Do not use cored solder.

4. Piping fabrication and installation shall conform to the requirements of Chapter V of ANSI B3 1.3.

5. Bends in soft temper tubing shall be long sweep, wherever possible. Bends shall be shaped with bending tools and shall be made without appreciable flattening, buckling, or thinning of the tube wall at any point. Tubing shall be cut square and burrs removed. Inside of fittings and outside of tubing shall be cleaned with steel wool and muriatic acid before sweating. Take care to prevent annealing of fittings and hard-drawn tubing when making connections. The qualification of brazing procedures, brazers, and brazing operators shall be in accordance with the requirements of Articles XII and XIII, Section IX, ASME Boiler and Pressure Vessel Code.

H. Cast Iron Soil Pipe and Fittings

1. Piping Internal to Building:
   a. Piping interior to buildings is specified under Specification section 15400 Plumbing.
2. Underground – Exterior to Buildings:
   a. Pipe and fittings: Coated service weight cast iron hub and spigot soil pipe, ASTM A74, ANSI A112.5.1, Federal Spec. WW-P-401e.
   b. Gasket: Neoprene rubber, CS-188.

I. Fiberglass Reinforced Plastic Pipe and Fittings

1. 2"-24" Pipe. The pipe shall be manufactured by the filament winding process using an amine cured epoxy thermosetting resin to impregnate strands of continuous glass filaments, which are wound around a mandrel at a 54-3/4 inch winding angle under controlled tension. Pipe shall be heat cured and the cure shall be confirmed using a Differential Scanning Calorimeter. Pipe shall be supplied with a matching tapered bell and a matching tapered spigot. Pipe shall have a minimum continuous steady pressure rating of 225 psig at 210° F in accordance with ASTM D2992 Procedure A. All pipe shall be 100% hydrotested at the factory before shipment at a minimum pressure of 300 psig.
2. Flanges and Fittings. All fittings shall be manufactured using the same type materials as the pipe. Fittings may be manufactured either by compression molding, spray-up/contact molding, or filament winding methods. Fittings shall be adhesive bonded matched tapered bell and spigot, threaded or grooved adapters, or flanged. Fittings shall be certified to ASTM D5685. Flanges shall have ANSI B16.5 Class 150 bolt hole patterns.
3. Adhesive shall be manufacturer's standard for the piping system specified.
4. Gaskets shall be 1/8" thick, 60-70 durometer full-face type suitable for the service shown on the drawings and as recommended in the manufacturer's standard installation procedures.
5. Acceptable Products. RED THREAD II as manufactured by NOV Fiber Glass Systems or equal.

J. High Density Polyethylene Pipe (HDPE) and Fittings

1. HDPE pipe sizes ½ inch through 64 inch shall be suitable for pressure water and sewer applications. The pipe material shall meet the requirements of ASTM D 3350 with cell classification of 345464C/E or 44557C. Pipe shall meet the requirements of AWA C901 / C906 and have a minimum continuous steady pressure rating of 200 psig at 80° F in accordance with ASTM D2737.
2. Flanges and Fittings. All fittings shall be manufactured using the same type materials and have the same pressure rating as the pipe.
   a. Butt Fusion Fittings - Fittings shall be made of either PE4710 or PE 3608, with a minimum Cell Classification as noted in 2A.01A. Butt Fusion Fittings shall meet the requirements of ASTM D3261. Molded and fabricated fittings shall have a pressure rating equal to the pipe unless otherwise specified in the plans.
   b. Electrofusion Fittings - Fittings shall be PE4710 or PE 3608, with a minimum Cell Classification as noted in 2A.01A. Electrofusion Fittings shall have a manufacturing standard of ASTM F1055. Fittings shall have a pressure rating equal to the pipe unless otherwise specified

c. Flanges and Mechanical Joint Adapters (MJ Adapters) – Flanges and Mechanical Joint Adapters shall be PE4710 or PE 3608, with a minimum Cell Classification as noted in 2A.01A. Flanged and Mechanical Joint Adapters can be made to ASTM D 3261 or if machined, must meet the requirements of ASTM F 2206. Flanges shall have ANSI B16.5 Class 150 bolt hole patterns.

3. The pipe shall be marked in accordance with the standards to which it is manufactured.

4. Color identification by the use of stripes or colored exterior pipe product shall be blue for potable water, or green for wastewater/sewage, or purple (lavender) for reclaimed water.

1. Marking tape shall be approved by the engineer and placed between 6 and 12 inches above the crown of pipe. Marking tape shall be minimum 3 inch width with minimum 1 inch tall letters. Tape shall be have a 0.35 mil (0.00035") solid aluminum foil core with a laminated repeating warning message "WARNING –(USE) PIPE BELOW" under a 3.75 mil clear film backing and have a 5 min overall thickness. Tape shall be color coded for the appropriate use as shown in the following table:

Color	Use
YELLOW	GAS
BLUE	POTABLE WATER
GREEN	SEWER
PURPLE	NON-POTABLE WATER

K. Insulating Flanges, Couplings and Unions. Materials and ratings shall be in accordance with the applicable piping system as listed by service in the Piping Schedule. Dielectric flanges and unions shall be equal to Epco Sales, Inc., of Cleveland, Ohio; Capitol Insulation Unions Insulating couplings shall be equal to Dresser STAB-39; R. H. Baker Series 216.

L. Couplings

1. Flexible couplings, flanged coupling adapters, or expansion joints shall be provided for piping systems at connections to equipment, and where shown. The Contractor may install additional flexible couplings to facilitate piping installation, provided that it submits complete details describing location, pipe supports, and hydraulic thrust protection.

2. Acceptable types of couplings for ductile iron pipe are as follows:
   a. Flexible Couplings: Equal to Dresser Style 153, with zinc-plated bolts and nuts. Thrust ties shall be provided to sustain the force developed by 1-½ times the test pressure specified.
   b. Transition Couplings: Transition couplings used to connect pipes with small differences in outside diameter shall be equal to Dresser Style 162.
   c. Flanged Adapters:
      i) Flanged coupling adapters shall be used for joining plain end cast iron or ductile iron pipe to flanged valves, pumps and fittings. Flanged adapters shall be suitable for working pressures to 150 psig.
      ii) Flanged coupling adapters in sizes 12-inches and smaller shall consist of an ASTM 126, Class B cast iron flanged body drilled to mate with a 125 pound cast iron flange per ANSI B16.1, a cast iron follower ring, a rubber-compound, wedge section gasket, a sufficient number of track head and electroplated steel bolts to properly compress the gasket.

iii) Flanged coupling adapters in sizes 12-inches and larger shall consist of a high strength steel, flanged body drilled to mate with a 125 pound cast iron flange per ANSI B16.1, a high strength steel follower ring, a rubber-compound, wedge section gasket, a sufficient number of track head and electroplated steel bolts to properly compress the gasket.

iv) Rubber gasket shall be composed of a resilient synthetic rubber compound suitable for use in wastewater containing oil and grease.

d. Grooved Couplings

i) Couplings shall conform to the requirements of ANSI/AWWA C606 - Grooved and Shouldered Joints. Gaskets shall be compatible with the piping service and fluid utilized, in accordance with the coupling manufacturer's recommendations. The wall thickness of grooved piping shall conform to the coupling manufacturer's recommendations to suit the highest expected pressure. To avoid stress on equipment, equipment connections with grooved couplings shall have rigid-grooved couplings or flexible type coupling with harness in sizes where rigid couplings are not available, unless thrust restraint is provided by other means. Couplings shall be bonded. The Contractor shall have the coupling manufacturer's service representative verify the correct choice and application of couplings and gaskets, and the workmanship, to assure a correct installation. To assure uniform and compatible piping components, all grooved fittings, couplings, and valves shall be from the same manufacturer.

ii) Grooved couplings for Ductile Iron pipe shall be equal to Victaulic Style 31.

3. Acceptable types of couplings for steel pipe are as follows:
   a. Flexible Couplings: Equal to Dresser Style 38. Thrust ties shall be as specified above for ductile iron pipe couplings.
   b. Transition Couplings: Equal to Dresser Style 162.
   c. Flanged Coupling Adapters: Equal to Dresser Style 128. Thrust restraint shall be as specified above for ductile iron flanged coupling adapters.

4. Flexible Connectors (Bellows Type): Elastomeric bellow type flexible connectors shall be of the double arched type and shall be rated for a working pressure of 150 psig and maximum operating temperature of 150 °F. Connectors shall be flanged and shall be provided with thrust restraint system to limit elongation and compression as required. Bellows type flexible connectors shall be equal to General Rubber Corporation, or PROCO Products Inc., or FLEXICRAFT Industries.

5. All fittings and connections for tubing shall be equal to Swagelok.

M. Expansion Joints

1. Expansion joints shall be designed in accordance with Expansion Joint Manufacturer's Association (EJMA) standards for pressure, temperature and service as specified.

2. Expansion joints shall be multi-ply bellows type designed for temperatures up to 300 °F and pressures up to 100 psig. Bellows shall be constructed of 316 L stainless steel. Unless otherwise specified, end connections shall be 316 L SS flanges.

3. Expansion joints rated travel requirements (axial compression and extension) shall be as indicated on the Drawings.

4. The contractor shall submit detailed calculations and manufacturer's Shop Drawings of all proposed expansion joints, piping layouts, and anchors and guides, including information on

expansion joint material, material thickness, temperature and pressure ratings, travel ratings and axial spring rates.

5. Expansion joints shall be equal to Hyspan Precision Products Inc., Or Flexonics, Inc. Or FLEXICRAFT Industries.

N. Pipe Hangers and Supports

1. General:
   a. The Contractor shall be responsible for the proper design, fabrication, location, and installation of all pipe supports in accordance with the specified requirements. Shop drawing submittals shall be in accordance with the requirements of the General Conditions of the Contract Documents.
   b. The Contractor shall review pipe support details and locations as proposed in the drawings and shall submit calculations justifying the details and locations of supports to be installed. Calculations shall be prepared and stamped by a professional engineer registered in the state of Georgia.
   c. The Contractor shall be responsible for adequacy and appropriateness of pipe supports systems. Submittals of calculations and review by the engineer shall in no way relieve the contractor of the sole responsibility for design of pipe supports.
   d. All pipe supports and component parts shall conform to the latest requirements of the Code for Pressure Piping ASME/ANSI B31.1 and Manufactures Standardization Society (MSS) Standard Practice SP-58, SP-69, SP-89 and SP-90 except as supplemented or modified by the requirements of this specification.
   e. Pipe support design shall conform to the requirements of the latest edition of the AISC Manual of Steel Construction for miscellaneous and supplementary steel. Tube steels shall be ASTM A500 Grade B, structural shapes A36, plates A-572 or equal. Stainless steel structural members shall conform to ASTM requirement Type 316L.
   f. The Contractor shall be responsible for coordinating all pipe support designs for all trades to ensure compliance with all of the requirements of this specification.
   g. The Contractor shall design and provide all temporary pipe supports required during installation and testing.
   h. Manufacturers' catalog figure numbers are typical of the types and quality of standard pipe supports and hangers to be employed. Special support and hanger details are shown to cover typical locations where standard catalog supports may be inapplicable.
   i. No attempt has been made to show all required pipe supports in all locations, either on the Drawings or in the details. The absence of pipe supports and details on any drawings shall not relieve the Contractor of the responsibility for providing supports for the piping shown on the Drawings.
   j. All submerged and intermittently submerged piping supports, guides, and fasteners in pump station wet wells and other corrosive environments shall be Type 316 stainless steel unless otherwise shown. Concrete anchors and anchor bolts shall also be Type 316 stainless steel.
   k. Where piping connects to equipment it shall be supported by a pipe support and not by the equipment.
   l. All commercial pipe supports and hangers shall have a minimum safety factor of 5.

2. Building Piping:
   a. Horizontal piping shall be supported with adjustable wall brackets swivel-ring, split-ring, or Clevis type hangers as shown. Furnish galvanized protection shield and oversized hangers under all insulated piping. Pipe hangers for copper piping shall be copper plated and plastic coated to prevent galvanic corrosion. No metal portion of a support or hanger shall contact pipe directly.
   b. Stacked vertical and/or horizontal runs of piping along walls shall be supported by a fiberglass framing system attached with Type 316 stainless steel anchors or concrete inserts as applicable, equal to Unistrut, B-Line or equal within the framing channel limitations. No pipe shall be supported from the pipe above or below it.
   c. Pedestal pipe supports shall be adjustable, with stanchion, saddle, and anchoring flange as shown. Provide neoprene waffle isolation pad under anchoring flanges, adjacent to equipment or where otherwise required to provide vibration isolation. Pads shall be equal to Mason Industries, Inc., Korfund Korpad.
   d. Horizontal piping hanger support rods shall attach to steel beams with C-clamps or beam clamps; to concrete with inserts, brackets or flanges fastened with flush shells; to wood not less than 2-½ inches thick with lag screws and angle clips.
   e. Piping supports for vertical piping passing through floor sleeves shall be galvanized steel riser clamps.
   f. All hangers, rods, clamps, protective shields, metal framing support components, and hanger accessories shall be hot dip galvanized.
   g. Horizontal pipe support or hanger spacing and hanger rod sizing shall be as shown on the schedule herein.
   h. The load rating for universal concrete inserts shall not be less than that of the hanger rods they support.
   i. When supporting ductile iron pipe, locate hanger rods at all non-rigid joints and at each change of direction.
   j. Vertical sway bracing shall be provided where shown, or on 10-foot maximum centers.
   k. All piping shall be supported in a manner, which will prevent undue strain on any valve, fitting, or piece of equipment. In addition, pipe supports shall be provided at changes in direction or elevation, adjacent to flexible couplings, and where otherwise shown.
3. Spacing of Hangers. Pipe support spacing requirements shall be as recommended by the pipe manufacturer, but in no case shall the spacing of hangers exceed the following:

MAXIMUM UNSUPPORTED PIPE SPAN (FEET)

Nominal Pipe Size-Inches	Cast or Ductile Iron	Steel	PVC		Copper
			Schedule 40	Schedule 80	
1/2	-	5	3.0	3.5	5
3/4	-	6	3.0	3.5	5
1	-	7	3.33	3.8	6
1-½	-	9	3.5	4.0	8
2	-	10	3.5	4.33	9
2-½	-	11	4.0	4.75	10
3	-	12	4.25	5.0	10
3-½	-	13	4.25	5.0	10
4	8	14	4.5	5.25	12
6	10	17	4.8	6.0	
8	10	19	5.0	12	
10	10	22	5.5	12	
12	12	23			
14	12	25			
16	12	27			
18	14	28			
20	14	30			
24	14	32			
30 and larger	14	32			

O. Slab, Floor, Wall, and Roof Penetrations and Closures

1. All piping penetrations of slabs, floors, walls, and roofs shall be ductile iron wall pipes with integrally cast seep rings, unless otherwise noted on the Drawings. It shall be the Contractor's responsibility to verify the size and location of all building and structure penetrations prior to pouring concrete.
   a. Ductile Iron Wall Pipes:
      i) Provide ductile iron wall pipes where ductile iron piping passes through concrete walls, floors, slabs and roofs, which are to be watertight and where shown on the Drawings. Wall pipe end connections shall be as shown on the Drawings and as specified herein. Wall pipes shall be of a thickness equal to or greater than the remainder of the piping in the line and shall comply with the requirements for fittings in the applicable Specifications. All wall pipes shall be provided with seep rings. Seep rings shall be of ductile iron and cast integral with the wall pipe.
      ii) Flanges set flush with the face of concrete shall be tapped for stud bolts.
      iii) Coat outside wall of pipes as specified in Section 09900, Painting. Support wall pipes by formwork to prevent contact with reinforcing steel.
   b. Pipe Sleeves:
      i) Piping passing through concrete or masonry shall be installed through galvanized steel pipe sleeves where shown on the Drawings. Holes drilled with a suitable rotary drill will be considered in lieu of sleeves in existing walls.

ii) All sleeves in exterior or water-bearing walls shall have a center flange for water stoppage. The annular space between pipes and sleeves in exterior walls shall be watertight. The joint shall be caulked with rubber sealant, or sealed by a modular mechanical unit consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and wall sleeve. The interconnected rubber links shall be assembled with zinc phosphate-plated steel bolts and nuts and steel pressure plates under each bolt head and nut to prevent the nut from turning when the bolt is tightened. Tightening of the bolts shall cause the rubber sealing links to expand, resulting in a watertight seal between the pipe and wall sleeve opening. Closures shall be sized according to manufacturer's instructions for the size of pipes shown on the Drawings.

iii) Wall sleeves shall be coated with the appropriate system for the intended location as specified in Section 09900, Painting. When placing non-insulating type wall sleeves in concrete forms, support them by formwork to prevent contact with the reinforcing steel.

P. Flexibility: Unless otherwise specified, piping 2 inches in diameter and larger passing from concrete to earth or from below a structure to outside of the structure shall be provided with two pipe couplings or flexible joints. The first joint shall be within 2 feet of the face of the structure. The second joint shall be located 2 feet or one pipe diameter (whichever is greater) after the first joint. Where required for resistance to pressure, mechanical couplings shall be restrained as specified elsewhere.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General

1. All exposed piping shall be firmly anchored and supported by pipe supports or anchors as shown or required. Pipe supports shall be furnished as shown on the Drawings or in accordance with the requirements of Paragraph 2.01 L of this section. All pipe shall be carefully placed to the proper lines and grades as shown on the Drawings.

2. Full lengths of pipe shall be used wherever possible. Short lengths of pipe with couplings will not be permitted. Pipe shall be cut to exact measurement and shall be installed without forcing or springing.

3. Lines which slope shall have the right-of-way over lines whose elevations can be changed. Offsets, transitions, and changes in direction in pipes shall be made as required to maintain proper headroom, slope, etc.

4. Piping shall be installed in such manner and at such times as will require a minimum of cutting and repairing of building structures. In case any such cutting or repairing is necessary, it shall be done only with the permission of the Engineer. Cutting and repairing shall be performed by craftsmen of the trade which originally executed the work, and repairs shall match the original condition.

5. All changes in direction in piping systems shall be made with suitable fittings.

6. When storing and installing pipe, care shall be taken to prevent damage to the pipe coatings. All damaged coatings shall be repaired to the satisfaction of the Engineer.

7. A liberal number of unions and/or flanged joints shall be used to permit the ready removal of any section. Unions shall be installed in all piping connections to equipment, to regulating valves, and wherever necessary to facilitate the dismantling of piping and removal of valves and other items requiring maintenance. Flanges on equipment may be considered as unions.

8. Installed piping shall not interfere with the operation of or accessibility to doors and/or windows, shall not encroach on aisles, passageways and equipment, and shall not interfere with the servicing or maintenance of any equipment.

9. The interior of all piping shall be free from obstructions and protrusions. All burrs shall be removed from the inside and outside edges of all cut pipe by reaming. Cutting shall be done in such a manner so as to leave a smooth end at right angles to pipe threads. Tool marks and unnecessary pipe threads shall be avoided. Cuttings and other foreign material shall be removed from the inside of the pipe prior to installation.

10. After installation, the interior of all piping shall be cleaned as necessary to remove flux, slag, scale, rust, dirt, oil, and other foreign material. As piping is installed, open ends shall be covered or plugged as necessary to prevent the entrance of foreign matter and to maintain the required cleanliness.

11. Changes in pipe size shall be made using reducing fittings, not bushings. If centerline elevation is not specified, use eccentric reducers in horizontal piping. On liquid lines, eccentricity shall be down with top of pipe level. On vapor and gas lines, eccentricity shall be up with bottom level.

12. Indicated locations and sizes of equipment connections are approximate; exact locations and sizes of piping, valves, etc., shall conform to approved shop drawings. Connection sizes shall not be smaller than scheduled size or equipment outlet size, whichever is larger.

13. One inch vent and drain valves shall be inserted in all high and low points of all pipes.

14. Required straight runs of piping upstream and downstream of flow measuring devices shall be smooth.

15. Minimum pipe cover shall be 3 feet, as measured from the pipe barrel, unless otherwise indicated on the Drawings.

B. Installation of Steel Piping

1. Pipe threads shall be concentric with the outside of the pipe and shall conform to ANSI B2.1. When threading stainless steel pipe, dies shall have 20 to 30 degree hook. Finished joints shall have no more than three threads exposed. Before assembly, pipe ends and threads shall be inspected and any defective pieces replaced. All joints shall be properly aligned before connection to prevent thread damage. Pipe dope shall be used on the male threads of all threaded connections. Teflon thread tape shall be applied two threads back from the end of the pipe of fitting to prevent shredding. Excess pipe dope shall be trimmed or cleaned off to provide adherence for paints or coatings. After joining, exposed threads in underground piping shall be given a heavy coat of bituminous paint or other suitable protective compound prior to backfilling.

2. All flanges shall be faced and drilled and shall be true and perpendicular to the axis of the pipe. Flanges shall be cleaned of all burrs, deformations or other imperfections before joining. Flanged joints shall be installed so as to ensure uniform gasket compression. All bolting shall be pulled up to the specified torque by crossover sequence. Where screwed flanges are used, the pipe edge shall not extend beyond the face of the flange, and the flange neck shall completely cover the threaded portion of the pipe. Where slip-on flanges are

used, the distance from the end of the pipe to the gasket face of the flange shall not exceed "t" plus 1/4-inch, where "t" is the pipe wall thickness. Unless otherwise required, bolt holes shall straddle the vertical and horizontal axes of the pipe. Connections to equipment shall be made in such a way that no strain is placed on the equipment flanges.

3. Flexible bellows-type connectors shall be installed in their undeformed configuration, in accordance with the joint manufacturer's instructions. Control rods shall be installed to permit fully rated expansion joint compression, and to limit expansion joint extension to 1/16-inch.

4. For flanged connections between steel piping and cast or ductile iron piping or valves, steel flanges shall be flat faced and furnished with full-face gaskets, insulating bushings, and, when buried, stainless steel bolts.

5. Where steel pipe is connected to copper tubing, insulating bushings or couplings shall be used to prevent galvanic corrosion.

C. Installation of Stainless Steel Pipe, Tubing and Fittings

1. General: Stainless steel pipe shall be installed in a neat and workmanlike manner, properly aligned and cut from measurements taken at the Site to avoid interferences with structural members, architectural features, openings, and equipment. Exposed pipe shall afford maximum headroom and access to equipment, and where necessary piping shall be installed with sufficient slopes for venting or drainage of liquids and condensate to low points. Installation shall be free from defects.

2. Supports and Anchors: Piping shall be firmly supported with fabricated or commercial hangers or supports as specified herein. Where necessary to avoid stress on equipment or structural members, the pipe shall be anchored or harnessed. Expansion joints and guides shall compensate for pipe expansion due to temperature differences.

3. Valves and Unions: Unless otherwise indicated, connections to fixtures, groups of fixtures, and equipment shall be provided with a shutoff valve and union, unless the valve has flanged ends. Unions shall be provided at threaded valves, equipment, and other devices requiring occasional removal or disconnection.

4. The Contractor, during handling and installation stages, shall use extreme care to avoid the contact of any ferrous materials with the stainless steel piping. All saws, drills, files, wire brushes, etc. shall be used for stainless steel piping only. Pipe storage and fabrication racks shall be non ferrous or stainless steel or rubber lined. Nylon slings or straps or alloy chains or cable shall be used for handling stainless steel piping. After installation, the contractor shall wash and rinse all foreign matter from the piping surface. If rusting of embedded iron occurs, the contractor shall pickle the affected surface with Oakite oxidizer SS or equal, scrub with stainless steel brushes and rinse clean.

5. Painting of the stainless steel pipe is not required. However, the contractor shall be responsible for supplying and installing the stainless steel piping with a consistently clean surface. Identifying spool piece marks shall be removed with paint thinner or solvents and the entire stainless steel surface shall be washed with detergent and rinsed clean.

6. After installation, the piping system shall be tested by the Contractor according to Part 3 of this Section.

7. Welding shall be in accordance with Section 05120 and the requirements below.

8. Welded Joints: All welding shall be conducted in accordance with latest editions of Section IX, ASME Boiler and Pressure Vessel Code and the American National standard Code for Pressure Piping, ANSI B31.2 and B31.3, as applicable.

9. Welding electrodes for shielded metal arc process on Type 304L and 316L stainless steel pipe shall be AWS 5.4, E 308L; Gas Tungsten Arc or Gas Metal Arc process shall be AWS 5.9, ER 308L. The direct current, reverse polarity, shielded metal arc or gas metal arc processes or direct current, straight polarity, gas tungsten-arc process shall be used for all field welding.
   a. All welders and welding operators shall be qualified at the Contractor's sole expense by an ASME-approved testing laboratory before performing any welding under this section. Qualification tests shall be in accordance with Section IX, Article III of the ASME Boiler and Pressure Vessel Code. Welders and welding operators shall be qualified for making groove welds in Type 304, 304L, 316 and 316L stainless steel pipe in position 6G for each welding process to be used.
   b. Pipe edges shall be prepared preferably by machine shaping or cutting with an aluminum oxide blade. Oxygen or arc cutting are acceptable only if the cut is reasonably smooth and true and all slag is removed either by chipping or grinding. Beveled ends for butt welding shall conform to ANSI B16.25. Surfaces to be welded shall be clean and free of paint, oil rust, scale, slag, or other material detrimental to welding. Prior to welding, wire brush joints to be welded with stainless steel wire brushes or stainless steel wool.
   c. No welding shall be performed if there is impingement of any rain, snow, sleet, or high wind on the weld area, or if the ambient temperature is below 32 degrees F. If the ambient is less than 32 degrees F, local preheating to a temperature warm to the hand is required.
   d. Each layer of deposited weld metal shall be thoroughly cleaned prior to the deposition of each additional layer of weld metal, including the final pass, with a power-driven stainless steel wire brush. Surface defects, which will affect the soundness of weld shall be chipped out or ground out.
   e. Welds shall be free of cracks, incomplete penetration, weld undercutting, excessive weld reinforcement, porosity, slag inclusions and other defects in excess of the limits prescribed in Chapter V of ANSI B31.2 and B31.3, as applicable.

D. Installation of Ductile Iron Pipe

1. When new or existing pipe is required to be cut, the pipe shall be cut in such a manner as to leave a smooth end normal to the axis of the pipe.

2. All cutting of ductile iron pipe shall be performed with a cutting saw. All burrs shall be removed from the inside and outside edges of all cut pipes. All damaged linings and coatings shall be repaired.

3. Cut pipe with milling type cutter, rolling pipe cutter, or abrasive saw cutter. Do not flame cut.

4. Ends of pipe shall be in accordance with the type of joint to be made. Dress cut ends of mechanical joint pipe to remove sharp edges or projections, which may damage the rubber gasket. Dress cut ends of pipe for flexible couplings and flanged coupling adapters, as recommended by the coupling or adapter manufacturer. Dress cut ends of push-on joint pipe by beveling, as recommended by the pipe manufacturer.

5. Prior to connecting flanged pipe, the faces of the flanges shall be thoroughly cleaned of all oil, grease, and foreign material. The rubber gaskets shall be checked for proper fit and thoroughly cleaned. Care shall be taken to assure proper seating of the flange gasket. Bolts shall be tightened so that the pressure on the gasket is uniform. Torque-limiting wrenches shall be used to ensure uniform bearing insofar as possible. If joints leak when the hydrostatic test is applied, the gaskets shall be removed and reset and bolts retightened.

6. Mechanical, push-on and restrained joint pipe shall be joined in accordance with the manufacturer's recommendations. Provide all special tools and devices such as special jacks, chokers, and similar items required for proper installation. Lubricant for the pipe gaskets shall be furnished by the pipe manufacturer, and no substitutes shall be permitted under any circumstances.

7. Ductile iron pipe shall be assembled in accordance with ANSI/AWWA C600.

8. Mechanical Joints
   a. The surfaces with which the rubber gasket comes in contact shall be brushed thoroughly with a wire brush just prior to assembly to remove all loose rust or foreign material which may be present and to provide clean surfaces which shall be brushed with a liberal amount of soapy water or other approved lubricant just prior to slipping the gasket over the spigot end and into the bell. Lubricant shall be brushed over the gasket prior to installation to remove loose dirt and lubricate the gasket as it is forced into its retaining space.
   b. Joint bolts shall be tightened by the use of wrenches and to a tension recommended by the pipe manufacturer. When tightening bolts, the gland shall be brought up toward the pipe bell. If effective sealing is not attained at the maximum torque indicated above, the joint shall be disassembled and reassembled after thorough cleaning. Overstressing of bolts to compensate for poor installation shall not be permitted.
   c. After installation, bolts and nuts in buried piping shall be given two heavy coats of a bituminous paint. Bolts and nuts for exposed or submerged service shall 316 SS in accordance with this specification.

9. Flanged Joints
   a. All flanges shall be true and perpendicular to the axis of the pipe. Flanges shall be cleaned of all burrs, deformations, or other imperfections before joining. Flanged joints shall be installed so as to ensure uniform gasket compression. All bolting shall be pulled up to the specified torque by crossover sequence. Where screwed flanges are used, the finished pipe edge shall not extend beyond the face of the flange, and the flange neck shall completely cover the threaded portion of the pipe.
   b. Connections to equipment shall be made in such a way that no torque is placed on the equipment flanges. Connecting flanges must be in proper position and alignment and no external force may be used to bring them together properly.
   c. Flanged filler shall be used only where shown on the Drawings or approved by the Engineer to make up minor differences in pipe length, less than 3-inches. Joint bolts shall be increased in length by the thickness of the flange filler.

10. Grooved Joints: Grooves for grooved couplings and fittings shall be made with specially designed grooving tools to the manufacturer's recommendations and conforming to AWWA C606. Grooves shall be clean and sharp without flaws, and the pipe ends shall be accurately cut at 90 degrees to the pipe axis.

11. Installing Pipes
    a. Proper and suitable tools and appliances for safe and convenient handling and laying of pipe and fittings shall be used. Care shall be taken to prevent the pipe coating from being damaged, particularly cement and other linings on the inside of the pipes and fittings. Any damage shall be remedied as directed by the Engineer.
    b. All pipe and fittings shall be carefully examined by the Contractor for defects just before installing and no pipe or fitting shall be installed if it is defective. If any defective pipe or fitting is discovered after having been installed, it shall be removed and replaced in a satisfactory manner with a sound pipe or fitting by the Contractor at Contractor's own expense.
    c. All pipes and fittings shall be thoroughly cleaned before they are installed and shall be kept clean until they are used in the completed work. Open ends of pipe shall be kept plugged with a bulkhead during construction.
    d. All elbows, tees, brackets, crosses, and reducers in pressure piping systems shall be adequately restrained against thrust.
    e. Flexible bellows-type connectors shall be installed in their undeformed configuration, in accordance with the joint manufacturer's instructions. Control rods shall be installed to permit fully rated expansion joint compression, and to limit expansion joint extension to 1/16-inch.
    f. Wall pipe and wall sleeves shall be accurately located and securely fastened in place before concrete is poured. All wall pipe and sleeves shall have wall collars properly located to be in the center of the wall where the respective pipes are to be installed. Pipe passing through the sleeve shall extend no more than two feet beyond the structure without a pipe joint.
    g. Wall pipe and wall sleeves shall be constructed when the wall or slab is constructed. Blocking out or breaking of the wall for later installation shall not be permitted.
    h. Cutting or weakening of structural members to facilitate pipe installation shall not be permitted. All piping shall be installed in place without springing or forcing.

E. Installation of Sanitary and Waste Drain and Vent Piping

1. Set sanitary and waste drain and vent piping installed above floor slab true and plumb.
2. Set exposed risers as close to walls as possible.
3. Make roof penetrations watertight.
4. Extend vents at least 1 foot above roof.
5. Properly slope sanitary and waste drainage piping encased in concrete.
6. Coordinate routing of drains through steel reinforcement with affected trades.
7. Make changes of direction in waste piping with combination Y and 45degree bend fittings.
8. Cleanout Fittings and Plugs:
    a. Install where shown and where required by plumbing code.
    b. T or Y branches or trap hubs shall be of the same material as the pipe in which they are installed.
9. Sanitary waste piping shall be sloped at a minimum of 1%. Vent piping shall be sloped to drain towards waste system.

F. Buried Piping System Thrust Restraint

1. General: Thrust restraint for all buried ductile iron pressure piping systems shall be accomplished by the use of restrained joints as specified hereinbefore.

2. Buried Pressure Pipelines:
   a. Thrust restraint shall be capable of restraining the buried pressure pipelines for pressures up to 1-½ times the corresponding hydrostatic test pressures listed in the Piping Schedule.
   b. Restrained joint type fittings for ductile iron pipe shall be as specified hereinbefore and on the Drawings.
   c. The Contractor shall provide restrained joints for all buried piping with test pressure higher than 20 psig.

G. Pipe Dope

1. All threaded connections shall be made up using Teflon pipe dope applied to the male threads only.

2. Virgin Teflon thread tape shall be equal to Hercules Packing Company "Herculon", 3-M Company "Scotch No.48", or Crane Packing Company "Teflon Thread tape".

3. Teflon thread paste may be used in place of tape on very large or very small joints.

H. Wall Pipes and Pipe Sleeves

1. Wall pipes and pipe sleeves embedded in concrete walls, floors, and slabs shall be embedded as specified in Section 03300, Cast-In Place Concrete and as shown. Support all pipes embedded in concrete walls, floors, and slabs with formwork to prevent contact with the reinforcing steel.

I. Flexible Couplings, Flanged Coupling Adapters, and Service Saddles: Prior to installation, thoroughly clean oil, scale, rust, and dirt from the pipe to provide a clean seat for the gasket. Care shall be taken that the gaskets are wiped clean before they are installed. If necessary, flexible couplings and flanged coupling adapter gaskets may be lubricated with soapy water or manufacturer's standard lubricant before installation on the pipe ends. Install in accordance with the manufacturer's recommendations. Bolts shall be tightened progressively, drawing up bolts on opposite sides a little at a time until all bolts have a uniform tightness. Workmen tightening bolts shall use torque-limiting wrenches.

J. Insulating Flanges, Couplings, and Unions: Install insulating flanges, couplings, or unions wherever copper and ferrous metal piping are connected, wherever submerged metallic piping is connected to unsubmerged piping, and where shown on the Drawings. Insulated joints connecting submerged piping to exposed piping shall be installed above maximum water surface elevation and before the first pipe support not having coated anchor bolts or adhesive-bonded concrete anchors. All submerged metallic piping shall be isolated from the concrete reinforcement.

K. Insulation

1. All piping and equipment shall be insulated in accordance with manufacturer's instructions including types of insulating cements, lagging adhesives, and weatherproof mastics if different from those specified.
2. All insulation shall be applied over clean, dry surfaces with all joints butted firmly together, but not until piping system has been pressure tested and any leaks corrected. Insulation shall not extend beyond flanges nor cover nameplates or code inspection stamps. Insulation shall run continuous through wall openings, ceiling openings, and pipe sleeves, unless otherwise noted.
3. Where connection is shown to existing piping, the existing insulation shall be cut back to remove the portion damaged by the piping revisions, and new insulation installed. The joint between the old and new insulation shall be finished as hereinbefore specified.
4. The Contractor shall furnish precut, sized sections of closed cell rigid insulation with vapor barrier to be inserted under piping and centered at each hanger location. Provide continuous vapor barrier at all joints between rigid insulation and pipe insulation.
5. Insulate all valve bodies, flanges, and pipe couplings. Provide removable insulation sections on all devices that require access for maintenance of equipment or removal, such as unions, strainer end plates, etc. Do not insulate flexible pipe couplings.
6. Finished appearance of all insulation shall be smooth and continuous. Provide coating of insulating cement where needed to obtain this result. Joints shall be lapped and the integrity of vapor seals maintained in strict accordance with manufacturer's instructions. Staples and screws shall not be used to secure components of systems that are vapor sealed.
7. Care shall be taken to apply the insulation and vapor barrier coating on exterior piping so that it will not be damaged when the prefabricated aluminum fitting covers are applied. The prefabricated aluminum covers shall serve as weatherproof enclosures over fittings. No screws or rivets shall be used in fastening the fitting covers, as they may puncture the vapor seal.
8. Exterior flanges and unions shall have removable prefabricated aluminum covers.

3.02 SURFACE PREPARATION AND SHOP PAINTING

A. All ferrous piping not specified to be galvanized or otherwise coated shall be cleaned and shop primed or coated in accordance with the requirements of Section 09900, Painting.

3.03 FIELD PAINTING

A. Following installation and testing, all exposed and submerged piping, including insulated piping, shall be field primed and painted in accordance with the requirements of Section 09900, Painting. Stainless steel pipe and fittings shall not be painted.

3.04 PIPING IDENTIFICATION

A. Piping Systems: Identification of piping systems shall conform to ANSI A13.1, Scheme for the Identification of Piping Systems, unless otherwise specified herein.

B. Process Piping Code: All exposed pipe shall be identified by color and labeling to show its function. Stencil-painted labels and arrows showing the direction of flow shall be installed every

20 feet or each change of direction at each valve, and on each side of wall penetrations and in valve chambers. Piping which is not painted shall be provided with 6-inch-wide color bands as specified. Color bands of an approved tape may be used on PVC, FRP and stainless steel pipe and other pipe, which does not readily accept painted finish. The color, banding and labeling shall conform to the schedule in Section 09900, Painting.

C. Process Valve Identification: After the painting of process piping is complete, the Contractor shall stencil the tag numbers of all valves numbered on the Process and Instrumentation Drawings, on the pipe adjacent to the valve for pipe 2 inches and over. Characters shall be 2 inches high minimum and shall be oriented to be visible from the valve operating position. When the valve has extended operator shaft or chain operator, the number shall be placed at both the operating position and at the valve, if practicable; this requirement does not apply if the valve is buried or in a pit. Valves in pipes under 2 inches shall have characters as large as the pipe will permit or at the Engineer's option on an adjacent surface. Characters shall be preferably white; however, if this would not provide sufficient contrast to the pipe, the Engineer may select another color. Paint used shall be of the same type and quality as that used for painting the pipe.

3.05 TESTING

A. General: Conduct pressure and leakage tests on all newly installed pipelines. Furnish all necessary equipment and material and make all taps in the pipe, as required. The Engineer will monitor the tests. Test pressures shall be as specified in the Piping Schedule.

B. Testing New Pipe Which Connects to Existing Pipe: New pipelines, which are to be connected to existing pipelines shall be tested by isolating the new Pipe.

C. Preparation and Execution

1. Buried Pressure Piping:
   a. Conduct final acceptance tests on buried pressure piping that is to be hydrostatically tested after the trench has been completely backfilled. The Contractor may, if field conditions permit, as determined by the Engineer, partially backfill the trench and leave the joints open for inspection and conduct an initial service leak test. The acceptance test shall not, however, be conducted until all backfilling has been completed.
   b. Buried pressure piping that is to be pneumatically tested or subjected only to an initial service leak test shall have all joints exposed for the acceptance test.
2. Exposed Pressure Piping: Conduct the tests on exposed piping after the piping has been completely installed, including all supports, hangers, and anchors, but prior to insulation.

D. Hydrostatic Leak Tests

1. Equipment: Furnish the following equipment for the hydrostatic tests:

Amount	Description
2	Graduated containers
2	Pressure gauges
1	Hydraulic force pump
	Suitable hose and suction pipe as required

2. Procedure: Water shall be used as the hydrostatic test fluid unless otherwise specified. Test water shall be clean and shall be of such quality as to minimize corrosion of the materials in the piping system. Vents at all high points of the piping system shall be opened to purge air pockets while the piping system is filling. Venting during the filling of the system also may be provided by the loosening of flanges having a minimum of four bolts or by the use of equipment vents. All parts of the piping system shall be subjected to the test pressure specified in the Piping Schedule. The hydrostatic test pressure shall be continuously maintained for time duration specified in pipe schedule and for such additional time as may be necessary to conduct examinations for leakage. Examination for leakage shall be made at all joints and connections. The piping system, exclusive of possible localized instances at pump or valve packing, shall show no visual evidence of weeping or leaking. Any visible leakage shall be corrected at the Contractor's sole expense.

3. Test pressure shall be measured at pump base elbow where applicable.

4. Initial Service Leak Tests:
   a. Equipment: Equipment used for initial service leak testing may be the same as that specified under Paragraphs Hydrostatic Leak Tests herein before.

      Procedure: The initial service leak test shall be performed by gradually bringing the piping system up to normal operating pressure and holding it there continuously for a minimum time of 10 minutes. Examination for leakage shall be made at all joints and connections. Soap bubbles shall be used to detect leaks in pneumatically-tested systems. The piping system, exclusive of possible localized instances at pump or valve packing, shall show no visual evidence of weeping or leaking. Any visible leakage shall be corrected at the Contractor's sole expense.

5. Test Records: Records shall be made of each piping system installation during the test. These records shall include:
   a. Date of test.
   b. Description and identification of piping tested.
   c. Test fluid.
   d. Test pressure.

6. Remarks, to include such items as:
   a. Leaks (type, location).
   b. Repairs made on leaks.

3.06 INTERIM CLEANING

A. Care shall be exercised during fabrication to prevent the accumulation of debris within piping sections. All piping shall be examined to assure removal of foreign objects prior to assembly. Shop cleaning may employ any conventional commercial cleaning method if it does not corrode, deform, swell, or otherwise alter the physical properties of the material being cleaned.

3.07 FINAL CLEANING

A. Following assembly and testing and prior to final acceptance, all pipelines installed under this section, except plant process air lines and instrument air lines, shall be flushed with water and all accumulated construction debris and other foreign matter removed. Flushing velocities shall be a minimum of 2.5 feet per second. Cone strainers shall be inserted in the connections to attached equipment and left there until cleaning has been accomplished to the satisfaction of the Engineer. Accumulated debris shall be removed through drains 2-inch and larger or by dropping spools and

valves. Immediately following drainage of flushed lines, the piping shall be air dried with compressed air.

B. Plant process air and instrument air piping shall be blown clean of loose debris with compressed air.

3.08 CORROSION PROTECTION OF PIPING SYSTEMS

A. All atmospheric exposed piping and piping components including, but not limited to, pipe hangers, supports, expansion joints, pipe guides, flexible couplings, vent and drain valves and fasteners shall be painted in accordance with Section 09900, Painting, as applicable to the base metal material.

B. Corrosion protection for buried piping systems, other than copper piping, is not required.

3.09 CORROSION PROTECTION FOR COPPER PIPING

A. Atmospheric Exposed Copper Pipe: Exposed copper piping shall be painted in accordance with Section 09900.

B. Exterior Coating for Buried Copper Pipe: All buried copper pipe shall be coated by hand taping with pipe tape. The pipe surface shall be solvent cleaned, SSPC-SP 1, and wire brushed, SSPC-SP 3, to remove all dirt and loose rust and mill scale, and immediately primed with the tape manufacturer's recommended primed in accordance with the manufacturer's recommendations. The tape shall be spirally applied to the pipe with a 50 percent overlap minimum after the primer has thoroughly dried. Joints shall be tape wrapped or heat shrink wrapped above grade to permit joint wrapping without contamination. Tape wrapping and heat shrink wrapping are specified under Paragraph Materials.

3.10 DISINFECTION

A. Pipelines intended to carry potable water shall be disinfected before placing in service. Disinfecting procedures shall conform to AWWA C651-86, as hereinafter modified or expanded.

B. Flushing: Before disinfecting, flush all foreign matter from the pipeline. Provide hoses, temporary pipes, ditches, etc. as required to dispose of flushing water without damage to adjacent properties. Flushing velocities shall be at least 2.5 fps. For large diameter pipe where it is impractical or impossible to flush the pipe at 2.5 fps velocity, clean the pipeline in place from the inside by brushing and sweeping, then flush the line at the highest possible velocity.

C. Disinfecting Mixture:

1. Disinfecting mixture shall be a chlorine-water solution having a free chlorine residual of 50 ppm, minimum. The disinfecting mixture shall be prepared by injecting: (1) A liquid chlorine gas-water mixture; (2) dry chlorine gas; or (3) a calcium or sodium hypochlorite and water mixture into the pipeline at a measured rate while fresh water is allowed to flow through the pipeline at a measured rate so that the combined mixture of fresh water and chlorine solution or gas is of the specified strength.
2. The liquid chlorine gas-water mixture shall be applied by means of a standard commercial solution feed chlorinating device. Dry chlorine gas shall be fed through proper devices for regulating the rate of flow and providing effective diffusion of the gas into the water within

the pipe being treated. Chlorinating devices for feeding solutions of the chlorine gas or the gas itself must provide means for preventing the backflow of water into the chlorine cylinder.

3. If the calcium hypochlorite procedure is used, first mix the dry powder with water to make a thick paste, then thin to approximately a 1 percent solution (10,000 ppm chlorine). If the sodium hypochlorite procedure is used, dilute the liquid with water to obtain a 1 percent solution. The following proportions of hypochlorite to water will be required:

Product	Quantity	Water
Calcium Hypochlorite(1) (65-70 percent Cl)	1 lb	7.5 gal.
Sodium Hypochlorite(2) (5.25 percent Cl)	1 gal.	4.25 gal.
(1) Comparable to commercial products known as HTH, Perchloron, and Pittchlor. (2) Known as liquid laundry bleach Clorox and Purex etc.		

4. Point of Application: Inject the chlorine mixture into the pipeline to be treated at the beginning of the line through a corporation stop or suitable tap in the top of the pipeline. Clean water from the existing system or another source shall be controlled so as to flow slowly into the newly installed piping during the application of chlorine. The rate of chlorine mixture flow shall be in such proportion to the rate of water entering the pipe that the combined mixture shall contain 50 ppm of free available chlorine. Valves shall be manipulated so that the strong chlorine solution in the line being treated will not flow back into the line supplying the water. Use check valves if necessary.

5. Retention Period:
   a. Treated water shall be retained in the pipeline long enough to destroy all nonspore-forming bacteria. With proper flushing and the specified solution strength, 24 hours is adequate. At the end of the retention period, the disinfecting mixture shall have a strength of at least 10 ppm of chlorine.
   b. Operate all valves, hydrants, and other appurtenances during disinfection to assure that the disinfecting mixture is dispersed into all parts of the line, including dead ends, new services, and similar areas that otherwise may not receive the disinfecting solution.
   c. Do not place concentrated quantities of commercial disinfectants in the line before it is filled with water.
   d. After chlorination, flush the water from the permanent source of supply until the water through the line is equal chemically and bacteriologically to the permanent source of supply.
   e. Disposal of Disinfecting Water: Dispose of disinfecting water in an acceptable manner that will protect the public and publicly used receiving waters from harmful or toxic concentrations of chlorine. Do not allow disinfecting water to flow into a waterway without adequate dilution or other satisfactory method of reducing chlorine concentrations to a safe level.

6. Collect two samples or sets of samples from each pipe or facility at least 24 hours apart. Submit samples to a state-approved laboratory for bacteriological (coliform and non-coliform) analysis. Continue disinfecting and testing until bacteriological clearance is achieved.

3.11 PIPING SCHEDULE

A. See process drawings for Pipe Schedule.

END OF SECTION 15060

SECTION 15100
VALVES AND PIPING APPURTENANCES

PART 1 - GENERAL

1.01 SCOPE

A. The work covered by this Section includes furnishing all labor, materials, equipment and incidentals required to furnish, install and test all valves, operators and appurtenances as shown and specified and as required to make the entire facility operable except for those valves and appurtenances required to be provided in other Sections of these Specifications. Items to be provided include but shall not be limited to the following:

1. Valves.
2. Operators, floor stands and valve boxes.
3. Yard Hydrants.
4. Hose Stations.
5. Potable Water Appurtenances

B. Related Work Specified Elsewhere

1. Section 09900 - Painting.
2. Section 15050 – Basic Mechanical Materials and Methods.
3. Section 15060 - Piping and Appurtenances.
4. Division 13 – Instrumentation.
5. Division 16 - Electrical

C. Contract Drawings show only functional features and some of the required external connections. They do not show all components required for a complete installation nor exact dimensions particular to any manufacturer's equipment. Contractor shall supply all parts, devices and equipment necessary to meet the requirements of the Contract Documents and shall make all dimensional adjustments particular to the equipment being furnished. All costs associated with such changes and adjustments shall be considered as being included in the price bid for the Work shown and specified.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

1. For each type and model of valve, provide:
   a. Assembly instructions and spare parts list.
   b. Preventative/corrective maintenance instructions.
   c. Certificate of seat compatibility with specified fluid exposure.

2. For each motor driven actuator provide complete actuator details, dimensions, schematics, wiring diagrams, weights, operating speed, motor currents at the specified voltage for each actuator, corresponding to locked rotor, maximum seating torque, average running load and speed.

3. Erection Drawings. Erection drawings shall include the procedures to be used in setting, supporting, and/or anchoring the valves, the fitting of line pipe to the valves for proper coupling, and for adjusting and testing all valve assemblies.

PART 2 - PRODUCTS

2.01 OPERATORS

A. General. All valves shall be equipped with operators. The operators shall be sized based on the maximum expected torque as per valve manufacturer's recommendations. The responsibility for proper operation shall reside with valve supplier. When the maximum force required to operate a valve under full operating head exceeds 40 pounds, gear reduction operators shall be provided. Gear operators shall be totally enclosed and lubricated. All valves shall open by turning counterclockwise.

1. Gate and Globe Valves: All gate, globe and angle valves shall be fitted with handwheels of suitable size or gear operators in accordance with the manufacturer's recommendation.

2. Chainwheel Operator: All Valves six feet or more above the floor level shall be provided with chainwheel operators in lieu of the handwheel operator and shall be the valve manufacturer's standard, with 316 SS chain to be furnished in the length required for operation.

3. Wrench Nut Operation: An AWWA nut or shaft key, as applicable shall be provided in lieu of handwheel where required for connection to extension stem and floor stand or as indicated on the Drawings. Nut shall be constructed of cast iron. No submerged or buried operator shall require maintenance following installation. Suitable gaskets, O-rings, and other features shall ensure permanent watertightness.
   a. Buried service operators on valves larger than 2-½ inches shall have a 2-inch AWWA operating nut. Buried operators on valves 2 inches and smaller shall have cross handle for operation by forked key. Provide gear operators on all valves from 6 inches and up and high reduction (special) gear operators on 10" and larger valves. All moving parts of the valve and operators shall be enclosed in a housing to prevent contact with the soil.
   b. Buried service operators for quarter-turn valves shall be designed to withstand 450 foot-pounds of input torque at the fully open or fully closed positions without damage to the valve or operator and shall be grease packed and gasketed to withstand a submersion in water to 10psi.
   c. Valves shall be installed with extension stems, as required, and valve boxes.

4. On quarter-turn valves, the valve operators shall be of the self-locking type to prevent the disc or plug from creeping and shall be provided with position indicators to show the position of the valve disc or plug. Operators of the worm and gear type shall have self-locking, worm gears, one-piece design, of bronze gear material, accurately machine cut. The worm shall be hardened alloy steel with thread ground and polished. Operators of the geared traveling nut type shall have threaded steel reach rods with an internally threaded bronze or ductile nut.

5. Valves provided with motor operators shall be provided as a complete unit from the valve supplier. All valve motor operators shall be provided from the same manufacturer.

2.02 VALVES

A. Gate Valves: Gate valves, 2½ inch diameter and smaller have screwed or solder ends as required and shall be Type 304 stainless steel solid wedge, union bonnet, rising stem gate valves such as Figures 47 and 48 as manufactured by Jenkins Brothers or equal products as manufactured by Kennedy Valve Manufacturing Company, Crane or equal. Valves shall be rated 200 psi.

B. Gate valves 4-inches through 12 inches in size shall be resilient-seated, non-rising stem type with 2-inch operating nuts for buried service and handwheels for exposed service conforming to AWWA Standard C-509.

C. Metal Ball Valves (4-Inch and Smaller): Ball valves up to 1-1/2-inch (incl.) in size shall have bronze 2-or 3-piece bodies with screwed ends for a pressure rating of not less than 600 psi WOG. Valves 2-inch to 4-inch in size shall have bronze 2-or 3-piece bodies with 125 lb or 150 lb flanged ends per ANSI B 16.1unless otherwise indicated. The balls shall be solid chrome plated brass or bronze, or stainless steel, with full port openings. The valve stems shall be of the blow-out proof design, stainless steel, with reinforced Teflon seal. The valve seats shall be of Teflon or Buna-N, for bi-directional service and easy replacement. Ball valves shall be as manufactured by ITT Engineered Valves; NIBCO, Inc or equal.

D. Wastewater Pump Control Valve. Pump control valves shall be provided with electric actuator pressure transducer and PLC pump control panel as a as a complete system package from a single manufacturer.

1. The Pump Control Valve shall have flanged connections, a globe body configuration, and have a single seat with seat bore equal to size of valve. The minimum travel of the piston shall be equal to 25% of the diameter of the seat. For true alignment (to correct lateral thrust and stem binding) the piston shall be guided above the seat a distance equal to no less than 75% of the diameter of the seat. Piston shall be cushioned and so designed as to insure positive closure. The spring(s) shall be enclosed in a protective chamber to close the main valve upon power failure. A mechanical scraper ring shall be utilized to protect the internal seals. Brass bushings with gauge cock on inlet and outlet of main valve shall be provided to receive pressure gauges for testing purposes. The design shall be such that repairs and dismantling of main valve may be made without its removal from the line. The valve shall be constructed from gray iron castings that conform to ASTM Specification A 126 Class B. Bronze parts shall conform to ASTM Specification B-62, and stainless parts shall conform to ASTM Specification A743 Grade CF-8 or CF 8M. The main valve shall be packed with a resilient seat packing and Buna-N O-ring seals to insure tight closure and prevent metal to metal friction and seating. The seat ring shall be grade 300 series stainless steel and shall be held in place via grade 300 series stainless steel fasteners. The seat support assembly shall be grade 300 series stainless steel. The flanged assemblies shall conform to ANSI standards for wall thickness of body caps, and flange thickness and drilling, subject to other specified standards. Ferrous surfaces of valve shall be coated with NSF Certified Epoxy (Tnemec Series N140F) in accordance with ANSI/NSF Std. 61, and conforms to AWWA D102 Inside System No. 1.

2. Electric actuator shall be as recommended by the valve manufacturer and suitable for torque and thrust requirements for proper valve operation. Provide NEMA 6 enclosure suitable for temporary submergence. Include an emergency hand wheel for emergency use.

3. Control panel for each valve shall be provided to coordinate pump start/stop operation using automatic throttling of the valve operation to maintain a pressure setpoint as set by a 4-20mA pressure transducer.
   a. The control system shall be housed within a fiberglass NEMA 4X waterproof and rustproof enclosure that will be mounted remote from the valve location.
   b. All components of this system including control switches, terminal blocks, interface fusing, the message center display, the PLC, and all associated components of the PLC shall be UL and CSA approved. All PLC inputs shall be 120V signals.
   c. The PLC module shall provide a green numbered LED for each corresponding input to indicate signal status.
      i) The following inputs shall be provided from the field devices as a minimum requirement:
         - Control Switch: Pilot device to start/stop.
         - Valve Open Limit Switch: Actuated when valve is 95% closed - (wired to normally closed contact of the switch to provide 120 volt signal as the valve opens)
         - System Pressure Switch: Senses pump discharge pressure
         - Pump Start Interlock: Provides a dry contact input signal when pump motor starter is energized
         - Valve Mounted Pressure Transducer: Provides a 4-20 mA signal to the PID control for control of valve inlet pressure or pumping pressure.
         - Valve Full Open Signal: Customer supplied contract to open the valve fully when the pump is running.
      ii) The following outputs shall be provided to the field devices:
         - Pump Motor Starter (Dry Contacts): Enables Pump Motor Starter to energize
         - Open Valve: When activated - opens valve
         - Close Valve: When activated - closes valve
      iii) All inputs and outputs are field wired to numbered terminal boards in the control panel
   d. The control system shall incorporate a message center display to indicate valve and system status. The following messages shall be included:
      - SYSTEM READY -
      - CONTROL SWITCH OFF
      - PUMP STARTING
      - WAITING FOR PRESSURE
      - CURRENT OPERATING PRESSURE
      - VALVE OPENING
      - SYSTEM NORMAL - VALVE OPEN
      - VALVE CLOSING
      - PUMP STOPPED
      - VALVE FAIL - STARTING
      - VALVE FAIL - RUNNING
      - ABNORMAL PRESSURE - STARTING
      - ABNORMAL PRESSURE - RUNNING

- PUMP MOTOR - FAILURE
- RESTART DELAY - 5 MINUTE - OR RESET H-O-A

e. Provide four (4) independent relay contacts that will close given various errors detected by the PLC.

f. Include System alarms highlighted by a flashing display describing the system fault. Upon fault detection, the system will undergo a safety shutdown. After all faults have been investigated for their causes and corrections, the control panel must be manually reset via the HAND-OFF-AUTO switch to clear all errors and enable the system for normal operation.

g. Furnish battery backup to prevent loss of internal memory upon loss of power. Furnish a new lithium battery with a minimum life expectancy of at 1 year. Battery failure is indicated by the LED in the control panel of the PLC and an error message on the display.

h. Provide remote communication via standard modem or PCMCIA Card modem to allow for remote monitoring, troubleshooting, and programming.

4. Wastewater Pump Control Valves shall be as manufactured by Ross Valve Mfg. Co., Model 70SWR-S–CE with electric actuator model 3 FCK-3 and model MC-2001P-010-005 pump control panel, or Equal with pressure setting indicator option.

E. Sewage Air and Vacuum Valves.

1. Sewage Air and Vacuum Relief Valves shall consist of a compact tubular all stainless steel fabricated body, hollow direct acting float and solid large orifice float in H.D.P.E. – stainless steel nozzle and woven dirt inhibitor screen, nitrile rubber seals and natural rubber seat.

2. The valve shall have an integral "Anti-Surge" Orifice mechanism which shall operate automatically to limit surge pressure rise or shock induced by closure to less than 1.5 times the valve rated working pressure. The intake orifice area shall be equal to the nominal size of the valve (i.e., a 6" valve shall have a 6" intake orifice).

3. Large orifice sealing shall be affected by the flat face of the control float seating against an EPDM rubber "O" ring housed in a dovetail groove circumferentially surrounding the orifice. Discharge of pressurized air shall be controlled by the seating and unseating of a small orifice nozzle on an EPDM rubber seal affixed into the control float. The nozzle shall have a flat seating land surrounding the orifice so that damage to the rubber seal is prevented.

4. The valve construction shall be 304 stainless steel and shall be proportioned with regard to material strength characteristics, so that deformation, leaking or damage of any kind does not occur by submission to twice the designed working pressure. Connection to the valve inlet shall be facilitated by flanged ends conforming ANSI B16.1 Class 150 or ANSI B16.5 Class 150 Standards. Flanged ends shall be fastened with stainless steel bolts inserted for alignment to the specified standard, nuts, washers and gaskets. Valve outlet shall be a swivel flange outlet for connection to vent piping.

5. Operation of the valve shall be as follows:
   a. Prior to the ingress of liquid into the valve chamber, as when the pipeline is being filled, valves shall vent through the large orifice to a transient pressure rise, on valve closure, of <1.5 x valve rated pressure. At higher sewage/effluent approach velocities, which have a potential to induce transient pressure rises greater than 1.5 times valve rated

pressure on valve closure the valve shall automatically discharge air/gas through the "Anti-Shock" Orifice and reduce sewage/effluent approach velocity, so that on closure a maximum transient pressure rise of less than 1.5 times valve rated pressure is realized.

b. Valves shall not exhibit leaks or weeping of liquid past the large orifice seal at operating pressures of 7.2 psi to twice rated working pressure. Valves shall be provided with a bias mechanism.

c. Valves shall respond to the presence of air/gas by discharging it through the small orifice at any pressures within a specified design range, 7.2 psi to 145 psi and shall remain leak tight in the absence of air.

d. Valves shall react immediately to pipeline drainage or liquid column separation by the full opening of the large orifice so as to allow unobstructed air intake at the lowest possible negative internal pipeline pressure.

6. Sewage air and vacuum relief valves shall be Vent-O-Mat Series RGX or equal,

F. Check Valve

1. Check Valves shall be suitable for cold working pressures of 250 psig, designed for wastewater, abrasive, and slurry service. The check valve shall be of the full body type, with a domed access cover and only one moving part, the flexible disc.

2. The valves shall be designed, manufactured and tested in accordance with American Water Works Association Standard ANSI/AWWA C508.

3. The Valves shall be provided with flanges in accordance with ANSI B16.1, Class 125.

4. Valve Design

a. The valve body shall be full flow equal to nominal pipe diameter at all points through the valve for valves larger than 3". The seating surface shall be on a 45 degree angle to minimize disc travel.

b. The top access port shall be full size, allowing removal of the disc without removing the valve from the line. The access cover shall be domed in shape to provide flushing action over the disc for operating in lines containing high solids content. A threaded port with pipe plug shall be provided in the access cover to allow for field installation of a mechanical, disc position indicator.

c. The disc shall be of one-piece construction, precision molded with an integral O-ring type sealing surface, and contain alloy steel and nylon reinforcement in the flexible hinge area. The flex portion of the disc shall be warranted for twenty-five years. Non-Slam closing characteristics shall be provided through a short 35 degree disc stroke and a memory disc return action to provide a cracking pressure of 0.25 psig.

d. The valve disc shall be cycle tested 1,000,000 times in accordance with ANSI/AWWA C508 and show no signs of wear, cracking, or distortion to the valve disc or seat and shall remain drop tight at both high and low pressures.

e. A screw-type backflow actuator shall be provided to allow opening of the valve during no-flow conditions. Buna-N seals shall be used to seal the stainless steel stem in a Lead-Free bronze bushing. The backflow device shall be of the rising-stem type to indicate position. A stainless steel T-handle shall be provided for ease of operation.

f. A bottom mounted oil dashpot (oil cushion) shall be provided to provide hydraulic control of the final 10% of valve closure and reduce valve slam and water hammer normally associated with rapid flow reversal conditions on pump shut down. The dashpot shall consist of a high pressure hydraulic cylinder, adjustable external flow

control valve, oil reservoir, pressure gauge, stainless steel air inlet valve, and piping designed to control the closing speed of the last 10% of travel in 1-5 seconds. A threaded brass dashpot bushing unit with a grease fitting for lubrication shall connect the cylinder to the valve and shall have an air gap to prevent hydraulic fluid from entering the valve and contaminating the water system. A snubber rod fitted with O-ring seals and rod wiper scrapers shall make contact with the lower portion of the disc's stainless steel strike plate.

5. Materials
   a. The valve body and cover shall be constructed of ASTM A536 Grade 65-45-12 ductile iron or ASTM A126 class B for 30 in. and larger.
   b. The disc shall be precision molded Buna-N (NBR), ASTM D2000-BG.
6. All valves shall be hydrostatically tested and seat tested to demonstrate zero leakage.
7. The exterior and interior of the valve shall be coated with an NSF/ANSI 61 approved fusion bonded epoxy coating.
8. Check Valves shall be Swing-Flex Check Valves, Series #500 as manufactured by Val-Matic Valve & Mfg. Corporation or equal.

G. Butterfly valves

1. Butterfly valves shall be short body, conforming to AWWA C504, Class 150B. Minimum working differential pressure across the valve disc shall be 150 psi.
2. Each valve body shall be tested under a test pressure equal to twice its design water working pressure.
3. Valves shall be bubble tight at rated pressures and shall be satisfactory for throttling service and frequent operation after long periods of inactivity. Valve discs shall rotate 90 degrees from the full-open position to the tight-shut position.
4. Valve Ends
   a. Buried: Mechanical joint
   b. Exposed: Flanged Class 125, ANSI B16.1.
5. Valve shafts: shall be carbon steel with Type 316 stainless-steel journals and static seals. Valve shafts shall be dual stub shafts or a one-piece shaft extending completely through the valve disc.
6. Actuator: Enclosed, gasketed gear, type fully grease packed with stop in open/closed position.
   a. Manually-actuated butterfly valves, 4 inches and larger, shall be equipped with gear actuators. All gearing shall be enclosed in a semi-steel housing and be suitable for running in a lubricant with seals provided on all shafts to prevent entry of dirt and water into the actuator. Actuators shall clearly indicate valve position and an adjustable stop shall be provided to set closing torque.
   b. Motor actuated valves shall be provided with motor actuators as herein.
7. The rubber seat shall be an integral part of the valve body. Rubber seats fastened to the disc by any means shall not be permitted.
8. Materials of construction shall be as follows:
   a. Body: Cast iron, ASTM A126, Class B
   b. Shaft: Carbon steel with ASTM A276, Type 316 stainless steel journals and static seals.

c. Disc: cast iron, ASTM A126, Class B or ductile iron, ASTM A536.

9. Manufacturer: Henry Pratt Company, Clow Valve Company, Dressor Industries, Dezurik, or equal.

H. Eccentric plug valves

1. General
   a. Valves shall be of the nonlubricated eccentric type with resilient-faced plugs and shall be furnished with end connections as shown on drawings. Flanged valves shall be faced and drilled to the ANSI 125/150 lb standard.
   b. Port areas for valves through 20 inches shall be minimum 80 percent of full pipe area and not less than 70 percent for larger valves.
   c. Valve pressure ratings shall be a minimum of 175 psi.
   d. Drop tight shutoff should be provided at full-rated working pressure in the normal flow direction and 50 psi in the other direction.
   e. Certified copies of proof-of-design test reports shall be furnished as outlined in AWWA C504, Section 5.5.
   f. Valves shall be Dezurik, Golden Anderson, or equal.
2. Valve Body
   a. Valve bodies shall be of ASTM A126 Class B cast iron in compliance with AWWA C504 Section 2.2.
   b. Bodies in 3 inches and larger valves shall be furnished with a welded overlay seat of not less than 90 percent pure nickel in accordance with AWWA C507 Section 7.2.
   c. Valves utilizing resilient seats attached to the body shall not be acceptable. As per AWWA C504 Section 35.2 and AWWA C507 Section 7.2, sprayed of plated sets are not acceptable, nor shall screwed in seats be acceptable.
3. Plugs
   a. Each valve plug shall rotate 90 percent from the fully open to the tightly shut position and shall seat at an angle of 90 percent from the pipe axis in which the valve is installed.
   b. Plugs shall be of ASTM A216 Class B cast iron in compliance with AWAA C504, Section 2.2.
   c. The plug shall be of one piece construction and shall be capable of withstanding the full pressure rating of the valve without use of additional structural reinforcing ribs that extended beyond the profile of the plug itself.
   d. Plugs shall be resilient faced with neoprene or hycar, suitable for use with raw sewage.
   e. Plugs with cast inlays shall not be acceptable.
4. Bearings
   a. Valves shall be furnished with replaceable, sleeve-type metal bearings conforming to AWWA C504, Section 3.6 and AWWA C507, Section 8.
   b. Bearing shall be of sintered, oil-impregnated and permanently lubricated Type 316 ASTM A743 Grade CF-8M or AISI Type 317L stainless steel in up to 36 inch size.
   c. For valves larger than 36 inches, the upper and lower plug journals shall be fitted with ASTM A240 Type 316 stainless sleeves with bearings of ASTM B30, Alloy C95400 aluminum bronze.
   d. Nonmetallic bearings shall not be acceptable.

5. Packing Seals
   a. Valves shaft seals shall be of the multiple V-ring type and shall be externally adjustable, repackable without removing the bonnet or actuator from the valve, and repackable under pressure.
   b. Shaft seals shall conform with AWWA C504, Section 3.7 and AWWA C507, Section 10.2.
   c. Valves utilizing O-ring seals or nonadjustable packing shall not be acceptable.
   d. All exposed nuts, bolts, springs, washers, etc., shall be stainless steel for buried valves and zinc plated for all others.
6. Valve Operators
   a. Manually-actuated plug valves, 4 inches and larger, shall be equipped with gear actuators. All gearing shall be enclosed in a semi-steel housing and be suitable for running in a lubricant with seals provided on all shafts to prevent entry of dirt and water into the actuator. Actuators shall clearly indicate valve position and an adjustable stop shall be provided to set closing torque.
   b. Motor actuated valves shall be provided with motor actuators as specified below.

I. Backflow Preventer:

1. Backflow preventers shall be the reduced pressure type, providing protection during the emergency conditions of either back-siphonage or backpressure or a combination of both. Backflow preventers shall be certified by a nationally recognized testing laboratory as conforming to current requirements of ASSE 1013, AWWA C 506, or USC-FCCC. The installation shall meet all applicable state and local code.
2. Sizes ¾-inch through 2-inches shall have bronze bodies with threaded connections, a bronze union on either side and a strainer installed upstream of the device. Gate valves shall be installed upstream and downstream of the device.
3. Sizes 2½ inches and larger shall be bronze with corrosion resisting moving parts and trim and flange connections. Gate valves shall be installed upstream and downstream of the device.
4. The device shall be equipped with three leak-proof test cocks. A fixed air gap, or funnel, shall be installed at the relief port. A drain line shall be piped from the discharge side of the air gap as shown on the Drawings and shall be supported independently from the device.
5. Backflow preventers shall be rated at a minimum 175 pounds cold water working pressure.
6. Backflow preventers shall be manufactured by Watts, Wilkins, Hersey or equal.

J. Pressure Reducing Valves

1. Provide bronze body, spring controlled, adjustable pressure reducing valve with threaded connections for sizes 2-inch and smaller.
2. Provide valves with high temperature diaphragm and renewable nickel alloy seat.
3. Provide with thermal expansion bypass.
4. Provide with separate bronze strainer with 20 mesh 316 stainless steel basket. Attach to valve with bronze nipple.

5. Rated for 300 psig maximum inlet water pressure with adjustable 25-75 psig outlet water pressure.

6. Pressure reducing valves shall be Watts 223SB or equal.

K. Pressure Gauges: Pressure gauges shall be non-liquid filled, bourdon tube type, ranged 0 to 200 psig. Case shall be solid front, plastic, non-liquid filled, 4-1/2" diameter with blow-out protection. All wetted parts shall be type 316 stainless steel. Accuracy shall be +/- 0.5 percent of range. Process connection shall be bottom, ½" NPT male. Pressure gauges shall have external adjustment. Provide 316 SS isolation diaphragm for pressure gauges in wastewater service. Pressure gauges shall be equal to Ashcroft Industrial Instruments.

L. Pressure Relief Valve

1. The pressure relief valve shall open when the inlet water pressure exceeds a set maximum level. It shall relieve to maintain that pressure and gradually close as the inlet pressure drops below the maximum pressure. The valve shall be a spring and hydraulically operated, direct acting, adjustable, diaphragm or piston type globe or angle valve as indicated on plans.

2. For inlet sizes 2-1/2 inch and smaller, the valve body shall be bronze with threaded inlet and outlet to standard NPT and with flanged top, suitable for an inlet pressure of 300 psi. The spring shall be adjustable with an adjusting screw, to regulate the pressure setting.

3. For inlet sizes 3-inch and larger, the valve body shall be carbon steel with flanged inlet and outlet and flanged top, suitable for an inlet pressure of 300 psi. The spring shall be adjustable with an adjusting screw, to regulate the pressure setting.

4. The valve trim shall be of stainless steel with stainless steel spring. The rubber seat shall be replaceable.

5. The valve shall be settable for a minimum relief pressure of 25 psi.

6. Pressure relief valves shall be equal to Cla-Val Company, OR Golden-Anderson OR Ross Valve Mfg. Co., Inc

2.03 MOTOR ACTUATED VALVES

A. General

1. Actuators shall be designed for use on the power supply as specified in the valve schedule and are to incorporate motor, integral reversing starter, local control facilities and terminals for remote control and indication connections housed within a self-contained, sealed enclosure.

2. In order to maintain the integrity of the enclosure, setting of the torque levels, position limits and configuration of the indication contacts etc. shall be carried out without the removal of any actuator covers over an Infra red interface. Sufficient commissioning tools shall be provided with the actuators and must meet the enclosure protection and certification levels of the actuators. Commissioning tools shall not form an integral part of the actuator and must be removable for secure storage. In addition, provision shall be made for the protection of configured actuator settings by a means independent of access to the commissioning tool.

3. The actuator shall include a device to ensure that the motor runs with the correct rotation for the required direction of valve travel irrespective of the connection sequence of the power supply.

B. The actuator shall be sized to guarantee valve closure at the specified differential pressure and temperature. The safety margin of motor power available for seating and unseating the valve shall be sufficient to ensure torque switch trip at maximum valve torque with the supply voltage 10% below nominal. For linear operating valves, the operating speed shall be such as to give valve closing and opening at approximately 10-12 inches per minute unless otherwise stated in the data sheet. For 90° valve types the operating time will be specified.

C. Environmental

1. Actuators shall be suitable for indoor and outdoor use. The actuator shall be capable of functioning in an ambient temperature ranging from 0°F) to 140°F, up to 100° relative humidity.
2. Actuators for hazardous area applications shall meet the area classification, gas group and surface temperature requirements specified in the schedule.

D. Enclosure

1. Actuators shall be 0-ring sealed, watertight to /IP68 7m for 72hrs, NEMA 4, 6. The motor and all other internal electrical elements of the actuator shall be protected from ingress of moisture and dust when the terminal cover is removed for site cabling, the terminal compartment having the same ingress protection rating as the actuator with the terminal cover removed.
2. Enclosure must allow for temporary site storage without the need for electrical supply connection.
3. All external fasteners shall be zinc plated stainless steel.

E. Motor

1. The motor shall an integral part of the actuator, designed specifically for valve actuator applications. It shall be a low inertia high torque design, class F insulated with a class B temperature rise giving a time rating of 15 minutes at 104°F at an average load of at least 33% of maximum valve torque. Temperature shall be limited by thermostats embedded in the motor end windings and integrated into its control.
2. Electrical and mechanical disconnection of the motor should be possible without draining the lubricant from the actuator gearcase.
3. Motor protection shall be provided as follows:
   a. Stall - the motor shall be de-energized within 8 seconds in the event of a stall when attempting to unseat a jammed valve.
   b. Over temperature - thermostat will cause tripping of the motor. Auto-reset on cooling
   c. Single phasing - lost phase protection.
   d. Direction – phase rotation correction.

F. Actuator gearing shall be totally enclosed in an oil-filled gearcase suitable for operation at any angle. Grease lubrication is not permissible. All drive gearing and components must be of metal construction and incorporate a lost-motion hammerblow feature. For rising spindle valves the output shaft shall be hollow to accept a rising stem, and incorporate thrust bearings of the ball or roller type at the base of the actuator. The design should be such as to permit the opening of the gearcase for inspection or disassembled without releasing the stem thrust or taking the valve out

of service. For 90° operating type of valves drive gearing shall be self locking to prevent the valve backdriving the actuator.

G. Hand operation

1. A handwheel shall be provided for emergency operation, engaged when the motor is declutched by a lever or similar means, the drive being restored to power automatically by starting the motor. The handwheel or selection lever shall not move on restoration of motor drive. Provision shall be made for the hand/auto selection lever to be locked in both hand and auto positions. It should be possible to select hand operation while the actuator is running or start the actuator motor while the hand/auto selection lever is locked in hand without damage to the drive train.
2. Clockwise operation of the handwheel shall give closing movement of the valve unless otherwise stated in the data sheet. For linear valve types the actuator handwheel drive must be mechanically independent of the motor drive and should be such as to permit valve operation in a reasonable time with a manual force not exceeding 400N through stroke and 800N for seating/unseating of the valve.

H. Torque and turns limitation to be adjustable as follows:

1. Position setting range – multi-turn: 2.5 to 100,000 turns, with resolution to 15 deg. of actuator output.
2. Position setting range – direct drive part turn actuators: 90° +/-10°, with resolution to 0.1 deg. of actuator output.
3. Torque setting: 40% to 100% rated torque.
4. Measurement of torque shall be from direct measurement of force at the output of the actuator.

I. Remote valve position/actuator status indication.

1. Four contacts shall be provided which can be selected to indicate any position of the valve. Provision shall be made for the selection of a normally closed or open contact form. Contacts shall maintain and update position indication during handwheel operation when all external power to the actuator is isolated.
2. The contacts shall be rated at 5A, 250V AC, 30V DC.
3. As an alternative to providing valve position any of the four above contacts shall be selectable to signal one of the following:□
   a. Valve opening, closing or moving
   b. Thermostat tripped, lost phase
   c. Motor tripped on torque in mid travel, motor stalled
   d. Remote selected
   e. Actuator being operated by handwheel
4. Provision shall be made in the design for an additional 4 contacts having the same functionality.

5. Provision shall be made in the design for the addition of a contactless transmitter to give a 4-20mA analogue signal corresponding to valve travel for remote indication when required. The transmitter will auto range to the set limits

J. Local position indication

1. The actuator display shall include a dedicated numeric/symbol digital position indicator displaying valve position from fully open to fully closed in 1% increments. Valve closed and open positions shall be indicated by symbols showing valve position in relation to the pipework to ensure that valve status is clearly interpreted. With main power on the display shall be backlit to enhance contrast at low light levels and shall be legible from a distance of at least 6 feet (2m).
2. Red, green, and yellow lights corresponding to open, closed, and intermediate valve positions shall be included on the actuator display when power is switched on. The digital display shall be maintained and updated during handwheel operation when all power to the actuator is isolated.
3. In addition, the actuator display shall include a separate text display element with a minimum of 32 characters to display operational, alarm and configuration status. Provision shall be made to orientate the actuator display through increments of 90□.

K. The digital display shall be capable of indicating real time torque and valve position simultaneously, both being displayed in 1% increments of valve position and actuator rated torque. In addition torque shall also be displayed in horizontal bar graph form.

L. The reversing starter, control transformer and local controls shall be integral with the valve actuator suitably housed to prevent breathing and condensation. The starter shall be suitable for 60 starts per hour and of rating appropriate to motor size. The controls supply transformer shall be fed from two of the incoming three phases and incorporate overload protection. It shall have the necessary tappings and be adequately rated to provide power for the following functions:

1. Energization of the contactor coils.
2. 24V DC output for remote controls.
3. Supply for all the internal electrical circuits.

M. Local controls

1. The actuator shall incorporate local controls for Open, Close and Stop and a Local/Stop/Remote mode selector switch lockable in any one of the following three positions: local control only, stop (no electrical operation), remote control plus local stop only. It shall be possible to select maintained or non-maintained local control.
2. The local controls shall be arranged so that the direction of valve travel can be reversed without the necessity of stopping the actuator.
3. Provision shall be made to orientate the local controls through increments of 90□.

N. Control facilities

1. The necessary control, wiring and terminals shall be provided in the actuator for the following functions:
2. Open and close external interlocks to inhibit local and remote valve opening and/or closing control. It shall be possible to configure the interlocks to be active in remote control only.
3. Remote controls fed from an internal 24V DC supply for any one or more of the following methods of control:
   a. Open, Close and Stop control.
   b. Open and Close maintained or "push to run" (inching) control.
   c. Overriding Emergency Shut-down to Close (or Open) valve from a normally closed or open contact.
   d. Two-wire control, energize to close (or open), de-energize to open (or close).
4. It shall be possible to reverse valve travel without the necessity of stopping the actuator. The motor starter shall be protected from excessive current surges during rapid travel reversal.
5. Provision shall be made for operation by distributed control system utilizing the following network systems.
   a. Modbus
   b. Profibus
   c. Foundation Fieldbus
   d. DeviceNet
   e. Pakscan

O. Monitoring facilities

1. Facilities shall be provided for monitoring actuator operation and availability as follows:
   a. Monitor (availability) relay, having one change-over contact, the relay being energized from the control transformer will de-energise under any one or more the following conditions:
   b. Loss of main or customer 24V DC power supply
   c. Actuator control selected to local or stop
   d. Motor thermostat tripped
   e. Actuator internal fault
2. Actuator text display indication of the following status/alarms:
   a. Closed Limit, open limit, moving open, moving closed, stopped
   b. Torque trip closing, torque trip opening, stalled
   c. ESD active, interlock active
   d. Thermostat trip, phase lost, 24V supply lost, Local control failure
   e. Configuration error, Position sensor failure, Torque sensor failure
   f. Battery low, power loss inhibit
3. Integral datalogger to record and store the following operational data:
   a. Opening last /average torque against position
   b. Closing last /average torque against position

c. Opening motor starts against position
d. Closing motor starts against position
e. Total open/closed operations
f. Maximum recorded opening and closing torque values
g. Event recorder logging operational conditions (valve, control and actuator)

4. The datalogger shall record relevant time and date information for stored data.
5. Datalogger data is to be accessed via non-intrusive IrDA communication. Sufficient standard intrinsically safe tools shall be provided for downloading datalogger and actuator configuration files from the actuators and subsequent uploading to a PC. The actuator manufacturer shall supply PC software to enable datalogger files to be viewed and analyzed.

P. Wiring and terminals

1. Internal wiring shall be tropical grade PVC insulated stranded cable of appropriate size for the control and 3-phase power. Each wire shall be clearly identified at each end.
2. The terminals shall be embedded in a terminal block of high tracking resistance compound.
3. The terminal compartment shall be separated from the inner electrical components of the actuator by means of a watertight seal and shall be provided with a minimum of 2 threaded cable entries with provision for a maximum of 4.
4. All wiring supplied as part of the actuator to be contained within the main enclosure for physical and environmental protection. External conduit connections between components are not acceptable.
5. A durable terminal identification card showing plan of terminals shall be provided attached to the inside of the terminal box cover indicating:
   a. Serial number
   b. External voltage values
   c. Wiring diagram number
   d. Terminal layout
   e. The code card shall be suitable for the contractor to inscribe cable core identification alongside terminal numbers.

Each actuator shall be supplied with a start-up kit comprising installation instruction manual, electrical wiring diagram and cover seals to make good any site losses during the commissioning period. In addition, sufficient actuator commissioning tools shall be supplied to enable actuator set up and adjustment during valve/actuator testing and site installation commissioning.

Q. Performance test certificate

1. Each actuator must be performance tested and individual test certificates shall be supplied free of charge. The test equipment should simulate a typical valve load, and the following parameters should be recorded.
   a. Current at maximum torque setting
   b. Torque at max. torque setting
   c. Flash test voltage
   d. Actuator output speed or operating time.

2. In addition, the test certificate should record details of specification such as gear ratios for both manual and automatic and second stage gearing if provided, drive closing direction, wiring diagram number.

R. Failsafe Integral Battery Backup

1. When specified in the valve schedule, the actuator shall provide valve failsafe operation by utilizing power from a battery source during AC supply mains failure. Under normal supply conditions the actuator operates from the AC electrical supply. On loss of electrical supply the actuator shall automatically switch over to receive power from a 24V DC battery supply allowing control of the valve to the specified failsafe position
2. The failsafe battery backup shall include a battery located in the actuator terminal cover, charged from an integral charging system when AC power is applied to the actuator. On loss of the normal AC supply the actuator shall automatically switch over to the 24V DC battery supply
3. Failsafe actuator operation shall be as specified in the valve schedule and shall be user configured to respond as follows:
   a. Automatic close on loss of supply
   b. Automatic open on loss of supply
   c. Stayput waiting for local or remote control command
4. Failsafe control or positioning shall be completed within 30 minutes of loss of AC supply and designed to prevent deep discharge damage to the batteries. Remote operation is by hardwired control systems only, derived from and external supply source as the actuator 24V DC supply is not supported under battery operation.
5. Batteries shall be lead-acid type designed to supply adequate power to operate valve through at least 4 cycles.
6. Battery backup system shall include charge state indication for depleted, low and full charge indication

2.04 WATER SERVICE LINE FITTINGS AND APPURTENANCES

A. Service Saddles, conforming to AWWA C800.

1. Ductile Iron
   a. For 1-inch diameter and smaller taps provide single strap saddles for mains 4-inch through 12-inch in diameter and double straps for mains larger than 12-inches in diameter.
   b. Body: Ductile iron ASTM-A536, threaded for corporation stop.
   c. Bolts, nuts and washers: Galvanized steel ASTM B633.
   d. Gaskets: Buna N.
2. Bronze
   a. For 1-inch diameter and smaller taps provide single strap saddles for mains 4-inch through 12-ince in diameter and double straps for mains larger than 12-inches in diameter.
   b. Body: Cast Bronze ASTM B584 threaded for corporation stop.

c. Bolts and nuts: Copper silicon alloy 651 ASTM B98.

d. Washers: Silicon Bronze, ASTM B36

e. Gaskets: Buna N.

3. Nylon Coated Ductile Iron

a. For 1-inch diameter and smaller taps provide single strap saddles for mains 4-inch through 12-inch in diameter and double straps for mains larger than 12-inches in diameter.

b. Body: Ductile iron ASTM-A584, threaded for corporation stop.

c. Bolts, nuts and washers: Type 304 stainless steel.

d. Gaskets: Buna N.

4. Service saddles installed on C900 PVC pipe shall be a 2 casting designed for use with the specified O.D. of the pipe. Each saddle shall accurately fit the contour of the pipe O.D. without causing distortion of the pipe. The sections shall be securely held in place with bolts, washers and nuts. The casting sections shall be tapped to receive the bolts.

B. Corporation Stops

1. Corporation stops shall be bronze body.

2. End connections shall conform with AWWA C800.

3. The inlet fitting shall be an iron pipe thread when used with a saddle and the outlet shall be an iron pipe thread to match the service line.

4. Size shall match service tap and service line.

2.05 HYDRANTS

A. Post Hydrants.

1. Post Hydrants shall be self-draining, non-freezing, compression type with 2-3/16-inch main valve opening. Inlet connection shall be 3-inch mechanical joint. Outlet shall be 2.5-inch.

2. Hydrants shall have a 3-inch ductile pipe riser with a cast iron stock top and a non-turning operating rod. Principal interior operating parts shall be brass and removable from the hydrant for servicing without excavating the hydrant.

3. Hydrants shall be set in 4 cubic feet of crushed stone to allow for proper drainage of the hydrant. Installation of the hydrants shall be in conformance with AWWA's recommendations.

4. Post hydrants shall be equal to Eclipse No.2 Post Hydrants as manufactured by The Kupferle Foundry Company.

B. Yard Hydrants.

1. Yard Hydrants shall be self-draining, non-freezing type. Inlet connection shall be 1-inch.

2. Yard Hydrants shall be Well Pro Hi-Capacity series WC-1000 or equal.

2.06 TAPPING SLEEVES AND VALVES

A. Tapping sleeve to be manufactured form gray iron ASTM A126 Grade B or ductile iron ASTM A536 65-45-12, with high strength low alloy steel zinc coated ASTM B-633 bolts and nuts.

B. Tapping valve shall conform to requirements AWWA C500 except as modified for passage and clearance of tapping machine.

1. Materials of construction shall be same as specified for gate valves in this section.
2. The mating valve flange must have a face to insure true alignment of valve and tapping machine.
3. The outlet end of the sleeve shall match connection to type of water main pipe.

2.07 VALVE BOXES

A. General. The Contractor shall provide cast-iron valve boxes.

B. Design.

1. Valve boxes shall be designed to be installed over each direct buried valve.
2. Boxes shall be of two piece extension type with slide-type adjustment and with flared base.
3. Covers shall be cast-iron and shall have cast-iron ring.
4. Box shall be of such length as will be adapted, without full extension, to the depth of the cover required over pipe at valve location.
5. Boxes shall be suitable for the valve size and depth of trench as recommended by the manufacturer

2.08 PROTECTIVE COATINGS FOR VALVES

A. Interior. Factory applied heat-cured epoxy coating conforming to AWWA C550, and field coat in conformance with Section 09900, Painting and Protective Coatings.

B. Exterior. Field coat exposed valves in conformance with Section 09900, Painting.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Aboveground valves shall be rigidly held in place using supports and hangers as shown on the Drawings and as specified. The stem orientation of valves in elevated piping shall be as approved by the Owner for accessibility, but no valve shall have stem in the downward direction. Saddle type valve supports shall be provided for all valves in vaults. Supports shall be of rugged construction providing at least 120 degrees under-support for the valve body, shall be constructed of steel as specified in Division 5, and shall be anchored to the foundations using galvanized anchor bolts.

3.02 TESTS

A. Field Tests. Test all valves and appurtenances for proper operating adjustments and settings and for freedom from vibration, binding, scraping, and other defects. The testing of the hydraulically and electrically controlled valves shall be supervised by a representative of the manufacturer who shall verify proper installation, adjustments, and performance. The adequacy of all pipe hangers and supports and valve supports to meet specified requirements shall be verified. All defects found shall be corrected as approved.

3.03 COORDINATION WITH INSTRUMENTATION

A. It shall be the responsibility of the Contractor to coordinate with Division 13 regarding the requirements of control valves.

3.04 COORDINATION WITH OTHER MECHANICAL SUPPLIERS

A. The installation and operation of the valve and motorized actuators shall be the unit responsibility of the valve supplier.

3.05 CLEANING

A. All valves and appurtenances shall be flushed clean of all foreign matter together with the piping as specified in other sections.

Motor Activated Valve Schedule

Valve Tag Number	FCV-203	FCV-501	FCV-504 and FCV-505	FCV-506 and FCV-507	FCV-511 to FCV-518	FCV-519	FCV-531 to FCV-533
Valve Type	Plug	Plug	Plug	Plug	Butterfly	Butterfly	Plug
Valve Size, Inches	30	48	12	20	6	8	8
Quality Standard	Dezurik or Equal	Dezurik or Equal	Dezurik or Equal	Dezurik or Equal	Dezurik or Equal	Dezurik or Equal	Dezurik or Equal
End Connection	Flanged	Flanged	Flanged	Flanged	Flanged	Flanged	Flanged
Valve Action on Loss of Power	Fail in Last Position	Fail in Last Position	Fail in Last Position	Fail in Last Position	Fail in Last Position	Close on Failure via Integral Battery Back-up	Fail in Last Position
Valve Speed	Adjustable	Adjustable	Adjustable	Adjustable	Manual Standard	Adjustable	Manual Standard
Service	Flow Return to Sewer	Jet Mix Pump Station/EQ Tank Isolation	Jet Mix Flush	Jet Mix Pump Isolation	EQ Flushing System	EQ Flushing System Isolation	EQ Flow Return Pump Drain
Fluid	Raw Wastewater	Raw Wastewater	Raw Wastewater	Raw Wastewater	Non-Potable Water	Non-Potable Water	Non-Potable Water
Flowrate (max)	20,900 gpm	46,500 gpm	3500 gpm	10,000 gpm	750 gpm	1500gpm	750 gpm
Differential Pressure (at Qmax)	80 ft	80 ft	80 ft	65 ft	80 psi	80 psi	80 ft
Valve Tag Number	FCV-203	FCV-501	FCV-504 and FCV-505	FCV-506 and FCV-507	FCV-511 to FCV-518	FCV-511 to FCV-518	FCV-531 to FCV-533

Other Requirements	Electric Actuator	Electric Actuator	Electric Actuator	Electric Actuator	Electric Actuator (modulating)	Electric Actuator	Electric Actuator
Additional Limit Switches	Open/Closed	Open/Closed	Open/Closed	Open/Closed	Open/Closed	Open/Closed	Open/Closed
Local-Off-Remote	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hand-Off-Auto Switch	No	No	No	No	No	No	No
Position Indicator Lights	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Potentiometer	No	No	No	No	Yes	Yes	Yes
Position Controller	No	No	No	No	Yes	Yes	Yes
Pushbutton Switches Open-Close-Stop	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Maximum Open/Close Time	120 Seconds	180 Seconds	60 Seconds	120 Seconds	20 Seconds	30 Seconds	30 Seconds
Voltage	460/3/60	460/3/60	460/3/60	460/3/60	208/3/60	208/3/60	460/3/60
"In Remote" Status Contact for Local-Off-Remote Switch	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Modulating Valve Requirements

FCV-511 to FCV-518				
Liquid Sizing Data: Water		Max Flow	Normal Flow	Min Flow
Flow Rate	gpm	1100	750	500
Inlet Pressure	psig	40	45	48
Outlet Pressure	psi	15	10	7.5
Temperature	degrees F	70	70	70
Specific Gravity (SG)		1.0	1.0	1.0
Vapor Pressure	psia	0.36	0.36	0.36
Calculated Cv		220	137	87

END OF SECTION 15100

SECTION 15108
STOP LOGS AND APPURTENANCES

PART 1 - GENERAL

1.01 DESCRIPTION

A. Furnish and install fiberglass stop logs, guides and lifting devices as shown on the drawings and as specified herein.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

1. Shop and erection drawings to include at a minimum parts list (identifying each component), dimensions, connection sizes and types and details of all accessory items
2. Certified setting plans, with tolerances, for anchor bolts.
3. Operating and maintenance instructions and parts lists.
4. Provide listing of reference installations as specified with contact names and telephone numbers.
5. Field testing procedures and equipment to be used.
6. Material Certification:
   a. Provide certification from the equipment manufacturer that the materials of construction to be provided are suitable for the service conditions specified and indicated. Provide proposed materials at no additional cost to the Owner.
   b. Where materials are not specified, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated.

B. A copy of the contract mechanical process drawings covering the stop log locations with addenda that are applicable to the equipment specified in this section, marked to show all changes necessary for the equipment proposed for this specification section. If no changes are required, mark all drawings with "No changes required" or provide a statement that no changes are required.

1.03 QUALITY ASSURANCE

A. Stop logs, grooves and lifting devices shall be the product of one manufacturer.

B. Stop logs, grooves and lifting devices shall be the manufacturer's standard cataloged product and modified to provide the specification and the service conditions specified and indicated.

C. Welding: In accordance with American Welding Society Code or equivalent.

D. Provide services of manufacturer's representative in accordance with the requirements of the General Conditions of the Contract Documents and as specified herein. Manufacturer of stop logs must have at least ten (10) operating installations with stop logs of the size specified or larger and in the same service as specified operating for not less than ten (10) years.

1.04 DELIVERY, STORAGE AND HANDLING

A. Stop logs and accessories shall be stored and protected in accordance with the requirements of the General Conditions of the Contract Documents and manufacturer's recommendations.

B. Shipping:

1. Ship equipment, materials and spare parts complete except where partial disassembly is required by transportation regulations or for protection of components.
2. Pack spare parts in containers bearing labels clearly designating contents and pieces of equipment for which intended.
3. The Contractor shall obtain spare parts from the manufacturer at the same time as pertaining equipment. The Contractor shall maintain possession of spare parts until Substantial Completion at which time all spare parts shall be turned over to the Owner.

C. Receiving:

1. Inspect and inventory items upon delivery to site.
2. Store and safeguard equipment, materials and spare parts in accordance with manufacturer's written instructions.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Plasti-Fab, Inc.

B. Ashbrook Simon Hartley

C. Or Equal

2.02 SERVICE CONDITIONS

A. Stop log sizes and operating data are indicated in the Stop Log Schedule as shown on the drawings.

2.03 FIBERGLASS STOPLOGS

A. Composition of the stop log laminate shall be in accordance with the recommendations shown in the Quality Assurance Report for Reinforced Thermoset Plastic (RTP) Corrosion Resistant Equipment prepared under the sponsorship of the Society of the Plastics Industry, Inc. (SPI). And the Material Technology Institute (MTI) of the Chemical Process Industry for "Hand Lay-up Laminates," and shall meet the specifications for Type I, Grade 20 laminates shown in Appendix M-1 of said report.

B. All stop logs shall be flat and level. Warpage throughout the entire stop log shall not produce a crown of more than 1/16 inch in any direction. Visual inspection for defects shall be made without the aid of magnification. Defects shall be classified as to type and level as shown in Table I of ANSI/ASTM D2563-0, approved 1977, or any subsequent revision.

C. The stop log cover shall be fabricated so as to totally surround the internal structural matrix and protect it against corrosion from moisture or chemical deterioration. Stop logs shall be designed so that the maximum fiber stress (ultimate or yield, whichever applies) does not exceed 2.5 times the working stress. Stop logs shall be suitably reinforced to withstand the maximum seating head with a deflection less than L/360 of the gate width, or 1/4 inch, whichever is less. Stop logs with unseating heads shall be designed for a maximum deflection of 1/16". Stop log covers which are fabricated from pressed or laminated sheet material and glued to a substructure shall not be acceptable.

D. Fiberglass Reinforced Polyester (FRP) shall totally encapsulate an internal-reinforcing structure. To assure maximum service life, the copolymer composite shall be ultraviolet stabilized and seamless to protect inner structural members from corrosion. Structural characteristics for a minimum 1/8 inch glass mat laminate shall meet the following minimum physical properties:

Tensile strength	14,700 psi
Flexural modulus	800,000 psi
Flexural strength	23,300 psi
Impact strength	9.0 ft-lbs/in
Water absorption	0.13% (in 24 hours).

E. Each log shall be molded individually to the exact dimensions specified. Stop logs shall be manufactured of reinforced thermoset plastic containing ultraviolet absorbers. The surface shall be resin-rich to a depth of 0.010 inches to 0.020 inches and reinforced with C-glass or polymeric fiber surfacing material. The surface shall be free of exposed reinforcing fibers. The composition of these layers shall be approximately 95% (by weight) resin. The remaining laminate shall be made up of copolymer composite and reinforcing fibers in a form, orientation and position to meet the mechanical requirements. Structural reinforcing shall be utilized to attain the necessary stiffness to meet deflection requirements, and shall be well encapsulated with a laminate not less than 1/4 inch thick on each side to insure against any permeation by water to the core area. T-316 stainless steel lifting pins/eyes shall be bonded to the log with sufficient reinforcing to withstand the lifting force.

F. The stop logs shall be equipped with elastomeric top seals to seal between the logs. A special labyrinth seal shall also be fastened to the guide to form a watertight joint with the stop logs. Seals shall be made of molded or extruded virgin neoprene having a hardness of 55 - 65 Shore A Durometer.

G. Guides shall be styled for embedment, wall mounting or in-channel mounting as specified in the schedule and as needed to meet project requirements. Guides shall be fabricated from type 316 stainless steel and shall have a slot suitable for mating with the stop log. Guides to be bolted to the structure wall shall be equipped with heavy duty slotted clips for ease of mounting to the channel wall by means of type 316 stainless steel anchor bolts. Inverts shall be flush with the channel bottom.

H. All guides shall be factory assembled with bonded corners and reinforced with butt straps. The corner shall be capable of withstanding a torque of 200 foot pounds without damage.

I. Allowable maximum leakage rate shall be 0.2 gpm/sq.ft. of wetted perimeter

J. Frames shall be mounted as shown on the contract drawings.

K. A lifting beam with automatic latching hooks shall be provided for each stop log size. The lifting beam shall be built in such a manner as to automatically latch on to the stop logs when lowered into the guide frame. The lifting beam shall also have a tag line release mechanism. Hook pins shall be made of T-316 stainless steel. The beam and hooks shall be of Type 316 stainless steel.

L. Details, calculations, and drawings shall show the method of fabrication and verify that the logs will withstand any normal pressures or forces exerted without buckling or otherwise being damaged.

M. A storage rack shall be provided for storing stop logs when not in use. Storage rack shall be suitable for wall mounting.

PART 3 - EXECUTION

3.01 GENERAL

A. Prior to installation, protect stored stop logs, grooves and appurtenances from damage due to exposure to sunlight, heat, dirt, debris, vandalism.

1. Store stop logs, grooves and appurtenances in accordance with the manufacturer's written instructions.

B. Clean debris, dirt, and gravel from grooves and channels before placing stop logs in place.

C. Erect and support stop logs in respective positions free from distortion and strain during handling and installation. Inspect material for defects in workmanship and material. Clean out debris and foreign material from channels, grooves and seats, test lifting mechanisms to check proper functioning, and check nuts and bolts for tightness. Repair, stop logs and other equipment which does not operate easily or are otherwise defective.

D. Install stop logs in accordance with manufacturers printed instructions.

E. Ensure that grooves are straight and true so stop logs move easily and seat tight without binding.

3.02 MANUFACTURER SERVICES

A. Provide services of factory-trained service technician, certified by the manufacturer to service the type of equipment specified in accordance with the requirements of the General Conditions of the Contract Documents and as specified herein.

1. Service technician must have a minimum of five (5) years of experience, all within the last seven (7) years, servicing the type and size of equipment specified.
2. Service technician must be present on site for all items listed below. Work-day requirements listed are exclusive of travel time, and do not relieve Contractor of the obligation to place equipment in operation as specified.

3. Assistance during equipment installation to include observation, guidance, instruction of Contractor's assembly, erection, installation or application procedures, inspection and checking of installation to furnish written approval of installation
   a. 1 work-day.

4. Training of Owner's personnel in the operation and maintenance of equipment as required. : Provide classroom and field operation and maintenance instruction including all materials, slides, videos, handouts and preparation to lead and teach classroom session.
   a. ½ work-day.

5. For the purposes of this paragraph, a work day is defined as an eight hour period at the project site, excluding travel time. The Engineer may request that a work day be furnished in a maximum of two trips.

6. Any additional time required of the factory trained service technician to assist in placing the equipment in operation or to correct deficiencies in installation, equipment or material shall be provided at no additional cost to the Owner.

3.03 FIELD PERFORMANCE TESTS

A. The Contractor shall obtain suitable water for field testing of stop logs. The Contractor shall be responsible, at no additional cost to the Owner for provision of temporary piping, pumping, and other ancillary equipment necessary for delivery of water to the diversions structure for stop log testing purposes. Test water shall be disposed of as directed by the Owner.

B. After installation of stop log frames, and after inspection, operation, testing and adjustment have been completed by manufacturer's field service technician, install and remove each stop log from each frame (6 places) to demonstrate its ability to operate smoothly and without jamming.

C. Leakage Test: Test the stop logs in each of the frames for leakage. Maximum seating and unseating head measured from stop log invert, leakage not to exceed 0.2 GPM per linear foot of sealing length.

D. Promptly correct or replace all equipment not conforming to the requirements of this Section revealed by or noted during tests, at no additional cost to the Owner, and repeat tests until specified results are obtained. Contractor to provide all labor, piping, equipment, flowmeters and materials necessary for conducting tests. Following three unsuccessful test attempts, replace non-conforming equipment at no additional cost to the Owner.

E. Make all adjustments to place equipment in specified working order at time of above tests.

F. Conduct leakage test with water. Water for testing shall be furnished by Contractor.

END OF SECTION 15108

SECTION 15250
MECHANICAL INSULATION

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Work described in this Section includes furnishing all labor, materials, equipment, tools and incidentals required for a complete and operable installation of mechanical insulation. All equipment shall be installed, adjusted, tested and placed in operation in accordance with these Specifications, the Contractor's recommendations and as shown on the drawings.

B. Contract drawings show only functional features and some of the required external connections. They do not show all components required for a complete installation nor exact dimensions particular to any specific material. Contractor shall supply all parts, devices and equipment necessary to meet the requirements of the Contract Documents and shall make all dimensional adjustments particular to the material being furnished. All costs associated with such changes and adjustments shall be included in the price bid for the Work shown and specified.

C. The types of mechanical insulation specified in this Section include the following: Piping System Insulation - Flexible Unicellular.

D. Related Work Specified Elsewhere: Section 15050 - Basic Mechanical Materials and Methods, Section 15891 – HVAC Ductwork, Section 15910 – HVAC Ductwork Accessories.

1.02 REFERENCES

A. This Specification references the latest edition of the publications listed below. Work shall be performed and materials shall be furnished in accordance with these publications as reference herein:

1. American Society for Testing and Materials (ASTM) Standards.
2. ASTM E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
3. National Fire Protection Association (NFPA) Standards.
4. NFPA 255 - Method of Test of Surface Burning Characteristics of Building Materials.
5. Underwriters Laboratories, (UL) Standards.
6. UL 723 Test for Surface Burning Characteristics of Building Materials.

1.03 SUBMITTALS

A. Submittals shall be made in accordance with the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

1. Manufacturer's technical product data and installation instructions for each type of mechanical insulation:
   a. Manufacturer's product number.
   b. k-Value and thickness.

c. Accessories included for each mechanical system requiring insulation.

2. Maintenance data and replacement material lists for each type of mechanical insulation. Include this data and product data in maintenance manual.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: Firms regularly engaged in manufacture of mechanical insulation products, of types and sizes required and whose products have been in satisfactory use in similar service for not less than 5 years.

B. Flame/Smoke Rating: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84, NFPA 255 method. Outdoor mechanical insulation may have flame spread index of 75 and smoke developed index of 150. Industrial mechanical insulation that will not affect life safety egress of building may have flame spread index of 75 and smoke developed index of 150.

C. Reference Standards: Comply with all Federal and State laws or ordinances, as well as the latest edition of all applicable codes, standards, regulations and/or regulatory agency requirements including the partial listing below:

i) ASTM, American Society for Testing Materials.
ii) ASME, American Society of Mechanical Engineers.
iii) OSHA, Occupational Safety and Health Act.
iv) ANSI, American National Standards Institute.
v) AWWA, American Water Works Association.
vi) NFPA, National Fire Protection Association.
vii) FM, Factory Mutual Engineering Corporation.
viii) UL, Underwriters Laboratories, Inc.

1.05 STORAGE AND PROTECTION

A. Deliver insulation, coverings, cements, adhesives, and coatings to site in containers with manufacturer's stamp or label, affixed showing fire hazard indices of products.

B. Protect insulation against dirt, water, and chemical and mechanical damage. Do not install damaged or wet insulation; remove from Project site.

PART 2 - PRODUCTS

2.01 GENERAL

A. Ductwork Insulation Accessories:

1. Provide staple, bands, wires, tape, anchors, corner angles and similar accessories as recommended by insulation manufacturer for applications indicated.

B. Ductwork Insulation Compounds:

1. Provide cements, adhesives, coatings, sealers, protective finishes and similar compounds as recommended by insulation manufacturer for applications indicated.

C. Flexible unicellular piping insulation: ASTM C1 534, Type I.

2.02 ACCEPTABLE MANUFACTURERES

Insulation products shall be manufactured by CertainTeed, Knauf, Johns Manville, Owens-Corning, IMCOA, Pittsburgh-Corning and Armstrong.

2.03 PIPE INSULATION

A. Materials (Indoor Piping for Temperatures 150° F and Less)

1. Piping insulation shall be flexible elastomeric closed-cell type, slipped on the pipe prior to connection whenever possible. Where the slip-on technique is not possible, the insulation shall be pre-slit and snapped over the pipe with pre-applied adhesive. Butt joints shall be sealed with insulation manufacturer's adhesive or heat fuse method. Where required, the insulation shall be covered with insulation manufacturer's finish. Sealer shall be latex caulk. Thermal conductivity shall not exceed 0.27 BTU.in/hr/Ft2/°F at 75 degrees F.
2. Fittings shall be insulated using fabricated fitting covers of flexible elastomeric closed-cell type insulation in accordance with the manufacturer's instructions. Join slit seams and mitered joints with insulation manufacturer's adhesive or heat fuse method.

B. Materials (Outdoor Piping Exposed to Weather or in Pressure Regulating Stations)

1. Premolded cellular glass thermal insulation shall be furnished in accordance with ASTM C 552 and C 585 fabricated for standard pipe sizes, fittings and valves.
2. Maximum thermal conductivity of 0.32 BTU.in/hr/Ft2/°F at 70 degrees F in accordance with ASTM C 177 and C 518.
3. Maximum water vapor permeability of 0.00 perm-in when tested in accordance with ASTM E 96.
4. Average density of 8.0 lb/ft3.
5. Maximum Flame Spread Rating of 5 and Smoke-Developed Rating of 0 when tested in accordance with NFPA 255.
6. Utilize installation adhesives and joint sealants as recommended by the insulation manufacturer.
7. Install 30 gauge smooth Type 316 stainless steel jacketing over insulation retained by stainless steel bands.
8. Insulation products shall be equal to Pittsburgh Corning Foamglass.

C. Description: Piping insulation thickness shall be 1-inch for pipes up to 2-inches, 1-1/2-inches for pipes over 2-inches and up to 4-inches, and 2-inches for pipes over 4-inches.

2.04 DUCTWORK SYSTEM INSULATION

A. Insulate the following cold ductwork:

1. HVAC supply ductwork between fan discharge or HVAC unit discharge and room terminal outlets.
2. Insulate neck and bells of supply diffusers.
3. HVAC return ductwork between room terminal inlet and return fan inlet, or HVAC unit inlet.
4. HVAC plenums and unit housings not pre-insulated at factory or lined.

B. Insulate each ductwork system specified above with one of the following types and thickness of insulation:

1. Rigid fiberglass, 1-1/2" thick, increase thickness to 2" in machine, fan and equipment rooms with vapor barrier.
2. Flexible fiberglass, 1-1/2" thick, application limited to concealed locations with vapor barrier.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions under which mechanical insulation is to be installed. Work shall not proceed until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

3.02 HVAC PIPING SYSTEM INSULATION

A. Insulate refrigerant suction piping systems with flexible unicellular, 1" thick for pipe sizes up to 1-1/2".

3.03 INSTALLATION OF PIPING INSULATION

A. Install insulation products in accordance with manufacturer's written instructions, these specifications and in accordance with recognized industry practices to ensure insulation serves its intended purpose:

1. Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job fabricated units (at Installer's option) except where specific form or type is indicated.
2. Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated.
3. Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.
4. Install insulation on pipe systems subsequent to installation of heat tracing, painting, testing and acceptance of tests.
5. Install insulation materials with smooth and even surfaces. Insulate each continuous run of

piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other.

6. Maintain integrity of vapor-barrier jackets on pipe insulation and protect to prevent puncture or other damage.

7. Butt pipe insulation against pipe hanger insulation inserts. For hot pipes, apply 3" wide vapor barrier tape or band over the butt joints. For cold piping apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3" wide vapor barrier tape or band.

3.04 INSTALLATION OF DUCTWORK INSULATION

A. Install insulation products in accordance with manufacturer's written instructions, these specifications and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.

1. Install insulation materials with smooth and even surfaces.

2. Clean and dry ductwork prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

3. Maintain integrity of vapor-barrier jackets on ductwork insulation and protect to prevent puncture and other damage.

4. Extend ductwork insulation without interruption through walls, floors and similar ductwork penetrations, except where otherwise indicated.

5. Omit insulation on lined ductwork where internal insulation or sound absorbing linings have been installed, except as otherwise indicated.

B. Protect outdoor insulation exposed to weather by installing outdoor protective finish or jacketing as recommended by manufacturer.

C. Install corner angles on external corners of insulation on ductwork in exposed finished spaces before covering with jacketing.

END OF SECTION 15250

SECTION 15400
PLUMBING

PART 1 - GENERAL

1.01 WORK INCLUDED

A. This Section includes the provision and installation of plumbing equipment, fixtures, specialties, and piping systems as shown on the Drawings and specified herein.

B. Work covered by this Section includes, but is not limited to:

1. Building internal potable water systems.
2. Building internal sanitary waste and vent systems.
3. Plumbing fixtures.
4. Plumbing equipment.

C. Sanitary drain inside building as covered under this specification shall be terminated 5'-0" outside the exterior walls for all drainage systems unless shown otherwise shown on the on the Drawings. Piping beyond 5'-0" is covered under Specification 15060.

D. Potable Water piping as covered under this specification shall be terminated at 1'-0" outside the exterior wall or floor. Piping beyond 1'-0" is covered under Specification 15060.

1.02 RELATED WORK

A. General Condition 28 – Working Drawings, Shop Drawings, Data on Material and Equipment, Samples, and Licenses.

B. 09900 -Painting

1.03 SUBMITTALS

A. Shop Drawings, Product Data, and Samples: Submit manufacturer's literature for all materials and equipment in accordance with requirements of DIV 1 and equipment specifications included in the Work. Required data shall include, but not necessarily be limited to :

1. Unit designation.
2. Unit dimensions and weight.
3. Complete electrical data including wiring diagrams.
4. Complete description of materials of construction including finishes.
5. Noise data for rotating equipment.

B. Operation and Maintenance Instructions: At completion of job, furnish copies of complete operations and maintenance instructions, neatly bound in leatherette covers. Label each cover with title and names Owner, AlE, and Contractor. Include complete description of operating and maintenance procedures required for all systems, controls, and equipment. Operation and

maintenance procedures for Owner-furnished/Contractor-installed equipment will be given to Contractor by Owner. Include these procedures in bound volumes.

1.04 QUALITY ASSURANCE

A. Fixtures, trim, and methods of piping and installation shall conform to local Plumbing Code. Fixtures in a given line shall be the product of one Manufacturer

B. Pipe, valves, fittings, and specialty items, unless otherwise specified, shall be new, full length, scale-free, and best quality of their respective kinds. In addition to tests required for specific materials and systems, manufacturer shall test or guarantee all materials to be as specified prior to delivery.

1.05 PRODUCT HANDLING, DELIVERY AND STORAGE

A. Receive and handle all materials with care so as not to cause damage. Use padded or strap slings, ect., as appropriate for materials being handled. Lift equipment by lift points provided or recommended by manufacturer.

B. Use proper tools, equipment, and procedures to handle and lay pipe. Do not damage pipe coating, wrapping, or linings. Repair or replace damaged pipe coatings, wrappings, or linings in accordance with manufacturer's instructions or as required to restore original protection.

C. Inspect all materials, upon receipt, for defects and for compliance with specifications.

D. Properly store all pipe, piping materials, etc., so as to prevent while in storage. Store all materials off ground or off floor. Store inside or cover all materials subject to deterioration from weather.

E. Store loose materials such as fittings, gaskets, bolts, nuts, small valves, traps, and specialties in adequate number of bins to properly separate. Protect ends of large fittings, valves, and pipe from weather and abuse. Properly grease all machined surfaces.

PART 2 - PRODUCTS

2.01 POTABLE WATER PIPING (CW,HW) / CONDENSATE DRAIN

A. Potable water piping 3 inches in diameter and smaller shall be as follows:

1. Tube:
   a. Aboveground: Type "L" hard temper copper water tube, ASTMB 88.
   b. Underground: Type "K" soft temper copper water tube, ASTMB 88. (No Joints Allowed), (Under Floor Slab on grade)
2. Fittings: Wrought copper and bronze pressure fittings, ANSI B16.22, or cast bronze pressure fittings, ANSI B16.18.
3. Joints: Solder joints using 95/5 solder, ASTM B 32.
4. Unions: Cast brass, ground joint type 200 psi WOG rated, FS WWU516a.

B. Valves: See attachment at the end of this section.

C. Flanges:

1. 2" Inches and Smaller: 150 pounds, forged steel, ASTM A 181, Grade I OR II, raised face, screwed, ANSI B16.5 (flat face to match flat face flanges).
2. 2-1/2" Inches and Larger: 150 Pounds, forged steel, ASTM A 191, Grade I or II, raised face, slip-on or weld neck, ANSI B16.5 (flat face to match flat face flanges).

D. Gaskets: 1116 inch thick compressed synthetic material, flat ring type, ANSI B16.21 (full face type to match flat face flanges).

E. Bolts: Carbon steel stud bolts, ASTM A 307, Grade B, ANSI B18.2.1, with two heavy semifinished hex nuts, ASTM A 307, Grade B, ANSI B18.2.2.

F. Joint Compound: TFE tape, 112 inch wide by three mil thick, Scotch brand; plastic lead seal (PLS) , John Crane; Loctite Pipe Sealant with Teflon; or Engineer approved equal.

G. Unions 2 Inches and Smaller: 150 Pound, galvanized malleable iron, ASTM A 197, ground joint, brass-to-iron seat, threaded.

2.02 SANITARY DRAIN & VENT PIPING

A. Pipe and Fittings Aboveground:

1. 1-1/2" Inches Through 10 Inches: Service weight no-hub cast iron soil pipe fittings with factory asphaltum coating, CISPI301.

B. Pipe and Fittings Underground:

1. 2" Inches Through 15 Inches: Service weight hub and spigot cast iron soil pipe and fittings with factory asphaltum coating, ASTM A 74.

C. Joints:

1. Joints in aboveground piping shall be no-hub.
2. Joints in underground piping shall be push-on.
3. No-hub joints shall be made using a neoprene sealing sleeve, a stainless steel shield, and stainless steel tightening device for each bands and stainless steel tightening device for each band, CISPI31O.
4. Compression joints in underground pipe and fittings shall be made using a neoprene gasket for push-on joining.

2.03 PLUMBING FIXTURES, TRIM AND EQUIPMENT

A. Plumbing fixtures, trim, and supports shall be as scheduled at the end of this section. ATTACHMENT "C"

2.04 PIPING HANGERS AND SUPPORTS

A. Pipe hanger and support material such as pipe, structural and rod attachments, pipe rolls, and spring hangers shall be compatible with the materials of the respective piping systems installed.

B. All similar support elements shall be of the same manufacturer.

C. Design Drawings will reflect the type and/or location of special or critical support requirements only, when required, and will be as detailed on the Design Drawings.

D. Detail, furnish, and install all hangers, supports, anchors, and guides required to properly support the various piping systems.

E. Detail, furnish, and install any miscellaneous structural members required to facilitate installation of hangers and supports.

F. Provide additional hangers and\or sway braces as required to prevent excessive vibration.

G. Adjustable steel clevis type pipe hangers are preferred rather than clamp hangers for uninsulated pipe. Where clevis type hangers are used on insulated lines, they shall have sufficient width to clear the pipe covering, including metal jacketing, if used.

H. Pipe lines shall be provided with complete hangers assemblies and shall include The pipe hanger washers, nuts, turnbuckles, rods, straps, clip angles, beam clamps, and through bolts. Any adjustable item shall have a locking device to hold it together during shock.

I. Do not provide rigid anchor points other than those indicated on Drawings.

J. The maximum spacing between pipe supports for straight runs of pipe shall be in accordance with the Plumbing Code and MSS SP-69, unless otherwise noted on the Drawings. This spacing does not apply where there are concentrated loads between supports, such as flanges and valves. Provide support in these instances in accordance with Article 3.02 Paragraph A.

K. Copper water tube shall be supported at 6'-0" intervals for piping 1-1/2 inches and smaller and at 10'-0" intervals for 2-inch size.

2.05 PIPE INSULATION

A. Fire and Smoke Hazard Ratings:

1. All insulation, adhesives, coatings, and sealers shall have fire and smoke hazard ratings, as tested by procedure complying with NFPA 255 and ASTM E84, not to exceed:
   a. Flame spread 25
   b. Smoke developed 50
   c. All components shall also be UL listed and so marked.
2. Accessories, such as adhesives, mastics, cements, tapes, and cloth for fittings shall have same component ratings as listed above. Accessories used shall be as recommended by manufacturer.
3. All products or their shipping cartons shall bear a label indicating that flame and smoke ratings do not exceed above requirements.
4. Any treatment of jackets or facings to impart flame-and-smoke safety shall be permanent. Use of water-soluble treatments is prohibited.

B. Insulation shall be fiberglass material with fine glass fibers bonded together with an inert thermosetting resin with vapor barrier and all service jacket composed of reinforced white kraft conform to the following.

1. Maximum Temperature Limit(F): 450
2. Density (lb/cu ft): 4
3. Factor (BTU-in/sq ft-hr-F) at 75F Mean: 0.23 max.

C. Products of equal quality will be acceptable from following manufacturers, subject to approval by Owner:

1. Owens-Corning;
2. Certain-teed;
3. Johns-Manville; or
4. Other approved equal.

D. All Potable water piping above floor shall be insulated I inch thick.

E. All ends and joints shall be taped and sealed.

2.06 MATERIALS FOR CLEANING AND TESTING

A. All detergents solvents, and other cleaning agents shall be compatible with the materials of fabrication of the systems, in which they are used. They shall not adversely affect the materials or mechanisms in the systems and they shall be acceptable to equipment manufacturers. All detergents, solvents, and other cleaning agents shall also be compatible with the process streams to be handled by the system in which they are used.

B. Blinds, gaskets, bolts, etc., used in isolating segments of systems shall conform to the specification for adjacent materials.

C. Furnish all labor, tools, and equipment required for pressure testing piping systems.

PART 3 - EXECUTION

3.01 GENERAL

A. Routing: Piping Drawings are generally to scale but piping shall be placed by calculated dimensions rather than dimensions scaled from Drawings. Route piping by shortest run consistent with good installation practice, clearance requirements, and expansion and flexibility provisions. Arrange piping to facilitate support of piping and ease of removal for inspection or servicing. Maintenance areas shall be clear of piping. Cut and hang pipe to align freely with flanges and fittings.

3.02 FABRICATION

A. Make all changes in size and direction of piping with fittings. Do not use miter fittings, face of flush bushings, close nipples, or street elbows, except as shown on Drawings. Use eccentric

reducing fittings or eccentric reducing couplings where required by Contract Documents, where required to prevent pocketing of liquid or non-condensables or as required to maintain a level bottom of piping elevation when using pipe support bridges which are all located at same elevation.

B. Use clean cut screwed thread with no stripping or burrs from cutting or threading. Dies shall be new, sharp, and properly designed for piping material. Clean threads on pipe and fittings thoroughly of cuttings, dirt, oil, or other foreign matter immediately before erection. Liberally coat male threads with thread lubricant or TFE thread tape and make up piping sufficiently for threads to seize. Do not mar or damage pipe and fitting surfaces. Do not use Permatex, lampwick, cord, wool, or any other similar material for thread sealant.

C. Locate valves, and other equipment which must be observed, adjusted, or serviced during operation, so that they are conveniently accessible.

D. Provide flanges or unions at all [mal connections so that equipment served may be removed without disturbing piping.

E. Install piping to coils, pumps, and other equipment at full size indicated on Drawings with size reductions installed at equipment.

F. Space pipe supports and arrange reducers to allow the system to be drained at low points and vented at high points. Pockets shall be avoided in lines.

3.03 SLEEVES, PLATES AND ESCUTCHEONS

A. Provide penetrations through walls, partitions, beams, and slabs with sleeves large enough to adequately accommodate pipe plus any insulation and thermal movement. Cut, patch, and install sleeves and inserts at location indicated on drawings.

B. Sleeves in walls and elevated slabs shall be standard weight carbon steel pipe having minimum internal diameter 1" inches larger than outside diameter of pipe left bare, or 1" inches larger than outside diameter of pipe insulation, unless otherwise indicated. Sleeves through slabs on grade or walls below grade shall be galvanized carbon steel or cast iron, sized as outlined above. Wall sleeves shall be flush on both sides of wall, and floor sleeves flush on ceiling side and extend 1 sleeves shall be flush on both sides of wall, and floor sleeves flush on ceiling side and extend a inch above floor, except where otherwise indicated or necessary to suit location and piping function.

C. Set sleeves in place before pouring concrete or securely fasten and grout sleeves with cement. Set wall sleeves as wall is constructed. Core drill sleeve holes through concrete floors or masonry walls where sleeves are inadvertently omitted. Do not use jackhammer or pavement breaker unless approved by Owner and engineer.

D. Fill annular space between pipe and sleeve through interior walls and elevated floor slabs with mineral wool or fiberglass.

E. Pack annular space between pipe and sleeves through exterior walls, walls below grade, and ground floor slabs with oakum, seal with lead wool and watertight mastic or asphalt, or linkseal units.

F. Pack annular space between pipe and sleeve through fire walls with mineral wool and close off ends with metal cap or plate.

G. Install pipe sleeves where indicated on Drawings to accommodate passage of certain piping services under foundations and elsewhere. Install pipe sleeves of material noted. Place a steel plate cut to closely fit pipe at each end of sleeve before back-filling.

H. Provide chrome-plated escutcheon where pipes pass through walls or floors in finished areas. Provide nickel plated steel plate where pipes pass through walls or floors in unfinished areas.

3.04 JOINTS BETWEEN DISSIMILAR METALS

A. Make joints between ferrous and non-ferrous screwed piping and equipment with insulating unions as manufactured by Capital Manufacturing Company, EPCO Sales, Inc., equal.

B. Make joints between ferrous and non-ferrous flanged piping and equipment with EPCO dielectric flange unions, EPCO or Duriron insulating gaskets, sleeves and washers, or equal.

C. Entire insulating joint including dielectric material shall be suitable to withstand temperature, pressure and other operating characteristics of service for which it is used.

3.05 UNDERGROUND PIPE INSTALLATION

A. General: Lay, align, anchor, and test pipe and make up joints. Perform excavating, cleaning, laying, jointing, and backfilling as concurrently as possible to maintain uniform installation. Do not leave un-jointed piping in trench overnight. Backfill and compact trench as pipeline installation progresses. Do not backfill joints until system has been tested and accepted.

B. Handling: Replacing or repair damaged materials to Condition equal to new material.

C. Alignment:

1. Install piping to conform accurately to lines and grades indicated on Drawings or in Specifications. Do not drop or block up pipe to attain required grade. Remove and relay pipe if grade deviates by 1/4 inch or more from grade shown on Drawings or required.
2. Slope 3 inches diameter and larger gravity drain lines down in direction of flow at minimum 1/8 inch per foot unless indicated otherwise.
3. Slope gravity drain lines smaller than 3 inches diameter down in direction of flow at minimum 1/4 inch per foot unless indicated otherwise.

D. Pipe Crossings: Lay lower pipe, backfill with crushed stone, gravel, or concrete as directed and thoroughly compact to level of upper pipe. Maintain minimum 6 inches clearance between bells of upper and lower pipes.

3.06 WELDING

A. All welding of carbon steel shall be by one of arc welding processes including, but not limited to following:

1. Manual shielded metal arc;

2. Manual shielded metal arc with Tig root pass;
3. Tungsten inert gas (Tig); or
4. Metal inert gas (Mig).

B. Entirely cover threads with seal weld where seal welding of threaded joints is performed. Make up threaded joints to be seal welded without any thread compound.

C. Preheat and post heat welds when required in accordance with welding procedure.

D. Remove and repair defects in welds requiring repair in accordance with ANSI b31.3 as applicable. Drain piping with weld leaks discovered during hydrostatic test to level below leak before weld repair. Release pressure on piping with weld leaks discovered during pneumatic test before repairing weld.

3.07 BRAZING

A. Use non-ferrous metal or alloy filler metal having melting point above 800°F and below that of the metal being joined. Use filler metal and flux recommended by manufacturer for metals being joined in accordance with approved procedure.

3.08 SOLDERING

A. Perform soldering similar to brazing above, except use solder alloy that melts at a temperature below 800°F. Clean outside end of pipe and the inside cup of fitting with steel wool or sand cloth. Apply flux evenly but sparingly, until surfaces to be joined are completely covered. Use non-corrosive paste type flux recommended by manufacturer for solder alloy being used. Remove all excess solder with small brush while it is still in plastic state, but leave filler around cup of fitting as it cools. Unless indicated otherwise, for solder use Alloy 95-5 (tin/antimony) for temperatures up to 250°F and pressures up to 150 psig for 4 inches and smaller.

3.09 PAINTING

A. Painting of piping, valves, equipment, devices, and supports shall be as specified in Section 09900.

B. Paint all underground parts of valve boxes, valves, and metal anchor devices with Koppers Company, Inc., "Bitumastic 50" or approved equal. Paint inside and outside of valve boxes.

3.10 FIXTURE INSTALLATION

A. Adequately support all fixtures.

B. Connect supply and/or drain pipes to walls and not to floors. Exposed junctions to walls shall have chromium plated escutcheons neatly and firmly secured in place.

C. Exposed piping and metal work in connection with fixtures shall be chromium plated brass.

D. Provide stop valves for each plumbing fixture.

E. Install chrome plated pipe and fittings with a strap wrench. Any marred pipe or fitting shall be removed and replaced at no additional cost to Owner.

F. Caulk junction of fixtures with walls all around with non-shrink caulking compound.

3.11 INSULATION INSTALLATION

A. Install insulation and finishes according to manufacturer's recommendations. Butt joints tightly together and securely attach insulation materials. Clean and dry surfaces before insulation is applied. Cut and fit insulation around irregular surfaces, and apply covering tight and smooth.

B. Use insulation with continuous unbroken vapor seal on all cold surfaces where vapor barrier jackets are used. Insulate and vapor seal hangers, supports, anchors, or other items that are secured directly to cold surfaces to prevent condensation.

C. Protect insulation from physical damage at points of support where insulation must carry load imposed by support. Coordinate this requirement with types of hanger and support used.

D. Do not use partial lengths of any type insulation where full length will fit.

E. Apply all insulation, adhesives, and finishing materials in accordance with manufacturer's recommendations or instructions.

F. Unless otherwise noted, insulate all flanges and valves and conform to the same type and thickness as the adjacent pipe.

G. Apply I-inch through 2-inch thick insulation in a single layer broken joint method with all joints tightly butted together.

H. Fill all voids with broken insulation of the same material being used or with insulating cement.

I. Fitting insulation shall conform to the same type and thickness and shall be applied in the same manner as prescribed for adjacent pipe unless otherwise specified.

J. All insulation shall fit the surface of the pipe snugly and shall be fabricated or molded so as to leave not more than 1/8 inch void between the surface to be insulated and the insulation itself. All insulation joints shall be close fitting.

K. Flash all metal protrusions through hot insulation to prevent entrance of water.

L. For all metal protrusions through cold insulation, provide vapor stop.

3.12 FIXTURE INSPECTION AND TESTING

A. Visually inspect each fixture before and after installation for defects, proper operation, and stability of support.

B. Test each fixture for soundness, stability of support, and satisfactory operation.

C. Piping at fixtures shall be absolutely tight under test.

3.13 METHODS FOR CLEANING AND TESTING

A. Systems specified in this Section shall be cleaned and tested in accordance with the index in Attachment A:

3.14 CLEANING

A. General:

1. Provide and install all necessary temporary connections, strainers and other equipment to thoroughly clean the piping systems before start-up. Dispose of all cleaning agents and remove all temporary connections and strainers after cleaning is complete.
2. Piping should be cleaned just prior to installation and/or plant start-up when possible. All cleaned piping material shall be protected against contamination by sealing all open ends with clean plastic sheet or metal foil.
3. All cleaning procedures shall be subject to the approval of the Owner or his designated representative and will be completed to his satisfaction.

B. Cleaning Methods

1. Cleaning Method (Sanitary Drains)
   a. Prior to erection:
      i) Hammer, brush, etc., to loosen sand, dirt, scale, or other contaminants when necessary
      ii) Blow with air, or hose with clean water, and visually inspect for contaminants.
      iii) On pipes stored before erection, dry and seal the ends to prevent contamination during storage.
   b. After erection thoroughly flush the system with clean water to remove all foreign material.
2. Cleaning Method (Potable Water)
   a. Prior to erection:
      i) Surface clean as required.
      ii) Blow with air, or hose with potable water and visually inspect for contaminants.
   b. After erection:
      i) Flush system thoroughly with potable water for sufficient time to ensure thorough cleaning.
      ii) Flush system prior to making connection to interior potable water system.
      iii) After cleaning, potable water systems shall be disinfected as described below.

C. Disinfection of Potable Water Systems:

1. Provide nipples and valves as required to introduce disinfectant and water, to vent air and to drain the solution, whether or not these connections are shown on the Drawings.
2. Clean the system as specified in the Testing and Cleaning Index in Article 3.13.
3. Fill the system uniformly with a disinfection solution of 50 ppm available chlorine. The disinfectant shall be retained no less than 24 hours. As an alternative, a solution of 300 ppm

held for three hours is also acceptable. After the holding period, a test for residual chlorine shall be made. If none is found, the system shall be drained and the disinfection procedure repeated. When a positive residual chlorine test is accomplished, the system shall be flushed with potable water and put into operation. The methods used for disinfection should be in accordance with the latest published procedure of the AWWA C601.

4. For very minor jobs, such as replacement of a single fitting or repair of a valve, the item being installed can be precleaned and then disinfected by immersing it in a solution of 300 ppm of chlorine for one hour.

3.15 TESTING

A. General:

1. Equipment such as vessels, heat exchangers, pumps, compressors, and the like shall be isolated during testing of the piping system. Retest of equipment which has been shop tested is not required unless the equipment has been damaged or disassembled during shipment or erection. The test pressure for such a retest shall not exceed the shop test pressure and the Owner shall determine whether or not a retest is required. Inclusion of the equipment in the testing of piping systems shall not be done without' approval of the Owner.

2. Test pressure shall be as defined in the index in Article 3.13. Final test pressure for each test shall be maintained for a sufficient length of time to facilitate a complete inspection of all joints and connections, but no less than that specified by the applicable testing procedure. When it is necessary, for practicality, to include a vessel or other equipment, the test pressure shall not exceed the allowable cold limit of the equipment.

3. Detected leaks shall be repaired. Piping systems shall be retested if revisions or repairs are made in piping or pressure equipment.

4. Since the risk of failure, with the attendant possibility of injury, is appreciably greater during testing, all safety measures required by codes or ordinances applicable to the situation shall be taken.

5. Equipment or piping to be pressure tested shall not be insulated, covered, painted or concealed prior to test. Compression joint underground piping may be backfilled prior to pressure test except that joints shall remain exposed until after the test. Tie rods, clamps, etc., shall be in place and fastened.

6. These tests shall not be used to establish pressure ratings.

7. Protect all piping and equipment against over-pressure collapse from vacuum and hydraulic shock during the filling, testing, and draining procedures. Seats of iron valves shall not be subjected to a pressure in excess of the maximum cold working pressure of the valve. Pressure tests against other closed valves shall not exceed the manufacturer's cold pressure limit. Note that where significant differences in elevation exist, there is a risk of over-pressure in the lower portions of the system in order to attain test pressure in the upper portion of the system.

8. Apply test pressure only after the system and test medium are at approximately the same temperature, preferably not less than 60°F. Note that some applicable codes require testing above a specified minimum temperature. Water temperature shall not exceed 125°F.

9. Test, including the inspection of all joints, shall be made to the satisfaction of the Owner's Representative. Following the completion and approval of the test, restore all components of

the system to normal operating condition. This includes removing the temporary provisions installed for the test.

B. Preparatory Work:

1. Remove from the system all pumps, turbines, traps, shock arrestors, expansion joints, instruments, control valves, safety valves, rupture discs, filters, orifice plates, etc., which might be damaged by the test, or are designated by the Owner's Representative. Also remove all items such as orifice plates which might trap air in a system to be hydrostatically tested. Disconnect all instrument supplies.
2. Open but do not backseat all valves including bypass valves. Lines containing check valves shall have the source of test pressure on the upstream side.
3. Clean systems prior to testing.
4. Systems may be separated into sub-systems for testing if such action will expedite or simplify the testing.
5. During hydrostatic testing of lines with spring hangers designed for fluids lighter than water, travel stops or locks shall be installed on the hangers, or temporary solid rod supports must be provided during the entire time the line is filled with water to support its additional weight and prevent overloading the springs. Also provide temporary supports where required to prevent over-stressing supports other than spring hangers. When tests are completed, remove temporary supports, locks, stops, etc., and set supports for their cold load.

C. Testing Methods:

1. Test Procedure Tl (Hydrostatic Test)
   a. Only filtered water shall be used as test media.
   b. No hydrostatic testing shall be done when the ambient temperature is 40°F or lower unless special cold weather provisions are approved by the Owner.
   c. Provide vents and drains as required.
   d. All lines shall be thoroughly cleaned before testing.
   e. Items which are not to be subjected to the hydrostatic test shall be either removed or blanked off. Short sections of piping removed to permit the installation of blinds or blanks shall be tested separately.
   f. The test pump hookup for hydrostatic test shall permit applying the pressure gradually under close control. A valve shall be provided for isolating the piping from the pressure source during the test period. They system should be filled with water through a low connection point, case being taken that air is completely vented so that there are not air pockets remaining. The pressure shall be applied gradually and held at the specified value for the time required to visually check each weld, connection, joint, flange, etc., but not less than a minimum of one hour. Test readings may be taken at the lowest point of the line or system of lines with static head added to the minimum hydrostatic test pressure. Care shall be taken to ensure that at not point a dangerous over-pressure is experienced.
   g. The hydrostatic test shall be considered satisfactory if no visible leakage, cracks or other signs of distress are discovered on the piping or at any joints. There is no requirement for minimum pressure drop during the test period; however, the cause of any pressure loss other than that due to temperature change or similar reasons shall be justified to the satisfaction of the Owner's Representative.

h. Minor leaks in screwed or flanged joints may be repaired without retesting subject to the approval of the Owner's Representative.

i. Any welded joint found leaking shall be repaired in accordance with the original welding procedure and completely retested.

j. After completion of hydrostatic testing, the system shall be completely drained at all low points in such a way as to accomplish thorough flushing of the system. Test blinds, temporary supports, test equipment, etc., shall be removed, and any valves, orifice plates, short sections of piping, miscellaneous in-line equipment or instruments that were removed prior to testing shall be re-installed and the line left ready for service. New gaskets shall be used when re-installing flanged items.

k. Care shall be taken to ensure the complete removal of all water from the line or system after testing. If there is any danger of contamination or freezing, blowing out the fluid with air is necessary.

2. Test Procedure T5 (Leak Test for Interior Sanitary Drainage Systems):

a. Make tests as may be required by local plumbing authority, in addition to those specified, at no additional cost to the Owner.

b. Make tests on concealed piping before piping is closed-in.

c. Make air test by attaching air compressor or testing apparatus to suitable opening, close all other inlets and outlets to system and force air into system until there is uniform gauge pressure of 5 psi or sufficient to balance a column of mercury 10 inches in height. Hold pressure without introduction of additional air for a period of at least 15 minutes. Test every joint with soap suds while system is under air pressure.

d. Make water test in lieu of air test of soil and waste piping. Test piping either in its entirety or in sections. Do not make water test during cold weather until temporary heat is available. Close all openings except highest one and fill system with water to point of overflow, if test is applied to entire system. Close all openings except highest one in section under test and fill section to point of overflow, if system is tested in sections.

e. Test at least the upper 10 feet of next preceding so no joint or pipe in building (except the uppermost 10 feet of system) is submitted to test of less than 10-foot head of water, if system is tested in sections. Leave water in system or in portion under test for at least 15 minutes before inspection starts. Inspect joints for visible leakage.

f. Make final test of system after all plumbing fixtures have been set and their traps filled with water. Introduce into entire system pungent, thick smoke. Close openings when smoke appears at stack openings on roof. Build up pressure equivalent to I inch water column and maintain for 15 minutes before starting inspection.

g. Take apart, clean, and remake any joints not tight under test.

h. Furnish gauges, pumps, compressors, and instruments necessary for above tests.

3.16 INSPECTIONS

A. Inspections as required by local building authorities shall be held and certificates of inspection delivered to the Owner.

B. The Owner's Representative reserves the right to make any inspections. Give the Owner's Representative free access to his work, and whenever requested, shall furnish him with full information as to progress of the work and its various parts at place of fabrication or on the job site. Such inspection shall not relieve the Contractor from full responsibility for the quality and correctness of his work.

C. If the Specification, Owner's Representative's instructions, ordinances, law, or any other public authority requires any special tests or approval, the Contractor shall give the Owner's Representative timely notice of his readiness for inspection. If the inspection is by an authority other than the Owner's Representative, the Owner's Representative shall be informed as to the place and date fixed for such inspections.

3.17 ATTACHMENTS

A. The following Attachments are part of this Section:

1. Cleaning and Testing Index "A"
2. Valve List
3. Plumbing fixtures, drains, equipment "C"

END OF SECTION 15400

ATTACHMENT A – CLEANING AND TESTING INDEX				
Symbol	Service	Test	Test Pressure	Test Procedure
PW	Potable Water	Hydrostatic	150psig	T1
PWH	PW Hot	Hydrostatic	150 psig	T1
SSD	Sanitary Drain	Hydrostatic	10 ft H2O	T5
SV	Sanitary Vent	Hydrostatic	10 ft H2O	T5

ATTACHMENT B – VALVES

BALL VALVES

Two-Piece, Regular-Port, Brass Ball Valves with Brass Trim:
Manufacturers: Subject to compliance with requirements
- Hammond Valve.
- Jamesbury; a subsidiary of Metso Automation.
- Legend Valve.
- Marwin Valve; a division of Richards Industries.
- Milwaukee Valve Company.

Description:
- Standard: MSS SP-110.
- SWP Rating: 150 psig (1035 kPa).
- CWP Rating: 600 psig (4140 kPa).
- Body Design: Two piece.
- Body Material: Forged brass.
- Ends: Threaded.
- Seats: PTFE or TFE.
- Stem: Brass.
- Ball: Chrome-plated brass.
- Port: Regular.

Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:
Manufacturers: Subject to compliance with requirements
- American Valve, Inc.
- Conbraco Industries, Inc.; Apollo Valves.
- Crane Co.; Crane Valve Group; Crane Valves.
- Hammond Valve.
- Lance Valves; a division of Advanced Thermal Systems, Inc.
- Legend Valve.
- Milwaukee Valve Company.
- NIBCO INC.
- Red-White Valve Corporation.
- Watts Regulator Co.; a division of Watts Water Technologies, Inc.

Description:
- Standard: MSS SP-110.
- SWP Rating: 150 psig (1035 kPa).
- CWP Rating: 600 psig (4140 kPa).
- Body Design: Two piece.
- Body Material: Bronze.
- Ends: Threaded.
- Seats: PTFE or TFE.
- Stem: Bronze.
- Ball: Chrome-plated brass.
- Port: Full.

Class 125, Bronze Swing Check Valves with Bronze Disc

Manufacturers: Subject to compliance with requirements,

- American Valve, Inc.
- Crane Co.; Crane Valve Group; Crane Valves.
- Crane Co.; Crane Valve Group; Jenkins Valves.
- Crane Co.; Crane Valve Group; Stockham Division.
- Hammond Valve.
- Kitz Corporation.
- Milwaukee Valve Company.
- NIBCO INC.
- Powell Valves.
- Red-White Valve Corporation.
- Watts Regulator Co.; a division of Watts Water Technologies, Inc.
- Zy-Tech Global Industries, Inc.

Description:

- Standard: MSS SP-80, Type 3.
- CWP Rating: 200 psig (1380 kPa).
- Body Design: Horizontal flow.
- Body Material: ASTM B 62, bronze.
- Ends: Threaded.
- Disc: Bronze.

ATTACHMENT C - PLUMBING FIXTURES, DRAINS, EQUIPMENT

Plumbing Fixtures

WC-1 Water closet, floor mounted, elongated bowl, siphon jet, white vitreous china, chrome plated flush valve, 1-1/2" top inlet, 1.1-1.6 gallons per flush, bolt caps, 12" rough-in, solid plastic seat with check hinge.

L-1 Lavatory, wall mounted, white vitreous china, nominal 21"X18", chrome plated brass single lever faucet, 3/8" hot & cold water supplies, cross handled stops, 1-1/2" X 1-1/2" 20 gage chrome plated brass p-trap, drilled for concealed arm carrier.

EW Portable eyewash, with heated 16 gallon polyethelene water storage tank, , 120V-1,000 watt heater, submersible thermostat to maintain 70°F water temperature, ABS plastic eyewash heads, 0.4 GPM flow rate, supplied with 1-bottle of water preservative, pull-down activation arm, integral handles on top and sides, jacket shall be insulated, power cord.

Hb Hose bibb, 3/4" brass or bronze with non-removable vacuum breaker, metal hand wheel, hose threads.

Plumbing Equipment

EWH-701 Electric water heater, see schedule on DWG P0-001 for technical data.

Drains, Cleanouts and Accessories

FD-1 3" Floor drain, 6"diameter nickel bronze grate, cast iron body, adjustable head, flashing flange, trap primer connection.

FD-2 3" Floor drain, cast iron body, cast iron tractor grate, sediment busket, flashing collar, deep seal p-trap.

FCO Floor cleanout, cast iron body, bronze closure plug, size per pipe size on drawings.

CO End of line cleanout, cast iron body with brass cleanout plug.

WCO Wall cleanout, cast iron cleanout tee with brass cleanout plug, round stainless steel access cover.

YCO Yard cleanout, cast iron body, brass cleanout plug, set in concrete pad for exterior use.

TRAP PRIMER : Automatic primer that discharges a prime of water with a pressure drop in the water supply.

SECTION 15765
UNIT HEATERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Provide equipment, materials, accessories, and labor necessary to install electric heaters of the size, type, capacity, and characteristics shown on the Drawings and described in these Specifications.

1.02 SUMMARY

A. Section includes:

1. Propeller unit heaters with hot-water or electric-resistance heating coils, as scheduled on the plans.
2. Electric cabinet heaters with centrifugal fans and electric-resistance heating coils.

1.03 SUBMITTALS

A. Submit product data in accordance with Section 15050.

B. Submit:

1. Catalog cut sheets
2. Materials of construction
3. Paint, coating, finish, and color information
4. Heating capacity
5. Electrical data
6. Installation and maintenance instructions
7. Spare parts list

1.04 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

D. Heaters shall bear the UL label.

PART 2 - PRODUCTS

2.01 UNIT HEATERS

A. Provide items as scheduled on the Drawings.

B. Acceptable manufacturers:

1. Qmark
2. Markel
3. Berko

2.02 ELECTRICAL INFORMATION

A. Refer to electrical drawings for correct voltage and phase.

B. Provide all electrical components in accordance with Division 16.

C. Provide with control transformers for automatic controls with electric power characteristics as required for automatic.

D. Provide each unit with single point power connection. Power for all unit electric components including motors, heaters, control actuators and control transformers shall be wired from this single point of power connection.

PART 3 - EXECUTION

3.01 GENERAL

A. Install in accordance with manufacturer's recommendations.

B. Provide controls and interlocks to control and interlock as described in Section 15950.

END OF SECTION 15765

SECTION 15885
DRY MEDIA ODOR CONTROL SYSTEM

PART 1 - GENERAL

1.01 WORK INCLUDED

A. This Specification defines the requirements for a modular engineered dry media chemical scrubber odor control system. Provide materials, labor, and accessories necessary to completely fabricate and install the dry media odor control system shown on the Contract Documents.

B. The Contractor shall provide all equipment and work indicated below unless otherwise noted and any additional work to produce a completely finished job as required by the Engineer.

1.02 SUBMITTALS

A. Submit shop drawings and product data in accordance with the General Conditions of the Contract.

B. Submit the following:

1. Expected media life at specified airflow volumes and hydrogen sulfide (H2S), methyl mercaptans and dimethyl disulfide removal rates.
2. Dimensioned drawings, including bill of materials. Materials of construction, operating and dry weights, structural reactions.
3. Installation instructions.
4. Air flow and H2S, methyl mercaptans and dimethyl disulfide removal performance data for the equipment being provided.
5. Alternative arrangement if provided at no cost to the City.
6. Modular Odor Control Equipment
   a. Overall Dimensions.
   b. Net Weight.
   c. Operating Weight.
   d. Construction Materials.
7. Engineered Dry Media
   a. Name of Manufacturer.
   b. Type of Material.
   c. Quantity.
   d. Odor absorption performance of the media.
   e. Media Disposal.
   f. Material Safety Data Sheet (MSDS).
8. Test Results
   a. Submit test data on an actual prototype dry media odor control scrubber to verify system performance.
   b. Such testing shall have been conducted in a representative section of the full scale scrubber, at full scale media bed depth, and equivalent hydrogen sulfide loads.

c. Hydrogen sulfide, methyl mercaptans and dimethyl disulfide load rate to the test system shall, as a minimum, represent full scale operation at 20 ppmv for one hour.

d. Test data shall include:

i) Media temperature.

ii) Air discharge temperature.

iii) Combined hydrogen sulfide, methyl mercaptans, dimethyl disulfide and air volume flow rate at scrubber inlet throughout the test run.

iv) Continuous recording of scrubber discharge hydrogen sulfide concentration, measured to +/- 5 ppb accuracy.

v) Media bed pressure drop at specified air volume flow rate.

vi) Test results shall demonstrate a continuous air discharge containing less that 0.1 ppmv hydrogen concentration throughout the test.

vii) Tests shall verify that the proposed scrubber system will perform, as specified, with media at a start-up temperature as low as -40° F, without the requirement for supplemental heating.

1.03 OPERATION AND MAINTENANCE

A. Submit operation and maintenance data in accordance with the General Conditions of the Contract.

1.04 WARRANTY

A. Warrant in writing against defective or deficient equipment and workmanship in accordance with General Conditions of the Contract and as noted below.

B. Warrant, in writing, that the interior surfaces of all components and the mounting fasteners will withstand corrosive environment for five years.

C. Warrant, in writing, that each scrubber system will provide, in continuous duty, the performance outlined below.

1. The odor control system media shall be capable of removing not less than 99.5% odorous gases from sewage tunnel at an airflow rate of 6,000 cfm.

2. Media bed pressure drop shall not exceed 1.30-inches w.g. at 250 fpm of air velocity for a module measuring 24 x 12 x 12.

1.05 ANALYTICAL SERVICES

A. The manufacturer shall be able to provide in-house lab analysis of the equipment media predicting the remaining life cycle of the media. Such service shall be provided at the manufacturer's expense.

B. Such service shall be provided at the manufacturer's expense for a period of at least ten years.

C. Manufacturer or manufacturer's representative shall provide a minimum of one (1) eight hour day for startup and training on all units.

PART 2 - PRODUCT

2.01 ACCEPTABLE MANUFACTURERS

A. Acceptable odor control system shall be a Modular Chemical Scrubber, double walled side access system (see schedule and notes on plans for complete model number) as manufactured by Purafil, Inc..

B. Design has been based on Purafil with dry chemical media as manufactured by Purafil, Inc.

C. Only those manufacturers who manufacture and furnish media, which meets the requirements of this specification, shall be accepted.

D. The manufacturer shall be a single source provider of equipment, media and testing services and be certified to ISO-9001 standards. ISO certificate must be submitted at time of bid.

E. The manufacturer shall have local, factory-trained representatives.

F. The manufacturer shall also manufacture media in their own facility to ISO-9001:2008 standards. Written proof that chemicals and a disc capable of producing media at their headquarters must be provided. Re-sellers of equipment and media will not be accepted.

2.02 SIDE ACCESS HOUSING CONSTRUCTION

A. Housing shall be constructed of aluminum double-wall insulated casing. The unit shall be manufactured with monolithic panels for system rigidity and gasketed side access doors for servicing all components. Doors shall be on both sides of the unit. The unit shall feature exterior-mounted adjustable compression latches and handles. Closed cell gasketing shall be provided to prevent air leakage around doors and between the doors and filters.

B. All joints shall be sealed with adhesive sealant or approved equal. For outdoor operation, weatherproof pan with drip edge will be provided.

C. The scrubber housing shall be provided with base support.

D. The active scrubber housing shall be designed to facilitate standard fan and motor maintenance contained within the unit.

E. Door seals shall be self adhesive and designed for replacement.

F. Aluminum nameplate shall be provided, permanently attached to the unit. Nameplate shall be engraved with the scrubber type, order number and serial number.

G. The inlet shall contain a mist eliminator prior to the media beds and before the blower. The passive system shall also contain a mist eliminator prior to the media bed.

H. A clearance of at least thirty (30") is required to access the blower and media modules.

I. For all filtration sections, extruded aluminum filter slide tracks shall be provided to allow easy access for servicing of filters.

J. The manufacturer shall provide a differential pressure gauge and pressure taps to measure pressure drop throughout the unit.

K. Mist Eliminator filter tracks shall include nylon pile seal to mate with the sealing face of all filters.

L. The Side Access System includes a downward-slanted extruded aluminum filter slide tracks that support modular media containment devices via a corresponding angled notch in the module's frame to create self-sealing pressure and prevent air bypass.

M. Sound Insulation shall be provided at around the blower door for decibel reduction. Sound Pressure Level: 45 dBA at 50 feet rating according to ARI 270.

N. Rain or acoustical (see plans) louver shall be provided on outlet of the unit and shall extend the duration of the back side of the unit. Wind-Driven Rain Performance: Not less than 95 percent effectiveness when subjected to a rainfall rate of 8 inches per hour and a wind speed of 50 mph at a core-area intake velocity of 400 fpm.

O. Mist eliminator shall be mounted at inlet of the system, centered.

P. An inlet transition shall be provided to the Contractor's specified ductwork.

2.03 BLOWER

A. The Blower shall be located in the housing after the 4th stage of air cleaning. It shall have a backward curved, centrifugal, Fiberglass Reinforced Plastic (FRP) wheel and belt driven by a 230/460 volts 3 phase 60 Hz motor Blower motor.

B. Blower shall include sound attenuation gasketing.

2.04 CHEMICAL MEDIA SECTIONS

A. The housing shall contain four (4) chemical media sections as recommended by Purafil chemical analysis software or chemical analysis equal and designed to accommodate modular media containment devices, utilizing filter tracks.

B. The module shall have a nominal size of 24.0" wide x 12.0" high x 12.0" deep (610 x 305 x 305 mm) in direction of airflow with a medium bed depth of 3.0" (76.2 mm) and contain 1.0 ft3 (0.028 m3) of Purafil engineered media. The module shall be completely recyclable and/or disposable and constructed of 0.125" (3.175 mm) recyclable plastic.

C. The module shall be factory-filled with Purafil engineered and manufactured patented chemical media. The module must be factory-filled and vibrated to eliminate bypass.

D. Pressure drop at maximum air velocity through each chemical media section shall not exceed 1.30 iwg (324 Pa) for a module measuring 24 x 12 x 12 inches/610 x 305 x 305 mm (width x height x depth). Maximum air velocity through chemical media section shall be 250 ft/min (1.27 m/sec) for a module measuring 24 x 12 x 12 inches/610 x 305 x 305 mm.

E. The module with engineered, dry-chemical media shall be UL Classified Class 2. Manufacturer shall provide documentation.

F. Single-source manufacturer must provide in-house laboratory media life analysis at no-charge for as long as their media product is in operation.

G. System shall be designed for 250 ft/min.

2.05 FILTERS

A. The mist eliminator shall be designed to remove 99% of water vapor (>4 micron diameter). The mist eliminator shall be located at the air inlet. Water collected shall drain into a collector pan and into the drain system. The drain system, complete with loop seal (P-trap), is required to overcome the vacuum created by the downstream blower.

B. The mist eliminator pad shall be 2 inches in thickness at a minimum and shall consist of six layers of Kimre 1696 general purpose polypropylene mesh or approved equal.

C. Hinged access doors with gaskets shall allow for the mist eliminator to be removed, cleaned, and/or replaced.

D. Pressure taps and gages shall be installed to permit a local read out of the mist eliminator pressure drop.

E. Mist Eliminator shall be centered at inlet and designed to work at 500ft/min face velocity.

F. The mist eliminator shall have a blind flange for connection to incoming piping network.

G. An inlet transition shall be provided to the Contractor's specified ductwork.

2.06 CHEMICAL MEDIA

A. The unit shall contain four passes of Odormix SP as manufactured by Purafil, Inc.

B. The Odormix SP Media shall consist of an equal mix (by volume) of Purafil ESD's Odoroxidant SP Media and Odorkol

C. Media: Odoroxidant SP Media shall be manufactured of generally spherical, porous pellets formed from a combination of powdered activated alumina and other binders, suitably impregnated with potassium permanganate to provide optimum adsorption, absorption, and oxidation of a wide variety of gaseous contaminants. The potassium permanganate shall be applied during pellet formation, such as the impregnant is uniformly distributed throughout the pellet volume and is totally available for reaction. Odorkol Media shall be a premium grade, activated carbon with a high surface area available for adsorption.

D. Odormix SP Media shall have the following physical properties:

1. Odoroxidant SP Media
2. Moisture content: 35% maximum
3. Average crush strength: 35% minimum - 70% maximum
4. Average abrasion: 4.5% maximum
5. Bulk density: 50 lbs/ft3 (0.8 g/cc) +5%

6. Nominal pellet diameter: 1/16" (1.587mm)
7. Sodium permanganate content: 12% minimum

E. Odorkol Media

1. Moisture content: 5.0% maximum
2. CTC: 55 minimum
3. Base material: activated carbon
4. Bulk density: 30-32 lbs/ft3 (0.48-0.51 g/cc) +5%

F. Odormix SP Media shall be UL Classified Class 1.

G. Purafil media only will be accepted due to the high level of capacity. No equals will be accepted.

H. Only UL certified media will be accepted in this aluminum vessel with companies that contain additional product liability on their systems. Companies lacking this liability and UL certification will not be accepted.

I. All media must have proof that is made and produced in the United States for additional verification of product performance.

2.07 ACCESSORIES

A. Pressure Gage: Magnehelic type pressure gages shall be included with the scrubber to permit local read-out of pressure drop through the mist eliminator and at each media stage. Pressure gages shall be prepiped at the factory with stainless steel tubing and housed in aluminum boxes for weather protection.

B. Provide a minimum of 4-inches tall structural aluminum skid for installing the scrubber on the top of the concrete slab.

C. Provide a rain louver constructed of heavy gage aluminum and stainless steel bird screen.

2.08 MOTOR STARTER AND CONTROL PANEL (ACTIVE UNITS ONLY)

A. NEMA 4X, 316 stainless steel enclosure

B. Motor starter: FVNR, ATL, with overload heaters, NEMA sized for 30h.p. 460 VAC motor.

C. Control power transformer, 460/120 VAC, with fused primary and secondary.

D. Main circuit breaker, magnetic, with front-panel operating handle.

E. Operator interface and display:

1. "Hand-Off-Auto" selector switch
2. Indicating lamps (all lamps are push-to-test style):
3. "Fan Off"

4. "Fan Running"
5. Note: customer to supply 460 VAC power.
6. Contacts available for Photohelic gauge input and indicator light.
7. Control panel shipped loose to be installed in electric control room.

F. Remote monitoring Interface - provide the following dry contacts for interfacing remotely to the Plant Control system:

1. Common Trouble (Differential pressure or any other monitoring function)
2. Motor Running Indication (from motor Starter)
3. Motor Starter Common Trouble (overload or any interlocks provided)
4. Motor Starter Hand-OFF-Auto Selector Switch - Auto Position Indication (add a separate NO contact to AUTO Position of the selector switch)
5. Remote Start/Stop Output from Plant Control System (Powered by the Starter - when H-O-A is in Auto position closing this output contact will energize the motor starter)

PART 3 - EXECUTION

3.01 EXAMINATION AND PREPARATION

A. Inspect all equipment immediately upon delivery to site.

B. Do not install damaged equipment until repairs have been made in accordance with manufacturer's written instructions and approved by the Engineer. Damaged items shall be sent to factory for repair or replacement, unless otherwise approved by the Engineer.

C. Protect equipment in accordance with Specification Section 01611.

3.02 INSTALLATION

A. Install odor control systems and pieces of equipment in accordance with the manufacturer's written instructions.

B. Install scrubber on the factory furnished structural aluminum skid on concrete slab as shown on the Drawings. Anchor the system to the concrete slab with minimum 4-inch embedment.

C. Furnish the services of qualified factory representatives of the odor control system manufacturer for inspection, start-up, and instruction of operating personnel for an aggregate minimum of eight hours at the jobsite.

D. No additional payment shall be made for services required in Article 3.02.

3.03 ANALYTICAL SERVICES

A. The manufacturer shall be able to provide in-house lab analysis of the equipment media predicting the remaining life cycle of the media. Such service shall be provided at the manufacturer's expense.

B. No additional payment shall be made for services required in Article 3.03.

3.04 ACCEPTANCE

A. Demonstrate to the Engineer that the odor control system will function as required in these Specifications. The system supplier shall make, at his expense, necessary changes, modifications, and adjustments required to provide satisfactory operation.

B. Scrubber shall contain a full load of unspent media when accepted by the Owner.

C. No additional payment shall be made for services required in Article 3.04.

END OF SECTION 15885

SECTION 15890
AIR DISTRIBUTION DEVICES

PART 1 - GENERAL

1.01 DESCRIPTION

A. Work Included: Diffusers, Registers and Grilles

1.02 RELATED WORK

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.03 REFERENCES

A. Standards

1. National Fire Protection Association (NFPA): Standard 255, Test Methods for Surface Burning Characteristics of Building Materials.
2. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE): ASHRAE Std 70, Method of Testing for Rating the Performance of Air Outlets and Inlets; 1991.
3. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
4. SMACNA HVAC Duct Construction Standards - Metal and Flexible; 1995, Second Edition with Addendum No. 1.

1.04 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions.

B. Product Data: Data shall be submitted on the following items: Diffusers, Registers and Grilles.

1.05 QUALITY ASSURANCE

A. Manufacturers

1. Products scheduled on the drawings are the basis of design to establish performance criteria and size. Subject to compliance with these Specifications and the Drawings, the products of the following manufacturers are acceptable.
   a. Carnes
   b. Krueger
   c. Metal Aire
   d. Price
   e. Titus
   f. Tuttle & Bailey
   g. Or equal.

2. Manufacturer shall provide published performance data for all diffusers, registers and grilles. The devices shall be tested in accordance with ANSI/ASHRAE Standard 70.

1.06 DELIVERY, STORAGE AND HANDLING

A. Shipping

1. Ship equipment, material and spare parts complete except where partial disassembly is required by transportation regulations or for protection of components.
2. Pack spare parts in containers bearing labels clearly designating contents and pieces of equipment for which intended.
3. Deliver spare parts to the Owner after completion of work.

B. Receiving

1. Inspect and inventory items upon delivery to site.
2. Store and safeguard equipment, material and spare parts in accordance with manufacturers written instructions.

PART 2 - PRODUCTS

2.01 GENERAL

A. Finish: Diffusers, registers and grilles shall be provided with a factory applied white baked enamel finish unless indicated otherwise, herein or on the Drawings. Diffuser, register and grille finishes must pass a 100-hour ASTM B117 corrosive environments salt spray test without creepage, blistering or deterioration of film; a 250-hour ASTM D870 water immersion test; and the ASTM D2794 reverse impact cracking test with a 50-inch pound force applied.

B. Mounting: Coordinate mounting with surface/assembly in which mounted and provide manufacturer's standard frame and border to application.

C. Performance: Air distribution device performance (pressure drop and NC) shall be as scheduled at design airflow.

D. Grilles, Registers, and Diffusers

1. Duct mounted Side wall Diffuser: Supply grilles shall be aluminum and the sizes of supply grilles shall be the same as shown on plans & schedules. The deflection blades shall be available to the long or short dimension of the grille. Construction shall be of aluminum with 1-1/4-inch wide border. Provide opposed blade volume damper.
2. Heavy Duty Return Grille, 0-degree Deflection: Heavy duty bar grille, 0° deflection; steel construction with a 1¼-inch wide, 16 gauge steel border for wall surface mounting; 14-gauge steel bars reinforced by perpendicular, steel supports spaced on 6-inch centers; fully welded corners with a reinforcing patch for extra strength; countersunk screw holes; heavy-gauge steel volume damper operable from the face of the grille.
3. Eggcrate Grille: Eggcrate return grille; 1"x1"x1" aluminum core grid with minimum 90% free area; 1¼-inch wide heavy gauge extruded aluminum border with countersink screw

holes; mitred corners mechanically interlocked together for rigid frame; baked anodic acrylic finish, white unless noted otherwise; .

PART 3 - EXECUTION

3.01 STORAGE

A. Air distribution devices shall be stored on wooden pallets or rails, covered by 6 mil polyethylene cover, taped in place, until ready for installation.

3.02 INSTALLATION

A. Air distribution devices installation shall be per manufacturer's instructions for specific application and these Construction Documents. Coordinate frame and border type with assembly in which installed.

B. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement. Coordinate locations to avoid conflicts with partitions and ceiling features and devices (light fixtures, speakers, sprinklers, etc.) - coordinate with Architectural drawings.

C. Install diffusers to ductwork and wall surfaces with air tight connection. Provide continuous neoprene gasket around perimeter (concealed beneath device border frame).

D. Paint ductwork visible behind air outlets and inlets matte black.

E. Air distribution devices mounted in ductwork shall be secured to ductwork with sheet metal screws.

F. Air devices shall be installed flush and square to surface/assembly in which installed.

END OF SECTION 15890

SECTION 15891
DUCTWORK

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Work described in this Section includes furnishing all labor, materials, equipment, tools and incidentals required for a complete and operable installation of rectangular, round and flat-oval ducts and plenums. The ducts shall be supplied for heating, ventilating and air conditioning systems in pressure classes from minus 2 inches to plus 10 inches water gage. All systems shall be installed, adjusted, tested and placed in operation in accordance with these Specifications, the Fabricator's recommendations and as shown on the Drawings.

B. Contract Drawings show only functional features and some of the required external connections. They do not show all components required for a complete installation nor exact dimensions particular to any specific material. Contractor shall supply all parts, devices and equipment necessary to meet the requirements of the Contract Documents and shall make all dimensional adjustments particular to the material being furnished. All costs associated with such changes and adjustments shall be included in the price bid for the Work shown and specified.

C. Related Work specified elsewhere:

1. Section 07900 – Caulking and Sealants.
2. Section 08110 - Steel Doors and Frames.
3. Section 15050 - Basic Mechanical Materials and Methods.
4. Section 15250 - Mechanical Insulation.
5. Section 15910 - Ductwork Accessories.
6. Section 15990 - Testing, Adjusting and Balancing of HVAC Systems.

D. Definitions

1. Sealing Requirements: For the purposes of duct system sealing requirements specified in this Section the following definitions apply:
   a. A seam is defined as joining of two longitudinally (in the direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on the perimeter are deemed to be joints.
   b. Joints include girth joints; branch and sub-branch intersections; so-called duct collar tap-ins; fitting subsections; louver and air terminal connections to duct; access door and access panel frames and jambs; duct, plenum, and casing abutments to building structures.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

1. Product data including details of construction relative to material, dimensions of individual components, profiles, and finishes for the following items:

a. Duct liner.
b. Sealing materials.
c. Fire-stopping materials.

2. Shop drawings from duct fabrication shop, drawn to scale not smaller than ¼ inch equals 1 foot, on drawing sheets same size as the Contract Drawings detailing:
   a. Fabrication, assembly and installation details for metal and glass fiber ducts, including plans, elevations, section, details of components and attachments to other Work.
   b. Duct layout, indicating pressure classifications and sizes in plan view. For exhaust ducts systems, indicate the classification of the materials handled.
   c. Fittings.
   d. Reinforcing details and spacing.
   e. Seam and joint construction details.
   f. Penetrations through fire-rated and other partitions.
   g. Terminal unit, coil and humidifier installations.
   h. Hangers and supports, including methods for building attachment, vibration isolation and duct attachment.
3. Coordination drawings for ductwork installation shall show the following:
   a. Coordination with ceiling suspension members.
   b. Spatial coordination with other systems installed in the same space with the duct systems.
   c. Coordination of ceiling and wall mounted access doors and panels required to provide access to dampers and other operating devices.
   d. Coordination with ceiling-mounted lighting fixtures and air outlets and inlets.
4. Record drawings including duct systems routing, fittings, details, reinforcing, support and installed accessories and devices.
5. Maintenance data for volume control devices, fire dampers and smoke dampers.

1.03 QUALITY ASSURANCE

A. Reference Standards: Comply with all Federal and State laws or ordinances, as well as the latest edition of all applicable codes, standards, regulations and/or regulatory agency requirements including the partial listing below:

1. ASTM, American Society for Testing Materials.
2. ASME, American Society of Mechanical Engineers.
3. OSHA, Occupational Safety and Health Act.
4. ANSI, American National Standards Institute.
5. NFPA, National Fire Protection Association.
6. UL, Underwriters Laboratories, Inc.
7. ASHRAE, American Society of Heating, Refrigerating and Air Conditioning Engineers.
8. SMACNA, Sheet Metal and Air Conditioning Contractors' National Association.
9. TIMA, Thermal Insulation Manufacturer's Association.
10. ICBO, International Conference of Building Officials.

1.04 QUALITY STANDARDS

A. The duct system design, as indicated, has been used to select and size air moving and distribution equipment and other components of the air system. Changes or alterations to the layout or configuration of the duct system must be specifically approved in writing. Accompany requests for layout modifications with calculations showing that the proposed layout will provide the original design results without increasing the system total pressure.

B. Manufacturer shall provide written certification that the equipment provided under this Specification has been designed in accordance with these Specifications and is suitable for these service conditions.

1.05 STORAGE AND HANDLING

A. Deliver sealant and fire-stopping materials to site in original unopened containers or bundles with labels identifying manufacturer, product name and designation, color, expiration period for use, pot life, curing time and mixing instructions for multi-component materials.

B. Store and handle sealant fire-stopping materials in compliance with manufacturer's recommendations to prevent their deterioration or damage due to moisture, high or low temperature, contaminants or other causes.

C. Deliver and store stainless steel sheet with mill-applied adhesive protective paper, maintained through fabrication and installation.

1.06 WARRANTY

A. Provide a warranty against defective equipment and workmanship in accordance with the requirements of the General Conditions of the Contract Documents for a period of 1 year after substantial completion.

PART 2 - PRODUCTS

2.01 METAL DUCT MATERIALS

A. Provide sheet metal in thicknesses indicated, packaged and marked as specified in ASTM A 700.

1. Galvanized Sheet Steel: Lock-forming quality, ASTM A 527, Coating Designation G 90. Provide mill phosphatized finish for exposed surfaces of ducts exposed to view.

B. Reinforced shapes and plates, unless otherwise indicated, shall be galvanized steel reinforcing where installed on galvanized sheet metal ducts.

C. Tie-rods shall be galvanized steel, ¼-inch minimum diameter for 36-inch length or less; 3/8-inch minimum diameter for lengths longer that 36 inches.

2.02 SEALING MATERIALS

A. Joint and Seam Sealants: The term sealant used in this Section is not limited to material of adhesive or mastic nature, but also includes tapes and combinations of open weave fabric strips and mastics.

1. Joint and Seam Tape: 2-inch wide, Metallic Foil-faced not fabric type
2. Joint and Seam Sealant: One-part, non-sag, solvent-release-curing, polymerized butyl sealant; formulated with a minimum of 75 percent solids.
3. Flanged Joint Mastics: One-part, acid-curing, silicone elastomeric joint sealants, complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.
4. Fire-Resistant Sealant: Provide two-part, foamed-in-place, fire-stopping silicone sealant formulated for use in a through-penetration fire-stop system for filling openings around duct penetrations through walls and floors having fire-resistance ratings indicated as established by testing identical assemblies per ASTM E 814 by UL or other testing and inspecting agency acceptable to authorities having jurisdiction.

2.03 WEATHERPROOF DUCT INSULATION

A. Provide a minimum of 74mm 3 inches of rigid cellular polyurethane thermal preformed board insulation, or rigid cellular phenolic thermal preformed board insulation on exterior of supply ducts, return ducts, and plenums exposed to the weather.

B. Coat sides, ends and edges of insulation with a waterproof mastic. Apply insulation in a solid bed waterproof adhesive and additionally secure with one 20 gauge galvanized metal stud welded to the metal ducts and having stainless steel washers not less than 51 mm or 2 inches in diameter under the metal mechanical fasteners for bearing on the insulation and to hold on in place.

C. Provide studs at a rate of one per .0929 Square meters 1 square foot metal duct, spaced at maximum of 305 mm 12" centers along both edges of top, bottom and sides of ducts and at joints in insulation.

D. After the insulation is in place, cover joints and corner joints, with glass fiber reinforcing mesh in waterproof adhesive.

E. After covering is complete, coat exterior surfaces of insulation with an approved waterproof and weather-resistant aluminum pigmented mastic recommended by the insulation manufacturer for this type of application. Apply mastic in 2 equal coats to a minimum thickness of 6.35 mm .25 inch; reinforce between coats with a layer of glass fiber reinforcing mesh; lap glass fiber reinforcing mesh 153 mm 6 inches at joints. Insulation less than 305 mm 12 inches in least dimension shall not be used along the edges of the duct bottom. Slope insulation from top center line of horizontal rectangular ducts to top edges ducts with a minimum slope 83mm 1 inch per foot.

2.04 HANGERS AND SUPPORTS

A. Building Attachments: Concrete inserts, powder actuated fasteners or structural steel fasteners appropriate for building materials. Do not use powder actuated concrete fasteners for lightweight aggregate concrete or for slabs less than 4-inch thick.

B. Hangers: Galvanized sheet steel or round, uncoated steel, threaded rod. Vibration isolators in areas of moisture shall be silicone or non-porous rubber material and not spring-type.

C. Hangers Installed in Corrosive Atmospheres: Electro-galvanized, all-thread rod or hot-dipped-galvanized rods with threads painted after installation.

D. Straps and Rod Sizes: Conform with Table 4-1 SMACNA HVAC Duct Construction Standards for sheet steel width and gage and steel rod diameters. Hanger rods shall be a minimum of ¼" diameter.

E. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger.

F. Sleeves

1. Sleeves for round ductwork: Form with galvanized steel.
2. Sleeves for rectangular ductwork: Form with wood or galvanized steel.
3. Size sleeves large enough to allow for movement due to expansion and contraction.

G. For galvanized steel ducts provide hot-dipped galvanized steel support materials. .

2.05 RECTANGULAR DUCT FABRICATION

A. Except as otherwise indicated, fabricate rectangular ducts with galvanized sheet steel, in accordance with SMACNA HVAC Duct Construction Standards. Conform to the requirements in the referenced standard for metal thickness, reinforcing types and intervals, tie rod applications and joint types and intervals.

B. Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure classification.

C. Provide materials that are free from visual imperfections such as pitting, seam marks, roller marks, stains and discoloration.

D. Static Pressure Classifications: Except where otherwise indicated, construct duct systems to the following pressure classifications:

1. Supply Ducts: 3 inches water gage.
2. Return Ducts: 2 inches water gage, negative pressure.

E. Crossbreaking or Cross Beading: Crossbreak or bead duct sides that are 19 inches and larger and are 20 gage or less, with more than 10 sq. ft. of unbraced panel area, as indicated in SMACNA HVAC Duct Construction Standards, unless they are lined or are externally insulated.

2.06 RECTANGULAR DUCT FITTINGS

A. Fabricate elbows, transitions, offsets, branch connections and other duct construction in accordance with SMACNA HVAC Duct Construction Standard.

2.07 SHOP APPLICATION OF LINER IN RECTANGULAR DUCTS

A. Adhere a single layer of indicated thickness of duct liner with 90 percent coverage of adhesive at liner contact surface area. Multiple layers of insulation to achieve necessary thickness are prohibited.

B. Apply a coat of adhesive to liner facing in direction of airflow not receiving metal nosing.

1. Butt transverse joints without gaps and coat joint with adhesive.
2. Fold and compress liner in corners of rectangular ducts or cut and fit to assure butted edge overlapping.

C. Longitudinal joints in rectangular ducts shall not occur except at corners of ducts, unless the size of the duct and standard liner product dimensions make longitudinal joints necessary.

D. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely around perimeter; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.

E. Secure transversely oriented liner edges facing the air stream with metal nosings that are either channel or "Z" profile or are integrally formed from the duct wall at the following locations:

1. Fan discharge.
2. Intervals of lined duct preceding unlined duct.

2.08 ODOR CONTROL SYSTEM

A. All materials, fabrication, and installation are specified under Section 15885 "Dry Media Odor Control System"

PART 3 - EXECUTION

3.01 INSTALLATION

A. Construct and install each duct system for the specific duct pressure classification indicated. Provide openings in ductwork where required to accommodate thermometers and controllers.

B. Install ducts with fewest possible joints.

C. Use fabricated fittings for all changes in directions, changes in size and shape and connections.

D. Install couplings tight to duct wall surface with projections into duct at connections kept to a minimum.

E. Locate ducts, except as otherwise indicated, vertically and horizontally, parallel and perpendicular to building line; avoid diagonal runs. Install duct systems in shortest route that does not obstruct usable space or block access for servicing building and its equipment.

1. Conceal ducts from view in finished and occupied spaces by locating in mechanical shafts, hollow wall construction, or above suspended ceilings. Do not encase horizontal runs in solid partition, except as specifically shown.
2. Coordinate layout with suspended ceiling and lighting layouts and similar finished work.
3. Route ductwork to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Provide clearance of 1-inch where furring is shown for enclosure or concealment of ducts, plus allowance for insulation thickness, if any.

H. Install insulated ducts with 1-inch clearance outside of insulation.

I. Non-Fire-Rated Partition Penetrations: Where ducts pass interior partitions and exterior walls and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same gage as duct. Overlap opening on 4 sides by at least 1-1/2 inches.

3.02 SEAM AND JOINT SEALANT

A. Seal duct seams and joints to SMACNA Seal Class A (all transverse joints, longitudinal, seams, and duct penetrations). Seal externally insulated ducts prior to insulation installation.

3.03 HANGING AND SUPPORTING

A. Install rigid, round, rectangular and flat oval duct with support systems indicated in SMACNA HVAC Duct Construction Standards.

1. Support horizontal ducts within 2 feet of each elbow and within 4 feet of each branch intersection.
2. Support vertical ducts at a maximum interval of 16 feet and at each floor.

B. Upper attachments to structures shall have an allowable load not exceeding 1/4 of the failure (proof test) load but are not limited to the specific methods indicated.

C. Install concrete insert prior to placing concrete.

D. Install powder actuated concrete fasteners after concrete is placed and completely cured.

3.04 CONNECTIONS

A. Connect equipment with flexible connectors in accordance with Section 15910 Ductwork Accessories.

B. All duct connections shall comply with SMACNA HVAC Duct Construction Standards.

3.05 ADJUSTING AND CLEANING

A. Adjust volume control devices as required by the testing and balancing procedures to achieve required airflow. Adjustments shall be in accordance with Section 15990 Testing, Adjusting and Balancing Air Systems.

B. Vacuum ducts systems prior to final acceptance to remove dust and debris.

END OF SECTION 15891

SECTION 15895
FIBERGLASS DUCTWORK AND ACCESSORIES

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Furnish, fabricate and install all fiberglass reinforced plastic (FRP) ductwork to include fittings, accessories, dampers, hangers and any incidental work or components required to provide complete air supply, return and exhaust ductwork systems as shown.

B. In general, ductwork shall consist of any passageway made of FRP substantially air-tight, used for the conveying of air, gas or materials. Included are fittings, transitions, bracing, fasteners, sealers, supports and accessories such as access panels, access doors, turning vanes and manual air balancing dampers. All ductwork shall be of size and material as specified herein and as shown on the Drawings. All duct sizes indicated on the Drawings are clear, inside dimensions.

C. Any change in duct sizes, offsets, transitions and fittings required to accommodate job conditions shall be manufactured in compliance with SMACNA construction standards and have a maximum transitional angle of 25 degrees.

1.02 SUBMITTALS

A. Submit to the Engineer in accordance with the General Conditions, the Special Conditions, and Division 1, the following drawings and data. Ductwork shop drawings shall include typical details of discharge nozzles, transitions, elbows, fittings, accessory items such as access panels or access doors, turning vanes, volume control and splitter dampers, volume extractors, hangers and supports, joining methods, bracing and material gages. Drawings of general layouts of individual systems shall be submitted, scale shall be 1/4-in. = 1-ft-.0-in. minimum.

B. The following additional data shall be submitted.

1. Manufacturer's qualification and experience data, specifications and installation instructions, factory and field quality control procedures catalog data, brochures, descriptive matter, illustrations, diagrams and color charts of ductwork to be selected.
2. Specific handling and storage requirements for ductwork, joint kits and resin systems.
3. Sample coupons of laminate not less than one foot square. Provide sample laminate coupons for each method of manufacture and for both round and rectangular duct manufacturing methods.
4. Resin system data, including chemical environment service test data, case history data of similar installations (with contact addresses), resin pot life and time versus temperature data required for complete resin cure for laminate thicknesses actually proposed.
5. Submit design calculations signed and sealed by a professional engineer for all delegated design tasks and fabrication procedures. Also submit a letter certifying that the laminates fabricated with the proposed resin system will give satisfactory performance under the specified service conditions and stating the service conditions for which certification is provided and indicating compliance with specified pressure and vacuum design criteria.

6. Submit construction details for flexible connectors, expansion joints, elbows, transitions, junctions, hangers and supports, and flanged fittings including dimensioned laminate cross sections and flange fabrication and assembly details.
7. Submit results of factory readings taken with "Barcol Hardness Impressor" and provide procedure to field check for complete cure of resin.
8. Certified service tables for the resins being used and the expected contaminants showing satisfactory services for the required design conditions.
9. Detailed instructions for field joining of the ductwork to include quality control procedures.
10. Submit shop test reports for fiberglass reinforced plastic dampers.

1.03 QUALITY ASSURANCE

A. All FRP duct, supports, and fittings shall be from a single manufacturer.

B. All materials shall be supplied by a Manufacturer experienced in the fabrication of materials similar to those specified. Design and engineering shall be performed by personnel regularly employed by the Manufacturer who are experienced in the design of FRP systems similar to those specified.

C. The Manufacturer shall provide factory trained personnel for training of installers and for supervision and inspection of the installation. The use of local sales representatives for this service is not acceptable.

D. Corrosion resistance data shall be based on ASTM C581.

1.04 DELIVERY, STORAGE AND HANDLING

A. Equipment, material and spare parts are to be shipped complete except where partial disassembly is required by transportation regulations or for protection of components. No ductwork or components shall be shipped prior to complete resin cure.

B. Inspection of the duct and components will be made by the engineer or other representative of the owner after delivery. Materials shall be subject to rejection at any time on account of failure to meet any of the specification requirements. Material rejected after delivery shall be marked for identification and shall be immediately removed from the jobsite.

1.05 STANDARDS OF CONSTRUCTION AND INSTALLATION

A. All ductwork construction and installation details shown on the Drawings and specified herein are based on acceptable methods of construction and installation and are intended to define the quality of construction and installation to be furnished. Alternate details may be submitted for approval.

1.06 REFERENCE STANDARDS

A. These standards shall be considered as minimum requirements. This is a general list and not all standards listed are necessarily referenced elsewhere in this Section. Specific requirements of this Section and/or Drawings shall have precedence. The Engineer shall resolve conflicts between published requirements.

B. Air Movement and Control Association (AMCA)

C. American National Standards Institute (ANSI)

1. ANSI RTP-1 - Reinforced Thermoset Plastic Corrosion Resistant Equipment.

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

E. American Society for Testing and Materials (ASTM)

1. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
2. ASTM E477 - Standard Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.
3. ASTM C581 - Standard Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures Intended for Liquid Service.
4. ASTM D4167

F. Anti-Friction Bearing Manufacturers Association (AFBMA)

G. National Fire Protection Association (NFPA)

1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilation Systems.
2. NFPA 91 - Standard for Exhaust Systems for Air Conveying of Materials.
3. NFPA 252 - Standard Methods of Fire Tests of Door Assemblies.
4. NFPA 255 - Standard Method for Test of Surface Burning Characteristics of Building Materials.

H. Occupational Safety and Health Administration (OSHA)

I. Underwriters Laboratories (UL)

1. UL 555 - UL Standard for Safety Fire Dampers.
2. UL 723 - UL Standard for Safety Test for Surface Burning Characteristics of Building Materials.

J. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

PART 2 - PRODUCTS

2.01 MATERIAL

A. Design Conditions

1. Temperature: minus 10 degrees F to 125 degrees F
2. Pressure: 12-in H2O w.g. positive; 12-in H2O w.g. negative
3. Flow medium and velocity: air at 3,500 feet per minute
4. Wind load: 120 mph

5. Wall thickness (minimum): Thickness as necessary to meet the requirements of Paragraph 2.03K.

B. The following materials are expected to be in the air stream or surrounding area. Vinylester resin shall be used for all ductwork.

1. Hydrogen sulfide
2. Ammonia
3. Sodium hydroxide
4. Sodium hypochlorite
5. Organic compounds

2.02 CLASSES OF CONSTRUCTION

A. Ductwork shall be designed and constructed in accordance with ASME/ANSI RTP1-1989.

2.03 FIBERGLASS REINFORCED PLASTIC (FRP) DUCTWORK

A. FRP ductwork shall be of contact molded or filament wound construction, or a combination of these methods, to meet design criteria.

B. FRP ductwork shall have a flame spread rating of 25 or less inside and outside and a smoke developed rating of not more than 50 in accordance with NFPA 91. Sprinklers shall not be used for internal fire suppression.

C. Laminates shall consist of a 20 mil (finished thickness) minimum chemical resistant interior liner with an apertured synthetic surface veil embedded in a resin rich surface. The corrosion barrier shall be a minimum of 100 mils thick and include not less than two layers of 1-1/2 ounce mat with 25 percent glass and 75 percent resin content. The structural layer shall be of sufficient thickness to meet the minimum thickness requirements specified. The exterior surface layer shall be resin rich "C" - glass or appertured nexus veil not less than 20 mils thick. Outside finish shall be a pigmented, parrafinated gel coat with an ultra violet inhibitor. The inner surface shall be free of cracks and crazing with a smooth finish and with an average of not over two pits per square foot, providing the pits are less than 1/8-in in diameter and not over 1/32-in deep and are covered with sufficient resin to avoid exposure of inner surface fabric. Some waviness is permissible as long as the surface is smooth and free of pits.

D. Resins used in the laminate shall be premium corrosion resistant and fire retardant vinylester resins and shall contain 3 percent NYACOL as a fire retardant.

E. Fittings and Joints: All fittings such as elbows, laterals, tees and reducers shall be of the same resin as and equal or superior in strength to the adjacent duct section and shall have the same internal dimensions as the adjacent duct. Non-flanged duct joints shall be butt wrapped or bell and spigot joints. Bell and spigot joints shall be sealed with a standard butt joint overlay as per PS 15-69. The interior opening between the bell and spigot shall be sealed with a resin paste so that no glass fibers are exposed and all voids are filled. Field cut duct ends and exposed glass fibers shall be resin coated prior to joint assembly to maintain a continuous interior corrosion barrier. Coat all exterior surfaces of joints with a paraffinated resin-rich gel coat with UV inhibitors.

F. Total width of overlay for butt-wrap joints shall be not less than 6-in. for diameters from 6-in. up to and including 30-in., 36-in. and larger shall be not less than 10-in.

G. Round Standard Elbows

1. Standard elbow centerline radius shall be equal to 1.5 times the diameter.
2. Standard elbows up to 24-in. diameter shall be smooth radius molded elbows. Standard elbows 30-in. diameter and greater may be mitered sections as specified below.
3. 0 to 44 degree elbows shall contain one mitered joint and two sections. 45 to 80 degree elbows shall have a minimum of two mitered joints and three sections. Elbows greater than 80 degrees shall have a minimum of four mitered joints and five sections.

H. Rectangular Fittings

1. Fittings shall be factory manufactured to meet the specified design criteria and in accordance with approved submittals. Factory install reinforcing ribs as required to meet the specified deflection requirements and to provide a system free from pulsing, warpage, sagging and undue vibration.
2. forming vanes in all mitered rectangular elbows. Rectangular elbow turning vanes shall be of FRP construction, solid or double wall construction with an airfoil shaped profile.

I. Reinforcing

1. Round duct reinforcing shall be factory installed with spacing between reinforcing located to avoid all hangers and support saddles.
2. Rectangular duct and fitting reinforcing shall be factory located and installed to avoid duct hangers, support saddles, bracing, branch take offs and entries, and plenum connections. Routine field cutting and field relocation of factory installed reinforcing is not acceptable.

J. Tolerances

1. Out-of-roundness of duct shall be limited to plus or minus 1/8-in. or plus or minus one percent of duct inside diameter, whichever is greater for duct sizes 6-in. diameter and greater.
2. Rectangular duct tolerances shall be 3/16-in. for duct diameter up to 18-in. and plus or minus one percent for dimensions of over 18-in.
3. All unflanged duct shall be square on the ends in relation to the pipe axis and plus or minus 1/8-in. up to and including 24-in. diameter and plus or minus 3/16-in. for all diameters greater than 24-in.
4. Fittings
   a. The tolerance on angles of all fittings shall be plus or minus one degree, up to and including 24-in. diameter and plus or minus ½ degree for 30-in. diameter and above.
5. Flanges
   a. Flange faces shall be perpendicular to the axis of the duct within ½ degree.
   b. Flange faces shall be flat to within plus or minus 1/32-in., up to and including 18-in. diameter and flat within plus or minus 1/16-in. for 20-in. diameter and larger.
   c. Provide custom filler pieces as required to mate flanges squarely.

K. Calculations for wall thickness determination shall be based on the structural fiberglass reinforced wall only. Long term deflection shall not exceed one percent of duct diameter or duct width for rectangular ducts. Round and rectangular FRP ductwork shall be designed using a safety factor of 10 to 1 for pressure, a safety factor of 5 to 1 for vacuum service, and a wind load of 120 mph. Round duct shall be designed by Manufacturer to resist specified loadings but in no case shall FRP duct be less than the following thicknesses (without 0.10-in. liner and without exterior gel-coat thickness):

Diameter (-in)*	Filament Wound Thickness (-in)	Hand Layup Thickness (-in)
Less than 24	.225	.250
36 -42**	.375	.438

* Where rectangular duct is used the longest dimension shall be considered equivalent to diameter.

** Rectangular duct may be reinforced with angles or tees as required to meet the required pressure/vacuum service.

L. Ductwork with any portion of wall less than the required thickness shall be rejected.

M. All connections to expansion joints, butterfly dampers, fire dampers, tanks, or other equipment shall be flanged. Gaskets shall be chlorobutyl. Flanges shall be hand laid up to thickness specified in PS 15-69 except that minimum thickness shall be 3/4-in. Each flange face shall be ground flat, and a new 100 mil corrosion barrier shall be applied. The flange shall be anchored to a waxed table to ensure the flatness tolerance outlined above. The face shall be textured for use with full face chlorobutyl gaskets, 1/8-in. minimum thickness. Flange drilling shall be as per PS 15-69. All bolt holes shall be back spot faced for a washer seat. All flange bolts shall be torqued to values as recommended by manufacturer.

N. Fasteners: Furnish all bolts, nuts, washers and other fasteners required. Material of metallic fasteners shall be Series 316 stainless steel.

O. There shall be not less than a 1/4-in. buildup of FRP over the duct at each support and as shown on the Drawings.

P. Provide 1-in. minimum PVC pipe and PVC ball valve duct drains in the bottom of all main, branch and riser ducts to allow removal of condensate.

Q. All hangers and supports shall be Type 304 stainless steel. All duct hangers shall be provided per SMACNA recommendations and manufacturers requirements. Maximum spacing on duct hanger is 5'-0".

2.04 FLEXIBLE CONNECTORS

A. Furnish flexible connectors at each inlet and outlet of fan and in the duct runs where required for expansion, contraction and movement. Flexible connections shall be W-design units constructed of EPDM rubber 3/8-in. thick, reinforced with a strong synthetic asbestos-free fabric suitable for corrosive service. The flexible connections shall be designed to minimize the transmission of vibration from the fans to the ductwork at the suction and discharge connections. Expansion or contraction flexible connections shall be designed to allow 1-in. movement. Working length or "live" length shall be as designed by the Manufacturer to allow up to 1-in. of movement. Ends shall be flanged, with flanges matching duct connection flanges. Corners on rectangular expansion joints shall be molded and free of patches or splices. The flexible connections shall be

suitable for outdoor service and temperature ranges from minus 10 degrees F up to 125 degrees F, and pressure to 5 psig. Specially fabricated split Type 316 stainless steel retaining back-up bars shall be supplied to prevent damage to the EPDM rubber flanges when Type 316 stainless steel bolts are tightened.

1. Manufacturer:
   a. Holz Rubber Company.
   b. Mercer Rubber Company.
   c. Proco Products, Incorporated.
   d. Or equal.

2.05 TOOLS, SPARE PARTS AND MAINTENANCE MATERIALS

A. The duct system shall be furnished with the following:

1. One set of special tools required to maintain and repair the system.
2. All materials in kit form to make or repair joints. Additional kits shall be supplied sufficient to repair 10 percent of the joints. Materials shall be packaged in a painted steel case for long term storage.
3. Names and addresses of all manufacturers of: Fiberglass reinforcements, resins, hardeners and components used to repair and maintain the FRP duct system.

B. Spare parts shall be packed in sturdy containers with clear indelible identification markings and shall be stored in a dry, warm location, and provided in accordance with Section 01600.

C. Prices for spare parts and tools shall remain in effect for one year after final acceptance.

D. Material Safety data sheets for all components must be furnished.

2.06 FRP TRANSITION PIECES

A. Provide transition pieces as shown on Drawings and herein specified.

B. Construction:

1. Thickness of transition pieces shall be designed using a safety factor of 10 to 1 for pressure, a safety factor of 5 to 1 for vacuum service, and wind load of 120 mph, all with the pressure classification listed below.
2. Custom flanges shall be designed as required to connect to fans, coils, dampers and duct work. Coordinate flange sizes to match approved equipment dimensions.

C. Pressure Classification: Manufacturer shall design transition pieces so that they shall be free from buckling, pulsing, warpage and sagging at design pressures.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All ductwork shall be fabricated and erected where shown on the Drawings or as specified herein. Ductwork shall be rigidly supported and secured in an approved manner. Bracing and vibration isolators shall be installed, where necessary, to eliminate vibration, rattle and noise. Hangers shall be installed plumb and securely suspended from supplementary steel or inserts in concrete slabs. Lower ends of hanger rods shall be sufficiently threaded to allow for adequate vertical adjustment. Building siding and metal decking shall not be used to hang ductwork.

B. Wherever ducts are divided, the cross-sectional area shall be maintained. All such changes must be approved and installed as directed by the Engineer or as approved on shop or erection drawings.

C. During installation the open ends of ducts shall be closed to prevent debris and dirt from entering. Work shall be installed in accordance with the overall approved progress schedule and in cooperation with all other trades so there will be no delay to other trades.

D. The Drawings of the air ducts and air risers indicate the general location for installation of the ducts and risers. Should additional offsets or changes in direction be made, these changes must be considered in the original bid and shall be installed at no additional cost to the Owner.

E. All necessary allowances and provisions shall be made in the installation of the ducts for the structural conditions of the building. Ducts shall be transformed or divided as may be required. Wherever this is necessary, the cross-sectional area shall be maintained. All of these changes, however, must be approved and ducts installed as directed by the Engineer or as approved on shop or erection drawings.

F. The taper of all transformations shall be not more than 15 degrees.

G. Do not remove or alter factory installed duct reinforcing ribs except as required to accommodate duct alterations due to unexpected field conditions. Notify the Owners representative prior to starting any field modifications involving ductwork structural reinforcing members. Submit additional design calculations to demonstrate structural design integrity of ductwork and fittings requiring reinforcing modifications in the field.

H. No ductwork or components shall be shipped prior to complete resin cure.

3.02 DUCTWORK FITTINGS AND ACCESSORY ITEMS

A. Duct Elbows - Changes in direction and offsets shall be made in a gradual manner to facilitate streamline flow of air. All elbows shall have a centerline radius of not less than 1-1/2 times the width of the duct in the plane of the elbow. For rectangular ductwork where full radius elbows cannot be installed or abrupt elbows are shown, provide abrupt elbows equipped with shop-installed hollow, fiberglass air foil turning vanes. An access door shall be installed at each abrupt elbow, so located for easy access to turning vanes.

3.03 SUPPORTING OUTDOOR DUCTS

A. Performance Requirements

1. Delegated Design: Design FRP Duct supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

2. Structural Performance: Hangers and supports for FRP Duct shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
   a. See structural plans and specifications for wind load criteria.
   b. See structural plans and specifications for seismic load criteria.

3.04 QUALITY

A. All ductwork shall be free from pulsation, chatter, vibration or objectionable noise. After system is in operation, should these defects appear they shall be corrected by removing, replacing or reinforcing the work. Sound levels shall not exceed the minimum requirement as specified in ASHRAE 1980 Systems Volume, page 35.16, Table 23. No discreet tones will be allowed.

B. The maximum allowable leakage shall be 5 percent of air volume.

C. The Engineer reserves the right to reject acceptance of delivery of any or all pieces of equipment found upon inspection to have any or all of the following defects in the laminate:

1. Blisters
2. Chips
3. Crazing
4. Exposed glass
5. Cracks
6. Burned areas
7. Dry spots
8. Foreign matter
9. Surface porosity
10. Sharp discontinuity
11. Trapped air
12. Any item which does not satisfy the tolerances as specified.

3.05 CLEANING OF DUCTWORK

A. All ductwork, fans, outlets and other parts of the ductwork systems shall be maintained in a clean condition during installation.

B. Complete ductwork systems shall be cleaned prior to testing and air balancing. Cheese cloth shall be secured over all openings of the ductwork system for entrapment of dirt during the cleaning operation.

3.06 PAINTING

A. Louver blank-off panels and ductwork visible through louvers in exterior walls are to be painted black. Painting shall be performed under this Section and shall be as specified in Division 9.

3.07 TEST PORTS

A. Where shown on the Drawings and where required for testing and balancing instrument insertion ports shall be provided. Size and location of ports shall be coordinated with the Contractor performing air balancing. Ports shall be sealed with plastic snap lock plugs.

END OF SECTION 15895

SECTION 15899
PACKAGED OUTDOOR CENTRAL STATION AIR HANDLING UNITS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes packaged, outdoor, central-station air-handling units with the following components and accessories:

1. Direct-expansion cooling..
2. Economizer outdoor- and return-air damper section.
3. Integral, space temperature controls.

1.02 DEFINITIONS

A. Outdoor-Air Refrigerant Coil: Refrigerant coil in the outdoor-air stream to reject heat during cooling operations and to absorb heat during heating operations. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.

B. Outdoor-Air Refrigerant-Coil Fan: The outdoor-air refrigerant-coil fan in RTUs. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.

C. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, outdoor, central-station air-handling units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

D. Supply-Air Fan: The fan providing supply-air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

E. Supply-Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations and to reject heat (provide heating) during heating operations. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

1.03 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Conform to the requirements indicated on the structural (Drawing S001) and other Contract Documents, where applicable.

B. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.04 SUBMITTALS

A. Product Data: Include manufacturer's technical data for each RTU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and maintenance data.

E. Warranty.

1.05 QUALITY ASSURANCE

A. ARI Compliance:

1. Comply with ARI 210/240 and ARI 340/360 for testing and rating energy efficiencies for RTUs.
2. Comply with ARI 270 for testing and rating sound performance for RTUs.

B. ASHRAE Compliance:

1. Comply with ASHRAE 15 for refrigerant system safety.
2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
3. Comply with applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

D. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.

E. UL Compliance: Comply with UL 1995.

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.06 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of RTUs that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
2. Warranty Period for Gas Furnace Heat Exchangers: Manufacturer's standard, but not less than 10 years from date of Substantial Completion.
3. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than three years from date of Substantial Completion.

4. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Carrier Corporation.
2. McQuay International.
3. Trane; American Standard Companies, Inc.
4. YORK International Corporation.
5. AAON

2.02 CASING

A. Casing shall be insulated single wall construction.

B. Exterior Casing Material: Galvanized steel with factory-painted finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.

1. Exterior Casing Thickness: 0.0626 inch (1.6 mm) thick.

C. Casing Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

1. Materials: ASTM C 1071, Type I.
2. Thickness: 1 inch (25 mm).
3. Liner materials shall have air-stream surface coated with an erosion- and temperature-resistant coating or faced with a plain or coated fibrous mat or fabric.
4. Liner Adhesive: Comply with ASTM C 916, Type I.

D. Condensate Drain Pans: Formed sections of stainless -steel sheet, a minimum of 2 inches (50 mm) deep, and complying with ASHRAE 62.1-2004.

1. Double-Wall Construction: Fill space between walls with foam insulation and seal moisture tight.
2. Drain Connections: Threaded nipple both sides of drain pan.
3. Pan-Top Surface Coating: Corrosion-resistant compound.

E. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

2.03 FANS

A. Direct-Driven Supply-Air Fans: Double width, forward curved centrifugal; with permanently lubricated, motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and galvanized- or painted-steel fan scrolls.

B. Belt-Driven Supply-Air Fans: Double width, forward curved, centrifugal; with permanently lubricated, single-speed motor installed on an adjustable fan base resiliently mounted in the casing. Aluminum or painted-steel wheels, and galvanized- or painted-steel fan scrolls.

C. Condenser-Coil Fan: Propeller, mounted on shaft of permanently lubricated motor.

D. Fan Motor: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

2.04 COILS

A. Supply-Air Refrigerant Coil:

1. Copper-plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
3. Coil Split: Interlaced.
4. Stainless steel formed with pitch and drain connections complying with ASHRAE 62.1-2001.
5. Provide factory applied phenolic coating that will be compatible with the operating environment.

B. Outdoor-Air Refrigerant Coil:

1. Copper-plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
3. Provide factory applied phenolic coating that will be compatible with the operating environment.

2.05 REFRIGERANT CIRCUIT COMPONENTS

A. Number of Refrigerant Circuits: Two

B. Compressor: Hermetic, scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.

C. Refrigeration Specialties:

1. Refrigerant: R-407C or R-410A.
2. Expansion valve with replaceable thermostatic element.
3. Refrigerant filter/dryer.
4. Manual-reset high-pressure safety switch.
5. Automatic-reset low-pressure safety switch.
6. Minimum off-time relay.
7. Automatic-reset compressor motor thermal overload.
8. Brass service valves installed in compressor suction and liquid lines.

2.06 AIR FILTRATION

A. Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

1. Glass Fiber: Minimum 80 percent arrestance, and MERV 13.
2. Pleated: Minimum 80 percent arrestance, and MERV 13.

2.07 DAMPERS

A. Outdoor-Air Damper: Linked damper blades, for 0 to 100 percent outdoor air, with motorized damper.

B. Outdoor and Return-Air Mixing Dampers: opposed-blade, galvanized-steel dampers mechanically fastened to cadmium plated steel operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.

1. Damper Motor: Modulating with adjustable minimum position.
2. Relief-Air Damper: Gravity actuated or motorized, as required by ASHRAE/IESNA 90.1-2004, with bird screen and hood.

2.08 ELECTRICAL POWER CONNECTION

A. Provide for single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

2.09 CONTROLS

A. Control sequence of operation shall be as specified in Section 15950 HVAC Controls.

B. Basic Unit Controls:

1. Control-voltage transformer.

2. Wall-mounted thermostat or sensor with the following features:
   a. Heat-cool-off switch.
   b. Fan on-auto switch.
   c. Fan-speed switch.
   d. Automatic changeover.
   e. Adjustable deadband.
   f. Exposed set point.
   g. Exposed indication.
   h. Degree F indication.
   i. Unoccupied-period-override push button.
   j. Data entry and access port to input temperature set points, occupied and unoccupied periods, and output room temperature, supply-air temperature, operating mode, and status.
3. Remote Wall Mounted Annunciator Panel for Each Unit:
   a. Lights to indicate power on, cooling, heating, fan running, filter dirty, and unit alarm or failure.
   b. DDC controller or programmable timer and interface with HVAC instrumentation and control system.
   c. Digital display of outdoor-air temperature, supply-air temperature, return-air temperature, economizer damper position, indoor-air quality, and control parameters.

C. DDC Controller:

1. Controller shall have volatile-memory backup.
2. Safety Control Operation:
   a. Fire Alarm Control Panel Interface: Provide control interface to coordinate with operating sequence described in Division 16 Section Addressable Fire Alarm System – Systems Operational Description
3. Scheduled Operation: Occupied and unoccupied periods on seven 365-day clock with a minimum of two programmable periods per day.
4. Unoccupied Period:
   a. Heating Setback: 10 deg F. (5.6 deg C)
   b. Cooling Setback: 10 deg. F.
   c. Override Operation: Two hours.
5. Supply Fan Operation:
   a. Occupied Periods: Cycle fan to maintain space temperature.
   b. Unoccupied Periods: Cycle fan to maintain setback temperature.
6. Refrigerant Circuit Operation:
   a. Occupied Periods: Cycle or stage compressors to match compressor output to cooling load to maintain room temperature. Cycle condenser fans to maintain maximum hot-gas pressure.
   b. Unoccupied Periods: Compressors off.

7. Gas Furnace Operation:
   a. Occupied Periods: Modulate burner to maintain room temperature.
   b. Unoccupied Periods: Cycle burner to maintain setback temperature.

D. Interface Requirements for HVAC Instrumentation and Control System:

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
3. Provide BACnet or LonWorks compatible interface for central HVAC control workstation for the following:
   a. Adjusting set points.
   b. Monitoring supply fan start, stop, and operation.
   c. Inquiring data to include outdoor-air damper position, supply- and room-air temperature and humidity.
   d. Monitoring occupied and unoccupied operations.

2.10 ACCESSORIES

A. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. Outlet shall be energized even if the unit main disconnect is open.

B. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.

C. Coil guards of painted, galvanized-steel wire.

D. Hail guards of galvanized steel, painted to match casing.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." ARI Guideline B. Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Division 07 Section "Roof Accessories." Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.

B. Install wind and seismic restraints according to manufacturer's written instructions. Wind and seismically restrained vibration isolation roof-curb rails are specified in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

C. Install condensate drain, minimum connection size, with trap and indirect connection to nearest sanitary drain or area drain.

D. Duct installation requirements are specified in other Division 15 Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:

1. Connect supply ducts to RTUs with flexible duct connectors specified in Division 23 Section "Air Duct Accessories."
2. Install normal-weight, 3000-psi (20.7-MPa), compressive strength (28-day) concrete mix inside roof curb, 4 inches (100 mm)thick. Concrete, formwork, and reinforcement are specified in Division 03.

3.02 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing. Report results in writing.

B. Tests and Inspections:

1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
5. Remove and replace malfunctioning units and retest as specified above.

3.03 CLEANING AND ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site during other-than-normal occupancy hours for this purpose.

B. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

END OF SECTION 15899

SECTION 15910
DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Work specified in this Section is subject to the provisions of Section 15050.

B. Furnish and install ductwork accessories as necessary to install ductwork shown on the Contract Documents.

1.02 REFERENCES

A. This Specification references the latest edition of the publications listed below. Work shall be performed and materials shall be furnished in accordance with these publications where referenced herein:

1. Standard Mechanical Code.
2. Sheet Metal and Air Conditioning Contractor's National Association (SMACNA) Standards:
   a. HVAC Duct Construction Standards.
   b. Thermoplastic Duct (PV) Construction Manual.
   c. HVAC Systems Duct Design.
   d. Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems.
   e. Rectangular Industrial Duct Construction Standards.
   f. Round Industrial Duct Construction Standards.
3. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Standards:
   a. Equipment.
   b. HVAC Systems and Applications.
   c. Refrigeration.
   d. Fundamentals.
4. National Fire Protection Association (NFPA) Standards:
   a. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
   b. NFPA 90B - Warm Air Heating and Air Conditioning Systems.
5. Underwriter's Laboratories (UL) Standards:
   a. Factory Made Air Ducts and Connectors.
   b. UL 555 - Fire and Radiation Dampers.
   c. UL 555S - Leakage Rated Dampers for Use in Smoke Control Systems.

1.03 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions.

B. Submit product data on all ductwork accessories proposed for installation under this Section, including, but not limited to the following:

1. Air turning vanes.
2. Volume control dampers.
3. Backdraft dampers.
4. Spin-in collar fittings.
5. Flexible duct connectors.
6. Duct access doors.

C. Submittal data shall include catalog cuts, performance data, installation instructions and other information required to completely describe the proposed equipment and allow verification of conformance with the Specifications.

PART 2 - PRODUCTS

2.01 AIR TURNING DEVICES

A. Turning vanes shall be installed in all 90 degree square and rectangular elbows and at other locations shown. The turning vanes shall be double thickness type, with vanes secured to the runners and runners secured to the duct. Elbows in round ductwork and other radiused elbows shall have an inside radius equal to the diameter of the duct.

B. Splitters shall be made of the same thickness galvanized steel as the duct, 24 gauge minimum securely attached to a rod at the air leading edge and made of two thicknesses so the leading edge presents a round nose to air flow. Length shall be equal to 1-1/2 times the width of the smaller duct; 12-inch minimum.

2.02 VOLUME CONTROL DAMPERS

A. Single blade (up to 8-inches high), multi-blade (over 10-inches high), control damper.

B. Blades: Minimum 16 gauge galvanized steel, or extruded aluminum airfoil shape:

1. Pivot Rods: Steel, minimum ½-inch diameter or hex, 6-inches long. One rod extended to permit operation of damper from outside duct.
2. Maximum length 42-inches; maximum width 8-inches.
3. At Points of Contact, Except for Manual Balancing Application: Interlocking or overlapping edges, and compressible neoprene or extruded vinyl blade seals, designed for temperature of minimum 40 degrees F at specified leakage rate. In addition, hot and cold deck dampers, and dampers opening to the outside shall have compressible metal side seals.
4. Except for Manual Balancing Application, Leakage When Closed: Guaranteed less than 10 cfm per square foot at both 1-inch and 4-inches WG static pressure.
5. Opposed blade type for balancing and modulating applications, parallel blade type for 2-position applications.

C. Frames: Galvanized steel bar minimum 2-inches wide x 12 gauge for dampers 10-inches high or less, 3-1/2 x 7/8-inches, 16 gauge galvanized roll-formed channel with double thickness edges or 5 x 1 x 0.125-inch extruded aluminum channel for 11-inches high and larger.

1. Corner bracing.
2. Full size of duct or opening in which installed.

D. Bearings: Bronze sleeve, steel ball type, or Cycoloy 800.

1. Vertically Mounted: Thrust bearings.
2. Maximum Spacing: 42-inches.

E. Manually operated dampers shall be provided with cadmium-plated steel quadrant with device for locking damper in position.

2.03 BACKDRAFT DAMPERS

A. Heavy-duty damper with anti-leakage features, counter-balanced, parallel blade operation.

B. Operating Linkage: Factory assembled, steel construction.

C. Counterbalance Weight: Adjustable and mounted on the entering side. Not required on dampers located in ductwork on the discharge of fans.

D. Frame: 16 gauge galvanized 3-1/2-inch channel with 7/8-inch double thickness flanges and corner bracing. Top and bottom stops and blade end seals shall be provided with galvanized angles spot welded to frame and sealed with sealer. Face of angles shall have replaceable, compressible polyurethane or neoprene seals.

E. Blades: Minimum 14 gauge extruded aluminum with extruded vinyl seals locked into blade edges; maximum length 48-inches. Pivot rods shall be plated steel or molded synthetic thermoplastic, ½-inch diameter or hex.

2.04 FIRE DAMPERS

A. Fire dampers shall be installed at all locations where ductwork penetrates any floor wall or partition with a fire rating of two hours or more or where otherwise shown on the Drawings. Fire dampers shall have a rating compatible with the floor, wall, or partition and shall be classified and labeled in accordance with UL 555.

B. Fire dampers shall be of formed light gauge steel or metal box frame construction with the damper located out of the air stream when fully open.

C. Acceptable Manufacturers: Air Balance, Nailor-Hart, Prefco, Ruskin or Greenheck.

2.05 SPIN-IN-COLLAR FITTINGS

A. Complete with air scoop and manual damper with locking device, for round duct connection to supply duct. Spin-in collars shall be by the same manufacturer as the flexible duct and shall be provided for each flexible duct take-off.

2.06 FLEXIBLE DUCT CONNECTIONS

A. Flexible duct connections shall be non-combustible, installed at all belt-driven equipment and where shown. Material shall be glass fabric double coated with neoprene (30 ounces per square yard minimum).

B. Provide duct supports on each side of flexible connections.

C. Connections to kitchen exhaust fans shall be designed for continuous use at 300 degrees F without using asbestos and shall be designed for use with grease laden air.

D. Acceptable Manufacturers: Ventfabrics, Duro-Dyne (Adamson Company), Thermaflex or Frenzelit.

2.07 DUCT ACCESS DOORS

A. Furnish in ductwork as indicated and wherever necessary for proper access to all instruments, controls, fire dampers, motorized dampers and equipment and for convenient inspection, maintenance and replacement of same, size to be ample for usage. Openings shall be reinforced on all sides with material or ductwork in which doors are installed. Access doors shall have a minimum length of 8"

B. Two-piece pan construction, consisting of outer side crimped over inner dished side. Not less than two hinges and not less than two heavy cam latches. All contact surfaces of doors covered with heavy dense felt securely fastened in place to make doors air-tight.

C. Access doors to be insulated or soundproofed with same material as ducts or casings where located.

D. Coordinate the location of access doors above inaccessible ceilings with the Engineer.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All ductwork accessories shall be installed in strict accordance with manufacturer's recommendations.

B. Verify operation of dampers without binding of the linkage throughout entire operating range.

C. Install flexible duct connectors with fabric in the midpoint of flexible range when in the static condition. Verify that full extension or compression is not reached in the operating mode.

D. Verify duct access door installation allows adequate accessibility to the duct device intended for access.

END OF SECTION 15910

SECTION 15950
HVAC CONTROLS

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Work described in this Section includes furnishing all labor, materials, equipment, tools and incidentals required for complete and operable HVAC controls. Extent of electric control systems work required by this Section is indicated on Drawings and Schedules, and by requirements of this Section. Control sequences are specified in this Section.

B. Refer to other Division 15 Sections for installation of manual volume dampers in mechanical systems.

C. All work shall be in compliance with current editions of THE National Electrical Code and ASHRAE design standards.

D. Refer to Division 16 Sections for the following work:

E. Power supply wiring for power source to control panels, starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.

F. Furnish control and interlock wiring under this section between field installed controls, indicating devices, motorized damper operators and unit control panels in compliance with the requirements of Division 16.

G. Control panel enclosures, starters, and disconnect switches shall be furnished under this section in accordance with the requirements specified under Section 11400.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

1. Product Data. Manufacturer's technical product data for each control device furnished, indicating dimensions, capacities, performance characteristics, electrical characteristics, finishes of materials, and including installation instructions and start-up instructions.
2. Schematic flow diagram of system showing fans, dampers, and control devices.
3. Label each control device with setting or adjustable range of control.
4. Control interlock wiring diagrams. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
5. Details of faces of control panels, including controls, instruments, and labeling.
6. Written description of sequence of operation.
7. Wiring diagrams.
8. Operation and maintenance manuals.

1.03 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Only firms regularly engaged in the manufacture of electric control equipment of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years shall be eligible to provide and install the equipment specified herein.

B. Codes and Standards

1. Electrical Standards. Provide electrical products, which have been tested, listed and labeled by UL and comply with NEMA standards.
2. NEMA Compliance. Comply with NEMA standards pertaining to components and devices for electric control systems.
3. NFPA Compliance. Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.

1.04 QUALITY STANDARDS

A. Manufacturer. Subject to compliance with requirements, provide electric control systems of one of the following.

1. Barber-Colman Co.
2. Honeywell, Inc.
3. Johnson Controls, Inc.
4. Landis & Gyr Powers, Inc.
5. Robertshaw Controls Co.
6. Or equal.

1.05 DELIVERY, STORAGE AND HANDLING

A. Provide factory shipping cartons for each piece of equipment, and control device. Maintain cartons through shipping, storage and handling as required to prevent equipment damage, and to protect equipment from dirt and moisture. Store equipment and materials inside and in original shipping packaging.

PART 2 - PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. General. Provide electric control products in sizes and capacities indicated, consisting of dampers, thermostats, sensors, controllers, and other components as required for a complete installation. Except as otherwise indicated, provide manufacturer's standard control system components as indicated by published product information, designed and constructed as recommended by manufacturer. Provide electric control systems with the following functional and construction features as indicated.

B. Dampers. Provide automatic control low leakage dampers as indicated, with damper frames not less than formed 13-ga galvanized steel. Provide mounting holes for duct or louver mounting as required. Provide damper blades not less than formed 16-ga galvanized steel, with maximum blade width of 8". Equip dampers with motors, with proper rating for each application. Damper section widths shall not exceed 48 inches.

1. Secure blades to ½" diameter zinc-plated axles using zinc-plated hardware. Seal off against spring stainless steel blade bearings. Provide blade bearings of nylon and provide thrust bearings at each end of every blade. Construct blade linkage hardware of zinc plated steel and brass. Submit leakage and flow characteristics, plus size schedule for controlled dampers.
2. For standard applications as indicated, provide parallel or opposed blade design (as selected by manufacturer's sizing techniques) with optional closed-cell neoprene edging.
3. For outside air dampers applications as indicated, provide parallel or opposed blade design (as selected by manufacturer's sizing techniques) with inflatable seal blade edging, or replaceable rubber seals, rated for leakage at less than 10 cfm/sq. ft. of damper area, at differential pressure of 4" w.g. when damper is being held by torque of 50 inch-pounds.

C. Damper Motors. Size each electric damper motor to operate dampers or valves with sufficient reserve power to provide 2-position action as specified. Damper motors shall be suitable for 120-volt, single phase power and each motor shall be arranged to fail to its last position.

D. Room Thermostats. Provide room thermostats with locking covers, and with concealed or readily-accessible adjustment devices and dead band, as indicated.

1. Provide thermostats with spiral bimetallic thermometers.
2. Thermostats. Provide 24 VAC thermostats of the bimetal actuated open contact, or bellows actuated enclosed snap-switch type, or equivalent solid-state type. Thermostat shall be UL-listed at electrical rating comparable with application. Provide bimetal thermostats, which employ heat anticipation.
3. Thermostat for split system air-conditioning unit shall be by the unit manufacturer.

E. Electric Contactors. Provide contactors for operating or limit control of electric heating loads, which are UL-listed for 100,000 cycles of resistive loads. Equip with replaceable molded coils and replaceable silver cadmium oxide contacts. Coat core laminations with heat-resistant inorganic film to reduce core losses. Provide line and load terminals on contactors with higher-than-35-amp rating, or provide one-piece formed-and-welded pressure type. Provide screw-type contactors for 35-amp-or-lower rating. Equip field-mounted contactors with suitable steel enclosures; and provide open-type mounting for those installed in factory-fabricated panels.

F. Fan Switches: Provide fan switches where indicated on the Drawings. Switches shall be factory sealed, shall be rated 600 VAC heavy-duty and shall have indicating lights. Selector switches shall be two or three position as indicated on the Drawings:

1. START/STOP.
2. HAND/OFF/AUTO.

G. Control Wiring: All control, interlock and starting circuit wiring, except where otherwise specified or noted on the plans, are to be furnished under this Section. Line voltage wiring shall

not be smaller than #14, 600 volt wire. All wire shall be run in conduit with outlet boxes and fittings in compliance with the requirements of Division 16, Electrical.

1. 24 volt wiring shall be not less than #18 gauge, with 600 volt insulation. Wiring run in partitions or above ceilings shall be run in plenum rated cable.
2. Control voltage shall not exceed 120 volts. Provide transformers and relays to comply with this requirement.

PART 3 - EXECUTION

3.01 INSPECTION

A. Examine areas and conditions under which electric control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION OF ELECTRIC CONTROL SYSTEMS

A. General. Install systems and materials in accordance with manufacturer's instructions and roughing-in drawings, and details on drawings. Install electrical components and use electrical products complying with requirements of applicable Division 16 Sections of these Specifications. Mount controllers at convenient locations and heights.

B. Control Wiring. The term "control wiring" is defined to include provision of wire, conduit and miscellaneous materials as required for mounting and connecting electric control devices.

C. Wiring System. Install complete control wiring system for electric control systems. Conceal wiring, except in mechanical rooms and areas where other conduit and piping are exposed. Provide multi-conductor instrument harness (bundle) in place of single conductors where number of conductors can be run along common path. Fasten flexible conductors bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support conductors neatly.

D. Number-code or color-code conductors, excluding those used for local individual room controls, appropriately for future identification and servicing of control system.

3.03 ADJUSTING AND CLEANING

A. Start-Up. Start-up, test, and adjust electric control systems in presence of manufacturer's authorized representative. Demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

B. Cleaning. Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

C. Final Adjustment. After completion of installation, adjust thermostats, damper operators, motors and similar equipment provided as work of this Section. Final adjustment shall be performed by specially trained personnel in direct employ of the manufacturer of primary temperature control system.

3.04 CLOSEOUT PROCEDURES

A. City's Instructions. Provide services of manufacturer's technical representative for four hours to instruct City's personnel in operation and maintenance of electric control systems. Schedule instruction with Engineer, provide at least 7-days of notice to Contractor and Engineer for training date.

3.05 SEQUENCE OF OPERATION

A. Odor Control -Units OC-401 & OC-501

1. Refer to specification section 13150-10 for sequence of operation for odor control unit OC-401.
2. Refer to specification section 13150-11 for sequence of operation for odor control unit OC-501.

B. Diversion Building

1. Air Handling Units
   a. AH-301 & AH-302 will modulate according to a thermostat located in the space, AH-302 is a 100% redundant unit for AH-301 and at a loss of power to AH-301, a maintenance worker will energize AH-302 at which point the respective motor operated dampers located in the main ductwork will cycle to allow for air from the air handling unit to flow to the space. The unit supplier shall provide an enthalpy controller so when the outdoor air temperature is 55 or lower and the humidity level is 50% or lower the unit will enter the economizer cycle and when the outdoor conditions rise above these set points then the economizer cycle will cease and the compressor will be engaged.
2. Ventilation Exhaust Fans
   a. There are two (2) ventilation exhaust fans. The fans shall operate on a lead control basis. The lead fan shall be energized by a signal from the Process Control System. Once energized the fan shall run continuously until a signal from the Process Control System to de-energize. The second fan is a 100% Standby backup. Once air flow is verified by an air flow switch, a signal shall be transmitted to the Process Controls that the process pumps may be started On a loss of air flow from the Lead fan, verified by the air flow switch, the backup fan shall be energized. If the secondary fan air flow is not established, then a signal shall be transmitted to the process control system to shut down the process pump(s) and send and alarm annunciation to the Process Control Room.
3. Unit Heater
   a. The Process Control System shall transmit a signal to enable power to the Unit Heaters. The unit heaters shall be started and stopped by a unit mounted thermostat. The unit heaters shall shutdown by the unit mounted thermostat and/or a signal from the Process Control System

C. Jet Mix Building

1. Air Handling Units
   a. AH-701 & AH-702 will modulate according to a thermostat located in the space AH-702 is a 100% redundant unit for AH-701 and at a loss of power to ahu-701 a maintenance worker will energize AH-702 at which point the respective motor operated dampers

located in the main ductwork will cycle to allow for air from the air handling unit to flow to the space. The unit supplier shall provide an enthalpy controller so when the outdoor air temperature is 55 or lower and the humidity level is 50% or lower the unit will enter the economizer cycle and when the outdoor conditions rise above these set points then the economizer cycle will cease and the compressor will be engaged.

2. Exhaust Fans
   a. Toilet Exhaust : The toilet exhaust shall be controlled on-off by a room wall switch.
   b. Ventilation Fans : There are two (2) ventilation exhaust fans. The fans shall operate on a lead control basis. The lead fan shall be energized by a signal from the Process Control System. Once energized the fan shall run continuously until a signal from the Process Control System to de- energize. The second fan is a 100% Standby backup. Once air flow is verified by an air flow switch, a signal shall be transmitted to the Process Controls that the process pumps may be started on a loss of air flow from the Lead fan, verified by the air flow switch, the backup fan shall be energized. If the secondary fan air flow is not established, then a signal shall be transmitted to the process control system to shut down the process pump(s) and send an alarm annunciation to the Process Control Room.

3. Unit Heaters
   a. The Process Control System shall transmit a signal to enable power to the Unit Heaters.
   b. The unit heaters shall be started and stopped by a unit mounted thermostat. The unit heaters shall shutdown by the unit mounted thermostat and/or a signal from the Process Control System.

END OF SECTION 15950

SECTION 15990
TESTING, ADJUSTING AND BALANCING OF HVAC SYSTEMS

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Work described in this Section specifies the requirements and procedures for HVAC systems testing, adjusting and balancing. Requirements include measurement and establishment of the fluid quantities of the HVAC systems as required to meet design specifications, and recording and reporting the results.

B. The Contractor shall procure the services of an independent air balance and testing agency, who is a current member in good standing of the Associated Air Balance Council (AABC), approved by the Engineer and who specializes in the testing, balancing and adjusting of heating, ventilating and air conditioning systems. The agency shall be certified by the National Environmental Balancing Bureau (NEBB) in those testing and balancing disciplines required for this Project and having at least one Professional Engineer registered in the state in which the services are to be performed and certified by NEBB as a Test and Balance Engineer.

C. Test and balance all HVAC systems including the following:

1. Supply air systems, all pressure ranges including variable volume and double duct systems.
2. Return air systems.
3. Verify temperature control system operation.

D. Test systems for proper sound and vibration levels.

1. Related Work specified elsewhere: Section 15950 - HVAC Controls.

E. Definitions

1. Systems testing, adjusting and balancing is the process of checking and adjusting all the building environmental systems to produce the design objectives. It includes:
   a. The balance of air distribution.
   b. Adjustment of total system to provide design quantities.
   c. Electrical measurement.
   d. Verification of performance of all equipment and automatic controls.
   e. Sound and vibration measurement.
2. Test: To determine quantitative performance of equipment.
3. Adjust: To regulate the specified fluid flow rate and air patterns at the terminal equipment.
4. Balance: To proportion flows within the distribution system (submains, branches and terminals) according to specified design quantities.
5. Procedure: Standardized approach and execution of sequence of work operations to yield reproducible results.

6. Report forms: Test data sheets arranged for collecting data in logical order for submission and review. These data should also form the permanent record to be used as the basis for required future testing, adjusting and balancing.

7. Terminal: The point where the controlled fluid enters or leaves the distribution system. There are supply outlets on air terminals and exhaust or return inlets on air terminals such as registers, grilles, diffusers, louvers and hoods.

1.02 REFERENCES

A. This Specification references the latest edition of the publications listed below. Work shall be performed and materials shall be furnished in accordance with these publications as reference herein:

1. Associated Air Balance Council (AABC) Standards: National Standards for Total System Balance.

2. National Environmental Balancing Bureau (NEBB) Standards: Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.

3. Sheet Metal and Air Conditioning Contractor's National Association (SMACNA) Standards: HVAC Systems Testing, Adjusting and Balancing.

1.03 SUBMITTALS

A. Submittals shall be made in accordance with the General Condition of the Contract Documents. In addition, the following specific information shall be provided:

1. Submit testing agency's name for approval; include resume of at least ten similar projects including testing dates, project name, system description and contractor.

2. Name of certified Test and Balance Engineer assigned to supervise the procedure and the technicians proposed to perform the procedures.

3. Submit a synopsis of the testing, adjusting and balancing procedures and agenda proposed for the Project.

4. Maintenance and operating data that includes how to test, adjust and balance the building systems.

5. Copies of test reports intended for use.

B. Preconstruction Plan Check and Construction Review

1. The Contractor is to ensure that the testing agency is provided with up-to-date Contract Documents and all Contractor submittals related to the Work required by this Section.

2. Provide a preconstruction plan check in accordance with the procedure specified in the referenced standards. Submit a written report of the plan check to the Engineer for review prior to commencement of HVAC Systems installation.

3. Provide periodic construction review during the progress of related HVAC systems installation in accordance with the procedures specified in the referenced National Standards.

C. Pre-TAB Checklist: Prior to the Testing, Adjusting and Balancing (TAB) Work for any HVAC system, submit a completed AABC "Systems Ready to Balance Checklist" to the Engineer for records. The Contractor is to ensure that all work is complete and ready for TAB.

D. Certified Reports: Submit testing, adjusting and balancing reports bearing the seal and signature of the Test and Balance Engineer. The reports shall be certified proof that the systems have been tested, adjusted and balanced in accordance with referenced standards; are an accurate representation of how the systems have been installed; are a true representation of how the systems are operating at the completion of the testing, adjusting and balancing procedures; and are an accurate record of all final quantities measured, to establish normal operating values of the systems. Follow the procedures and format specified below:

1. Draft Reports: Upon completion of testing, adjusting and balancing procedures, prepare draft reports on the approved forms. Organize and format draft reports in the same manner specified for the final reports (drafts may be hand written). Submit 2 complete sets of draft reports. Only 1 complete set of draft reports will be returned.
2. Final Reports: Upon verification and approval of draft reports, prepare final reports, type written and organized and formatted as specified in Article 2.01. Submit 2 complete sets of final reports.
3. Calibration reports: Submit proof that all required instrumentation has been calibrated to tolerances specified in the referenced standards, within a period of six months prior to starting the Project.

1.04 QUALITY ASSURANCE

A. Reference Standards: Comply with all Federal and State laws or ordinances, as well as the latest edition of all applicable codes, standards, regulations and/or regulatory agency requirements including the partial listing below:

1. ASHRAE, American Society of Heating, Refrigerating and Air Conditioning Engineers - Fundamental Handbook, Ch. 13; System and Application Handbook, Ch. 57.
2. SMACNA, Sheet Metal and Air Conditioning Contractors' National Association - Testing, Balancing and Adjusting of Environmental Systems; HVAC Systems.
3. AABC, Associated Air Balance Council - National Standards for Total System Balance.
4. NEBB, National Environmental Balancing Bureau - Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems.

B. The testing agency shall be the single source of responsibility to test, adjust and balance the HVAC systems and produce the design objectives.

1.05 SEQUENCING AND SCHEDULING

A. Test, adjust and balance air-conditioning systems before refrigerant systems.

B. Test, adjust and balance air conditioning systems during summer season and heating systems during winter season, including at least a period of operation at outside conditions within 5o F wet bulb temperature of maximum summer design condition, and within 10oF dry bulb temperature of minimum winter design condition. Take final temperature readings during seasonal operation.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 REQUIRED DOCUMENTS

A. The Contractor shall provide the following, in a timely fashion, to the test and balance agency: Contract Drawings and applicable Specifications; addenda; change orders; reviewed shop drawings; reviewed equipment manufacturer's submittal data; and reviewed temperature control drawings.

3.02 COOPERATION

A. The Contractor shall cooperate fully with the test and balance agency and provide:

1. Completely operable systems.
2. The right to adjust the systems.
3. Access to system components.
4. Immediate labor and tools to make corrections and repairs, when required, without undue delay.
5. Balancing dampers as required by test and balance agency.

B. The Contractor shall start-up and maintain all heating, ventilating and air conditioning systems and equipment into full operation and shall continue the operation of same during each working day of testing and balancing. Start-up shall include, as a minimum, the following:

1. All equipment operable in safe and normal conditions.
2. Temperature control systems installed complete.
3. Proper thermal overload protection in place for electrical equipment.
4. Air Systems:
   a. Filters clean and in place.
   b. Duct systems clean of debris.
   c. Correct fan rotation.
   d. Fire and volume dampers in place and open.
   e. Coil fins cleaned and combed.
   f. Access doors closed and duct end caps in place.
   g. All outlets installed and connected.
   h. Duct systems leakage shall not exceed the rate specified.

C. If it is determined by the test and balance agency that drive changes are required, the Contractor shall obtain and install all necessary components.

D. The Test and Balance Agency shall cooperate with the Engineer and the Contractor to perform the work in such a manner as to meet the job schedule.

E. The test and balance agency shall leave all system components in proper working order, such as:

1. Replace belt guards.
2. Close access doors.
3. Close doors to electrical switch boxes.
4. Restore thermostats to specified settings.

F. All recorded data shall represent a true, actually measured or observed condition.

G. Any abnormal conditions in the mechanical systems of conditions, which prevent total system balance, as observed by the test and balance agency, shall be reported as quickly as possible to the Engineer.

3.03 PRELIMINARY PROCEDURES FOR AIR SYSTEM BALANCING

A. Before operating the system perform the following steps:

1. Obtain design drawings and specifications and become thoroughly acquainted with the design intent.
2. Obtain copies of approved shop drawings of all air handling equipment, outlets (supply, return and exhaust) and temperature control diagrams.
3. Compare design to installed equipment and field installations.
4. Walk the system from the system air handling equipment to terminal units to determine variations of installation from design.
5. Replace all system filters .
6. Check dampers (both volume and fire) for correct and locked position and temperature control for completeness of installation before starting fans.
7. Prepare report test sheets for both fans and outlets. Obtain manufacturer's outlet factors and recommended procedures for testing. Prepare a summation of required outlet volumes to permit a cross-check with required fan volumes.
8. Determine best locations in main and branch ductwork for most accurate duct traverses. Place outlet dampers in the full open position.
9. Prepare schematic diagrams of system "as-built" ductwork and piping layouts to facilitate reporting.

3.04 MEASUREMENTS

A. Provide all required instrumentation to obtain proper measurements, calibrated to the tolerances specified in the referenced standards. Instruments shall be properly maintained and protected against damage. Take all measurements in the system where best suited to the task.

1. Instruments shall meet the specifications of the referenced standards.
2. Use only those instruments, which have the maximum field measuring accuracy and are best suited to the function being measured.
3. Apply instrument as recommended by the manufacturer.

B. When averaging values, take a sufficient quantity of readings, which will result in a repeatability error of less than 5 percent. When measuring a single point, repeat readings until 2 consecutive identical values are obtained.

C. Take all readings with the eye at the level of the indicated value to prevent parallax.

D. Use pulsation dampeners where necessary to eliminate error involved in estimating averages of rapidly fluctuating readings.

3.05 TESTING, ADJUSTING AND BALANCING

A. Perform testing and balancing procedures on each system identified, in accordance with the detailed procedures outlined in the referenced standards.

1. Cut insulation, ductwork and piping for installation of test probes to the minimum extent possible to allow adequate performance of procedures.
2. Patch insulation, ductwork and housings using materials identical to those removed.
3. Seal ducts and piping, and test for and repair leaks. Seal insulation to re-establish integrity of the vapor barrier.
4. Mark equipment settings, including damper control position, valve indicators, fan speed control levers, and similar controls and devices, to show final settings. Mark with paint or other suitable, permanent identification materials.
5. Retest, adjust and balance systems subsequent to significant system modifications and resubmit test results.

B. Test and adjust mechanical systems for sound and vibration in accordance with the detailed instructions of the referenced standards.

C. Adjust all HVAC systems to deliver the specified air quantities within the following tolerances:

1. Equipment (fans, heat transfer equipment, and air terminal units): ±5%.
2. Air outlets: ±5%.

3.06 RECORD AND REPORT DATA

A. Record all data obtained during testing, adjusting and balancing in accordance with, and on the forms recommended by the referenced standards, and as approved on the sample report forms.

B. Prepare report of recommendations for correcting unsatisfactory performances when system cannot be successfully balanced.

3.07 DEMONSTRATION

A. Submit the final TAB report for review along with Contractor's completed checklist of recommendations for correcting unsatisfactory areas identified by testing agency.

B. Pre-test all systems prior to inspection and acceptance tests required by referenced standards. Provide detailed documentation of the referenced standard inspection tests by the Contractor and

include test procedures, participants, dates and times, instruments used, test data and a summation of test results. Submit test reports prior to system commissioning tests conducted by the City.

C. System Commissioning Tests

1. Tests shall demonstrate that capacities and general performance of air systems comply with Contract requirements.
2. At the time of system commissioning, recheck, in the presence of the Engineer, random selections of data (air quantities and air motion) recorded in the certified TAB test report.
3. Selections for checks in general will not exceed 25 percent of the total number tabulated in the report.

D. Train the City's maintenance personnel on troubleshooting procedures and testing, adjusting and balancing procedures. Review with the City personnel the information contained in the Operating and Maintenance Manual.

E. Schedule training with City with at least 7 days prior notice.

3.08 SERVICES

A. Retests: If random tests elicit a measured flow deviation exceeding the specified tolerances, the TAB report will automatically be rejected. In the event the report is rejected, readjust and test all systems, record new data, submit new certified Reports and perform new rechecks at no additional cost to the City; including time required by the Engineer.

B. Reinspection: TAB Agency shall make 2 return inspection trips to the project, one during heating design conditions and one during air conditioning design conditions for the purpose of checking out the entire system or group of systems.

C. Readjustments: Balancing agency shall make additional adjustments required during the reinspection.

END OF SECTION 15990

SECTION 15991
HVAC POWER VENTILATORS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes the following:

1. Centrifugal base-mounted ventilators.
2. Ceiling-mounted ventilators.
3. In-line centrifugal ventilators.

1.02 ACTION SUBMITTALS

A. Product Data:

1. Include rated capacities, furnished specialties, and accessories for each fan.
2. Certified fan performance curves with system operating conditions indicated.
3. Certified fan sound-power ratings.
4. Motor ratings and electrical characteristics, plus motor and electrical accessories.
5. Material thickness and finishes, including color charts.
6. Dampers, including housings, linkages, and operators.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Design Calculations: Calculate requirements for selecting seismic restraints.

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

B. Field quality-control reports.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For centrifugal fans to include in emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

C. UL Standard: Power ventilators shall comply with UL 705.

D. AMCA Compliance: Provide components that meet performance requirements and are licensed to use the AMCA seal.

PART 2 - PRODUCTS

2.01 CENTRIFUGAL BASE MOUNTED VENTILATORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide a product by one of the following:

1. Acme Engineering & Mfg. Corp.
2. New York Blower Company
3. Greenheck.
4. Loren Cook Company.
5. Penn Barry
6. Breidert

B. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

C. Housing: Removable, spun-aluminum, dome top and outlet baffle square, one-piece, aluminum base with venturi inlet cone.

1. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

D. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

E. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:

1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
4. Fan and motor isolated from exhaust airstream.

F. Accessories:

1. Disconnect Switch: Explosion-proof rated, nonfusible type, with thermal-overload protection mounted outside fan housing, factory wired through an internal aluminum conduit.
2. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.

2.02 MOUNTING VENTILATORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide or a product by one of the following:

1. Acme Engineering & Mfg. Corp.
2. Greenheck.
3. New York Blower Company.
4. Loren Cook Company.
5. Penn Barry.

B. Description: Centrifugal fans designed for installing in ceiling or wall or for concealed in-line applications.

C. Housing: Steel, lined with acoustical insulation.

D. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

E. Grille: Aluminum louvered grille with flange on intake and thumbscrew attachment to fan housing.

F. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

G. Accessories:

1. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
2. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
3. Filter: Washable aluminum to fit between fan and grille.
4. Isolation: Rubber-in-shear vibration isolators.
5. Manufacturer's standard roof jack or wall cap, and transition fittings.

2.03 IN-LINE CENTRIFUGAL VENTILATORS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Acme Engineering & Mfg. Corp.
2. Greenheck.
3. New York Blower Company.
4. Loren Cook Company.
5. Penn Barry.

B. Description: In-line, direct or belt driven centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.

C. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

D. Direct-Driven Units: Motor mounted in airstream, factory wired to an explosion-proof disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door.

E. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub, non-sparking.

F. Accessories:

1. Backdraft: Manufacturer provided gravity operated, located at fan outlet.
2. Companion Flanges: For inlet and outlet duct connections.
3. Fan Guards: 1/2- by 1-inch (13- by 25-mm) mesh of galvanized steel in removable frame. Provide OSHA approved guard for inlet or outlet for units not connected to ductwork
4. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

2.04 MOTORS

A. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

B. Enclosure Type: Totally enclosed, fan cooled and explosion-proof rated.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install power ventilators level and plumb.

B. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

C. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Division 07 Section "Roof Accessories" for installation of roof curbs.

D. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

E. Support suspended units from structure using threaded steel rods and spring hangers with vertical-limit stops having a static deflection of 1 inch (25 mm). Vibration-control devices are specified in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

F. Install units with clearances for service and maintenance.

G. Label units according to requirements specified in Division 15 Section "Identification for HVAC Piping and Equipment."

3.02 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 15 Section "Air Duct Accessories."

B. Ductwork adjacent to power ventilators shall be installed to allow service and maintenance.

C. Ground equipment according to Division 16 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 16 Section "Low-Voltage Electrical Power Conductors and Cables."

3.03 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation.
5. Adjust damper linkages for proper damper operation.
6. Verify lubrication for bearings and other moving parts.
7. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
8. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
9. Shut unit down and reconnect automatic temperature-control operators.

10. Remove and replace malfunctioning units and retest as specified above.

11. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Prepare test and inspection reports.

3.04 REDUNDANCY CONTROL

A. To be in compliance with the NFPA code 820 the exhaust fans for the Diversion and the Jet Mixing buildings must be operational while the pumps are in operation and to be assured of this, 100% redundancy has been provided for both of the buildings. The redundancy for the Diversion building was achieved through (2) wall mounted fans with gravity back draft dampers so that if on fan is de-energized the damper will close and the other fan will be energized and the damper will open, the fan selection will be done by the building control panel. For the Jet Mix building another type of fan had to be utilized and (2) fans were installed in a parallel fashion where the air flow is controlled by a normally closed motor operated damper interlocked with the fan motor, so that when the motor is energized the damper opens allowing air flow and conversely when the fan is de-energized.

END OF SECTION 15991

SECTION 15999
IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.

1.02 ACTION SUBMITTAL

A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.01 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: Aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
4. Fasteners: Stainless-steel rivets or self-tapping screws.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch Insert dimension thick, and having predrilled holes for attachment hardware.
2. Letter Color: Black.
3. Background Color: White.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for

greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

7. Fasteners: Stainless-steel rivets or self-tapping screws.

8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.02 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Red.

C. Background Color: Yellow.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.03 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches high.

PART 3 - EXECUTION

3.01 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.02 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.03 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Section 099100 "Painting."

B. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Pipe Label Color Schedule:

1. Domestic Water Piping:
   a. Background Color: Blue.
   b. Letter Color: White.
2. Sanitary Waste and Storm Drainage Piping:
   a. Background Color: Red.
   b. Letter Color: Black

3. Natural Gas:
   a. Background Color: Green.
   b. Letter Color: White
4. Maintenance facility service fluids:
   a. Background Color: Yellow.
   b. Letter Color: Black.

END OF SECTION 15999