Division 15

Mechanical

SECTION 15A

MECHANICAL EQUIPMENT

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MECHANICAL EQUIPMENT

1.0 SCOPE

This Specification Section includes furnishing, installing, testing and placing in operating condition all mechanical equipment and systems all as indicated on the drawings and described in the specification.

2.0 GENERAL

2.1 Work to be Provided

The Work to be provided shall consist of the following items:

.1 Four Ion Exchangers

.2 One Decarbonators

.3 One Aerator

.4 Two Settling Basins

.5 One Clarifier

.6 Three Gravity Filters

.7 Two Plate Filters

.8 Lime Feed System

.9 Ammonia Stripping and Feed System

.10 Coagulant Aid Feed System

.11 Carbon Dioxide System

.12 Ammonia Recovery System

.13 Compressed Air System

.14 Bulk Solids Conveyor

.15 Tanks

a. One (1) Product Water Storage Tank

b. One (1) Lime Slurry Tank

c. Two (2) Chemical Precipitators

d. One (1) Lime Silo

e. Three (3) Coagulant Aid Tanks

f. One (1) Backwash Water Storage Tank

g. One (1) Regenerant Day Tank

2.2 Codes and Standards

The Work shall conform to the latest edition and latest addenda thereto, as of the date of award, of the following codes and standards:

.1 American Society of Mechanical Engineers

Section VIII	Boiler and Pressure Vessel Code, Unfired Pressure Vessels
Section IX	Welding Qualifications

.2 American Water Works Association

D100-67	Steel Tanks-Standpipes, Reservoirs, and Elevated Tanks for Water Storage

.3 American Society for Testing and Materials

A36	Service Structural Steel
A516	Carbon Steel Plate for Pressure Vessels for Moderate Low Temperature

.4 U.S. Department of Health, Education and Welfare, Food and Drug Administration.

.5 Commonwealth of Pennsylvania Codes and Regulations

.6 Steel Structures Painting Council

2.3 Construction

.1 All equipment shall be of welded construction except as required for design.

The following equipment shall be in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII Unfired Pressure Vessels.

a. Ion Exchanger IE-1, IE-2, IE-3 and IE-4

b. Carbon Dioxide System

c. Ammonia Make-up System

All other equipment shall be in accordance with the AWWA D-100.

.2 Tank wall thickness shall in no case be less than 3/8 inch for tanks with a diameter of 8 ft. or larger, and not less than 5/16 inch for tanks of smaller diameters.

Corrosion allowance, where specified, shall be minimum 1/16 inch thickness added to the design thickness of shells, heads and nozzles.

Where required, nozzles shall be reinforced so that the attachment does not limit the test pressure of the tank, and also to withstand thermal loading from attached piping, sufficient to develop 50 percent of the allowable code pipe stress.

Individual requirements for tanks shall be as indicated on Drawings No.'s 2106 and 2107, Tank and Miscellaneous Details.

.3 Orientation and location of nozzles shall be as indicated on the drawings. Flanged nozzles shall be arranged so that bolt holes in flange straddle centerline of nozzle.

.4 Pipe support reinforcing pads shall be provided where required for pipe supports, anchors and guides for piping to be attached to the tank.

.5 Unless otherwise specified or indicated on the drawings, manways shall be minimum 18 inch O.D.

.6 Gooseneck type vent, and vent-overflow combinations, shall be provided with all tanks.

.7 Safety relief valves shall be provided as indicated. Safety relief valves shall be in conformance with the ASME Unfired Pressure Vessel Code, for gas and liquid service, and shall not be set at a pressure higher than the pressure for which the vessel is code stamped. The safety relief valves shall have code stamp.

.8 Horizontally mounted tanks shall be provided with supporting saddles. Saddles shall be drilled for anchor bolts suitable for concrete floor locations.

.9 Ladders shall be provided on outside of tanks as indicated on Drawings 2106 and 2107.

Rungs shall be minimum 3/4 inch diameter x 15 inch long and located on approximately 12 inch centers.

Stringers shall be minimum 3/8 inch x 2-1/2 inch.

Ladders shall be bolted with 3/4 inch bolts to tie-plates welded on tank.

.10 All surfaces shall be painted or coated as specified in Specification Section 9F - Finish Painting and Coatings unless specified under Materials of Construction.

3.0 DETAILED REQUIREMENTS

3.1 Ion Exchangers (Tag No. IE-1,2,3 & 4)

3.1.1 Design Conditions

Each ion exchangers shall be designed for a normal water upflow rate of 250 gpm during the exhaustion cycle and a normal downflow rate of 250 gpm during the regeneration cycle. Each vessel shall be 11 feet diameter and have a straight side wall of 13 feet. The ends of the tank shall be made with dished heads of proper radius. Each vessel shall be provided with two manholes, 12 in. by 18 in., one located at the bottom of the side wall and the other located in the top head of the vessel.

The tanks shall be designed for a working pressure of 75 psig at 70°F and a design pressure of 100 psig. The vessel shall conform to the requirements of Section VII of the ASME Boiler and Pressure Vessel Code. A code stamp is not required. The vessels shall be hydrostatic tested to 50% in excess of the design pressure.

3.1.2 Internal Construction

The internal construction of the ion exchangers shall consist of an underdrain, a middle regenerant distributor and an upper effluent collector. The underdrain shall be of the dished false bottom and strainer type. The strainers shall have venturi type slotted openings which prevent the entry of resin into the inner bottom.

The regenerant distributor shall be of the hub and lateral type and shall be located at the center of the straight side wall. The outlet collector shall be of the hub and lateral type. Each lateral shall be designed with the proper number of holes in each lateral and the number of laterals dependent upon proper pressure drop considerations. Each lateral shall be wrapped with wire mesh designed to prevent resin from escaping from the tank. Each collector shall be designed for a working pressure of 75 psig at 70°F and a design pressure of 100 psig.

3.1.3 Materials of Construction

The ion exchange vessel shell shall be constructed of intermediate tensile strength carbon steel plate conforming to ASTM-A516, Grade 55. The interior of the tanks shall be completely lined with a rubber lining not less than 3/16 in. thick. The lining shall be tested by means of a standard ASTM spark test at a minimum voltage of 10,000 volts.

The underdrain support plate shall be made of carbon steel and rubber covered. The strainers shall be made of Type 316 stainless steel. The regenerant distributor and the upper collector shall be made of stainless steel and wrapped with stainless steel wire mesh.

The exterior of the ion exchange vessels shall be painted in accordance with the requirements of Specification Section 9F, FINISH PAINTINGS AND COATINGS.

3.1.4 Ion Exchange Resin

Each ion exchanger shall contain 570 cu.ft. of resin. The resin shall be of the macrorecticular, weak base anion type containing tertiary amine functionality on a styrene-divinylbenzene matrix and conforming to the following requirements:

Ionic Form (as supplied)	Free Base
Shape	Spherical Particles
Moisture	50 to 58 percent after one exhaustion regeneration cycle
Density	38 to 42 lbs/cu.ft. after one exhaustion regeneration cycle
Shipping Weight	38 lbs/cu.ft.

Effective Size	0.40 to 0.50 mm.
Screen Grading	16 to 50 mesh, wet (U.S. Standard Screen)
Uniformity Coefficient	2.0 maximum
Fines Content	1.0 maximum through a 50 mesh U.S. Standard Screen
Swelling	Approximately 23 percent upon complete conversion from the free base to the chloride or sulfate form
Forms	37 to 40 percent

Total Exchange Capacity

a.	Volumetric	1.4 meq/ml minimum, as $CaCO_3$
b.	Weight	3.8 meq/g of dry resin min.

The resin shall be approved for use in the processing of potable water supplies by the U.S. Department of Health, Education and Welfare, Food and Drug Administration. The resin shall be IRA-93 manufactured by Rohm and Haas Company, Philadelphia, Pennsylvania,

3.2 Decarbonator (Tag No. DC-1)

3.2.1 Design Conditions

The decarbonator (DC-1) shall consist of a vertical open top cylindrical tank, 10 feet diameter by 35 feet high. The decarbonator shall be sized to have a 40 minute detention time at 475 gpm influent flow rate. The decarbonator shall be provided with a circumferential effluent weir, eight influent aeration nozzle assemblies, a safety ladder and platform; and other valves and appurtenances as specified herein and shown on the plans.

3.2.2 Influent Header

The inlet header shall consist of Class A pipe conforming to Section 15C, PIPING SYSTEMS for high pressure service under moderately corrosive conditions.

3.2.3 Influent Nozzle Assemblies

Each influent nozzle assembly shall consist of an ejector type jet pump, an air pipe and two butterfly valves. The ejectors shall be made of corrosion resistant bronze and shall have a 2-1/2 inch water inlet connection, a 4 inch air suction inlet connection, a 4 inch discharge pipe connection and a discharge nozzle section. Each ejector shall be capable of drawing 6 scfm of air when supplied with 95 gpm of water at an inlet pressure of 57 psig and a back pressure of 15 psig. Ejectors shall be Penberthy Model 190A or equal.

Air piping shall conform to the requirements specified in Specification Section 15C, PIPING SYSTEMS of this specification, for low pressure service under moderately corrosive conditions. Air piping shall be secured to the tank walls.

Valves shall be tight closing butterfly valves with manual handwheel operators for insertion between flanges. Valves shall conform to Section 15C, PIPING SYSTEMS for low pressure service under moderately corrosive conditions. Air piping shall be secured to the tank walls.

3.2.4 **Effluent Assembly**

The effluent assembly shall consist of a circumferential collection channel, adjustable weir plates and effluent piping terminating in a flanged nozzle as shown on the plans. The collection channel and weir plates shall be made of steel plate, 1/4 inch thick, conforming to ASTM A-36. The weir plates shall be notched as shown on the drawings.

3.2.5 Miscellaneous Accessories

The decarbonator tank shall be equipped with a safety ladder conforming to the requirements specified herein. A walkway consisting of supporting beams, steel grating and galvanized iron hand railing shall be furnished over the top of the tank. The walkway shall conform to Section 5A, MISCELLANEOUS METAL AND EMBEDDED STEEL.

3.2.6 Coating and Lining

The interior of the decarbonator including the circumferential collection weir channel shall be completely lined with a rubber lining not less than 3/16 inch thick. The lining shall be tested by means of a standard ASTM spark test at a minimum voltage of 10,000 volts. The exterior side of the tank, platform and safety ladder shall be painted in accordance with Section 9F, FINISH PAINTING AND COATINGS.

3.3 Aerator (Tag No. AR-1)

3.3.1 Design Conditions

The aerator shall be of the forced draft, counter current flow design, consisting of an inlet chamber, an aeration chamber, a storage and seal tank, and a forced draft fan. The aerator shall be suitable for mounting on a concrete base as shown on the drawings. The entire unit shall be of rectangular design, fully enclosed, with one hinged side to permit access for cleaning and maintenance.

3.3.2 Inlet Chamber

The inlet chamber shall provide means for distributing the flow evenly over the entire cross section of the aerator and for separating moisture from the air before discharging the air to the atmosphere. An air seal shall be provided on the water inlet. The distribution of flow shall be by means of spray nozzles.

3.3.3 Aeration Chamber

The aeration chamber shall have an effective cross section of not less than 36 sq.ft.and a height of not less than 16 ft. The chamber shall be filled with staggered slat trays spaced 6 inches on centers vertically. Alternate trays shall have slats running perpendicular to each other, and slats running in the same direction shall be staggered.

3.3.4 Storage Tank and Seal

A storage tank 30 inches deep and of the same cross section as the aeration chamber shall be provided below the aeration chamber. The storage tank shall contain an overflow weir to maintain an air seal of 6 inches over the end of the outlet pipe from the aeration chamber.

3.3.5 Forced Draft Blower

A motor driven blower shall be provided with the aerator. The blower shall be suitable for mounting on the aerator and shall have a capacity of not less than 500 scfm at a pressure of 4 inches of water.

3.3.6 Materials of Construction

The sides and top of the aerator shall be constructed of corrugated fiberglass. Each side panel should be removable with the three remaining sides remaining in place.

All supports and framing shall be constructed of red wood except for gusset plates which will be constructed of marine plywood.

The header laterals shall be constructed of fiberglass. The packing shall consist of 1"x2" redwood slats staggered with 7/8" spaces between the slats and staggered trays.

3.4 Settling Basins (Tag No. BS-1,2)

3.4.1 Design Conditions

The settling basins shall be 40 feet in diameter with a 8 ft. flooded water depth. The units shall be designed for a flow rate of 475 gpm per unit resulting in a rise rate, computed in the clarified water zone immediately below the effluent collector system, not exceeding 0.4 gpm per square foot per unit. The minimum detention time at the design flow rate shall be 150 minutes per unit.

The basin bottom shall have a slope of not less than 1 inch in 12 inches, sloping toward the center sludge sump.

3.4.2 Operation

The basins shall be equipped with an inlet wall, a settling zone and a sludge collection and removal system, all within a single circular tank. Treatment chemicals will be added to the influent water line external to the settling basins. The inlfuent water and treatment chemicals will enter the settling basin through an inlet water well. The water shall flow downward into the settling zone. In the settling zone, the clear water will move upward to the effluent collection system. The settled sludge will flow downward to the sludge collection and discharge system.

3.4.3 Effluent Collector

The effluent collector shall be of the open top rectangular flume type with submerged orifices on both sides of the flume providing for free discharge into the flume at the designed flow rate with a 4 inch head loss.

3.4.4 Sludge Removal System

The sludge removal system shall consist of the following components: 1) a sludge scrapper mechanism complete with motor, gear reducer, bearings, scrapper shaft, scrapper arms and blades; 2) a 4-inch diameter motor operated sludge blowoff valve and a frequency duration timer to allow variation of sludge blowoff rate by varing the percent of time that the valve is open; and 3) a 4 inch diameter motor operated flush valve connected to the service water system and a frequency duration timer.

3.4.5 Sampling Stations

Connections, fittings and cocks shall be provided at not less than three (3) sample points for determining the level of sludge in the sedimentation zone. All sample points shall terminate at a single location outside the tank.

3.4.6 Walkway

A walkway shall be installed spanning each tank. The scraper assembly shall be suspended from this walkway. The walkway shall consist of two parallel steel beams supporting a 3/16 in. checkered floor plate 36 inches wide. A 42 inch high handrailing consisting of double rows of horizontal pipe 1-1/4 inch diameter shall be provided. Plate and railings shall extend from one side of the tank to beyond the center of the tank to permit access to all mechanical parts. An access ladder with safety cage shall be provided on each basin at the point where the tank side wall meets the walkway.

3.4.7 Materials of Construction

The tank side wall shall be constructed of 1/4 inch thick steel plate, ASTM A283, properly stiffened at the top with suitable structured reinforcement. The internal construction shall be of 1/4 inch thick steel plate ASTM A283.

The tank bottom and sludge sump shall be constructed of reinforced concrete in accordance with Section 3A, CONCRETE. The bottom course of the shell shall be attached to a structural steel channel embedded in the concrete base.

The manufacturer is to furnish all valves and face piping necessary for proper operation in accordance with Specification Section 15C, PIPING SYSTEMS of this specification. Prior to shipment all surfaces are to be cleaned and coated in accordance with Specification Section 9F- Finish Painting and Coatings.

3.5 Clarifier (Tag No. SF-1)

3.5.1 Design Conditions

The clarifier shall consist of a steel tank, with interior steel partitions dividing the tank into a mixing zone, a flocculating zone and a sedimentation zone, a sludge recirculation drive and turbine, a sludge scraper, drive and mechanism, a walkway providing access to the turbine and scraper drives, a backflushing and desludging system, effluent collectors and chemical solution and sampling lines.

10" per bags

The 8 inch influent and 10 inch effluent nozzles shall be of the flanged type. The tank shall have a 4 inch overflow located approximately 3 inches above the top of the effluent flume. The nozzle for the desludging system shall be 4 inches in diameter.

The clarifier shall be designed for a flow of 475 gpm. The rise rate immediately under the effluent collectors shall not exceed 1.0 gpm per square foot. At this flow, the clarifier shall provide a total detention time of 90 minutes.

The clarifier tank shall have an overall diameter of not more than 26 feet and sidewater depth of 13 feet with 1-foot freeboard. The tank bottom shall have a slope of not less than 1 in 12, sloping toward a center sludge sump. Sludge shall be raked inward to a central sludge sump.

The drive unit shall be equipped with two (2) motors coupled to a suitable speed reducer, so that the recirculator may be operated with infinite variations over a four (4) to one (1) surge. The unit shall come complete with bearings, gears, shafts and turbine type recirculator impeller.

3.5.2 Desludging System

The desludging system shall consist of the following components: 1) sludge scraper mechanism with motor, gear, reducer, chain drive, bearings, scraper shaft, arms, and blades; 2) sludge sump, centrally located in the bottom of the softener; 3) a 4 inch diameter motor operated desludging valve and a frequency duration timer to allow variation of desludging rate by adjusting the percent of time the valve is open; and 4) a 4 inch diameter motor operated flush valve, connected to the service water system, and a frequency duration timer.

3.5.3 Effluent Collector

The effluent collector shall be of the open-top rectangular flume type with submerged orifices on both side of the flume providing for free discharge into the flume at the designed flow rate with a 4 inch loss of head.

3.5.4 Chemical Solution Lines

The clarifier shall include three (3) chemical solution lines from the outside tank wall to the point of application within the tank. The lines shall not be less than one (1) inch in diameter steel pipe.

3.5.5 Sampling Pipes

Piping, fittings, connections and cocks shall be provided for not less than five (5) sampling lines for determining the sludge level and concentration in the mixing, flocculation and sedimentation zones. All sampling lines shall be brought outside the tank wall and shall terminate at a single location. All sample lines shall be 1/2 inch in diameter.

3.5.6 Walkway

A walkway shall be installed spanning the tank. The scraper and recirculation assemblies shall be suspended from this walkway. The walkway shall consist of two parallel steel beams supporting a 3/16 inch checkered floor plate 36 inches wide. A 42 inch high handrailing consisting of double rows of horizontal pipe 1-1/4 inches in diameter shall be provided. Plate and railings shall extend from one side of the tank to beyond the center of the tank to permit access to all mechanical parts. An access ladder with a safety cage shall be provided at the point where the tank side wall meets the walkway.

3.5.7 Materials of Construction

The clarifier shall consist of the following:

.1 Tank sidewalls: 1/4 inch thick steel plate, ASTM A-283, properly stiffened at the top with suitable structural reinforcement.

.2 Tank internals: 3/16 inch thick steel plate ASTM A-283, except for structural members which shall be 1/4 inch thick steel plate (ASTM A-A36)

.3 Tank bottom and sludge sump shall be reinforced concrete in accordance with Section 3A, CONCRETE.

.4 The bottom course of the shell shall be attached to a structural steel channel embedded in the concrete bottom.

The manufacturer shall furnish all valves and face piping necessary for proper operation in accordance with Section 15C, PIPING SYSTEMS. Shop and finish painting of the surfaces shall be in accordance with Section 9F, FINISH PAINTING AND COATINGS.

3.6 Gravity Filters (Tag No. FT-1,2 & 3)

3.6.1 Design Conditions

Gravity flow, dual media filters shall consist of open steel tanks containing a false bottom underdrain system, filter media consisting of sand and anthracite, nozzles for filter influent and effluent and for air scour inlet.

All valves, controllers, air scour blower, and instrumentation shall be provided in accordance with Section 17A, INSTRUMENTATION.

3.6.2 Design Capacity and Dimensions

Each filter shall be 10'-0" high. The design service rate shall be 3 gpm per square foot of filter area for each filter. The total design flow for two (2) units shall be 475 gpm. The maximum backwash rate will be 15 gpm/sq. ft. The influent and effluent nozzles shall be 10 inch diameter flanged connections, while the air scour inlet nozzle shall be a 4 inch diameter flanged connection.

3.6.3 Wash-Water Collectors

The wash water collectors shall be semicircular in cross section. They shall be arranged so that the flow from any point in the filter surface will not have to travel more than three (3) feet in the horizontal direction and shall be so sized so that at a backwash rate of 20 gpm per sq. ft., the water will flow freely over the weir edges of the collectors. The collectors shall be set to provide a minimum of a 12 inch clearance from the collector bottom for a 50 percent expansion of the filter media. The overflow weirs shall have an adjustable edge for leveling of the weirs to insure the uniform distribution of the wash water over the surface of the filter.

3.6.4 Underdrain System

The underdrain system shall be of the perforated false bottom and strainer type. The strainers shall be of the one-piece stainless steel non-corrodible construction with venture-type slotted opening which will prevent the entry of filter media into the inner bottom during filtration and will be self cleaning during backwash. The strainers shall be designed for use with air scour during the backwash. They shall be arranged in a square pattern not more than nine inches on centers.

The false bottom shall be adequately stiffened by the addition of supports placed between the false bottom and the floor of the tank. The supports shall be designed to keep the false bottom from collapsing inward during filtration and from moving upward during the backwash operation.

A manhole shall be located in the side of the filter tank to provide access to the false bottom compartment.

3.6.5 Filter Media

The filter media shall consist of a 12 inch layer of filter sand and a 24 inch layer of anthracite. The filter media shall meet the following requirements:

.1 Sand shall have an effective size of 0.4-0.5 mm and a uniformity coefficient of not more than 1.6. It shall consist of hard durable and uncoated grains, either sharp or round and shall contain a total of not more than 5 percent flat particles and not more than 1 percent of clay, loam, dust and other foreign matter. A 2-gram sample crushed to pass a 50 mesh screen and digested without stirring in 10 ml of 40 percent hydrochloric acid at 65° to 75°F for 24 hours shall not show a loss of weight greater than 8.5 percent.

.2 Anthracite shall have an effective size of 0.85-0.95 mm and a uniformity coefficient of not more than 1.85. It shall be clean, hard, durable, free from long thin or scaly pieces, free from iron sulfites, clay and dirt. It shall have less than 1 percent dust, and shall be insoluble in acid and caustic. The hardness of the anthracite on the Mohs scale shall be in the range of 3.0 to 3.75. The specific gravity shall not be less than 1.55.

3.6.6 Materials of Construction

The tank shall be constructed of carbon steel plate conforming to ASTM A-36 with a minimum thickness of 1/4 inch. The tank is to be complete with adequate stiffening members, flanged nozzle connections (10" diameter influent and effluent connections and a 4" diameter air scour connection), and drain connections as shown on the drawings. All seams in the outer tank are to be butt welded and water-tight.

Shop and finish painting of all surfaces shall be in accordance with Section 9F, FINISH PAINTING AND COATINGS.

3.7 Plate Filters (Tag No. FT-4 & 5

3.7.1 Design Conditions

The plate and frame type filters shall be designed for a maximum filtering pressure of 75 psi and shall have a total filter area of approximately 150 sq. ft.
plates each.

The filter units shall be furnished complete with double acting hydraulic cylinder, motor operated shuttle shifter and push-pull rod control. Filters shall be Shriver Model 150-3 or approved equal.

3.7.2 Filter Plates

Six filter plates each having an effective filtering area of 25 sq. ft. shall be provided for each filter. The plates shall be of the double corner feed, closed discharge, and washing type and shall be made of cast iron. The plates shall be provided with Teflon impregnated asbestos sealing gaskets and with polypropylene filter cloth with propylene back up sheets caulked in place with polypropylene. The recess of each plate shall be 1-1/2 inches.

3.7.3 Shifter

Each filter shall be provided with a double acting hydraulic cylinder, motor operated shuttle shifter and push-pull rod control. The hydraulic pumping unit shall include a 1-1/2 HP (max.), 220/440 volt, 3 phase, 60 cycle motor.

3.8 Lime Slurry Feed System

3.8.1 Design Requirements

Lime slurry feed system shall supply lime to the Chemical Precipitators (CP-1 and CP-2) and to the High Rate Clarifier (SF-1).

3.8.1.1 Lime Silo (Tag No. TK-7)

A storage tank shall be provided for storing 80 tons of pebble limestone. The tank shall be 12 ft. in diameter by 25 ft. 6 inches in height. The bottom of the tank shall be sloped inwardly at an angle of 35° with the horizontal to the 24 inch diameter exit nozzle. The tank shall have a closed top which shall be fitted with a 4 inch lime fill nozzle and a 12 inch vent nozzle. The tank shall be constructed using carbon steel plate ASTM A-283.

3.8.1.2 Lime Feeder (Tag No. LF-1)

Contractor shall furnish a weigh-belt, scale beam gravimetric feeder with an adjustable electric gate control. The feed section shall be completely enclosed and dust tight. The feeder control shall have a variable speed drive so that the belt speed may be varied. The feeder shall be designed for a maximum feed rate of 1000 lbs per min. and for a minimum feed rate of 0.05 lbs per min. The feed rate shall be maintained with ±1% of set rate over a 10 to 1 range.

The feeder frame and deck shall be made of cast aluminum, feed section and feed gate shall be stainless steel, dust covers shall be mild steel, and belt shall be reinforced Buna-N rubber, 9" to 10" wide.

The feeder shall be Wallace & Tiernan Inc. Model G-100, BIF Model 37-15 or approved equal.

3.8.1.3 Hopper, Vibrator, Slide Gate and Flexible Connection

All necessary hoppers shall be furnished to fit between the lime silo (TK-7) and the gravimetric feeder. The hopper shall be made of carbon steel conforming to ASTM A-36.

An electrically operated vibrator on the converging hopper shall be furnished. The vibrator shall come complete with a timing mechanism so that the interval between operations and the time of each operation may be varied.

A slide gate valve shall be provided at the bottom of the converging hopper so that the flow of lime from the silo to the gravimetric feeder may be stopped. The slide gate shall be made of stainless steel.

A flexible type connection piece shall be furnished and installed between the slide gate discharge and the gravimetric feeder inlet. This flexible connection shall be made of rubber.

3.8.1.4 Lime Slaker

The lime slaker shall be of the pug mill or paste type with a fully automatic system for controlling the slaking water. The unit shall be capable of producing a maximum of 1000 pounds of quicklime per hour. The detention time at this flow rate shall be 5 minutes.

The slaker shall be complete with grit removal system and dust arresting sprays.

The slaker shall be fabricated of carbon steel. The mixing paddles shall be made of abrasion-resistant materials. Lime feeder and slaker shall be product of same manufacturer. Slaker shall be Wallace & Tiernan Model A-758. BIF Model 42-01 approved equal.

3.8.2 Lime Slurry Tank (Tag No. TK-2)

The lime slurry tank with a capacity of 5000 gallons, shall be 8 ft. in diameter with a 13 ft. straight side and a 120° included angle cone which has a depth of 28 inches. The tank shall have an open top. The exit nozzle shall be 3 inches in diameter.

The tank shall be fitted with four baffles each located 90° apart. Each baffle plate shall be 12 inches wide by 12 feet long and shall be mounted on the inside circumference of the tank.

The tank and baffles shall be constructed of carbon steel conforming to ASTM A-283.

The tank shall be equipped with a mixer. The mixer shall be of the top entering type and shall be supported by braces placed across the top of the slurry tank. The mixer shall be driven by a 2 hp, 230/460 volt, 3 phase motor. The mixer shaft shall be 2-1/2 inches in diameter and extend 168 inches below the mounting surface. Two impellers of the axial flow turbine type shall be mounted on the mixer shaft. Each impeller shall have a diameter of 46 inches.

3.8.3 Pumps

Lime Slurry Pump, P-10 and Lime Slurry Feed Pumps P-11 and P-12 shall be furnished by the supplier of the lime feed system. Detailed description of these pumps are given in Section 15B, PROCESS PUMPS.

3.9 Coagulant Aid Feed System

Coagulant Aid Feed System shall be a complete system for feeding coagulating aids to the settling basins (BS-1 and BS-2) and to the High Rate Clarifier (SF-1).

3.9.1 Design Conditions

3.9.1.1 Coagulant Aid Feed Pumps (Tag No. P-13 & P-22)

The two (2) chemical proportioning diaphragm pumps shall be fully adjustable over a 10:1 range by manually changing belt pulley positions and by varying the length of stoke. The units shall be rated for 20 gph at a discharge pressure of 125 psig. For detailed requirements see Section 15B PROCESS PUMPS.

3.9.1.2 Chemical Solution Tanks (Tag No. TK-3A, 3B &C)

The three (3) chemical solution tanks each having a capacity of 170 gallons shall be 3 ft. in diameter by 4 ft. high and shall be made of fiberglass, corrosion resistant plastic or plastic-lined steel. Each tank shall have a open top and shall come with a one-inch nozzle located as close to the bottom of the tank as possible. Each nozzle shall be equipped with a 1 inch quick disconnect fitting.

3.9.1.3 Mixers

Each solution tank shall be equipped with a clamp mounted, gear drive, portable mixer having a single marine propeller type impeller with a shaft length of 36 inches. Each motor shall have a maximum of 1/3 HP and a speed of 1750 rpm. The impeller rpm shall be 350 rpm.

3.10 Carbon Dioxide System

The liquid carbon dioxide storage system shall be furnished with refrigeration compressor and a gaseous carbon dioxide feed system complete with vaporizer.

3.10.1 Design Requirements

3.10.1.1 Storage Tank (Tag No. TK-8)

The storage tank shall be designed with a storage capacity of 24 tons of liquid carbon dioxide at a pressure of 300 psig and a temperature of $0^{o}F$. The tank shall have a diameter of not less than 6.5 ft. and shall be equipped with the following connections:

a. One 1-1/2" liquid fill connection

b. One 1" pressure equalizing connection

c. Three 1-1/2" liquid supply connections

d. One 1" vapor supply connection

e. One 1-1/2" vaporizer return connection

f. One 3" safety valve connection

g. Inlet and outlet connection for the refrigeration coil.

The tank shall be constructed in accordance with the ASME code for unfired pressure vessels, using a working pressure of 400 psig. Carbon steel plate conforming to the requirements of ASTM A516, Grade 55, having a minimum tensile strength of 55,000 psi shall be used to fabricate the vessel.

3.10.1.2 Refrigeration Unit and Coils

The refrigeration unit shall be capable of maintaining 24 tons of liquid carbon dioxide at $0^{o}F$ with a pressure of 300 psig in the storage tank. The compressor for the refrigeration unit shall be 5 HP using 240/480 V 3Ø - 60 cy electric power.

The storage tank shall be fabricated with cooling coils running length wise through the tank near the top to insure that the coils are located in the vapor space.

3.10.1.3 Insulation and Outer Shell

A minimum 4 inch thick, formed-in-place polyurethane insulation shall be used.

The outer shell of the tank unit shall be made of epoxy resin impregnated fiberglass and shall be fitted over the insulation.

3.10.1.4 Instrumentation and Alarms

The storage tank unit shall be equipped with a 0-600 psi gauge and a level gauge calibrated to read in pounds.

The tank shall also be equipped with a pressure switch which will cause the compressor to operate whenever the pressure in the tank has been reduced to approximately 295 psig and stops the compressor whenever the pressure in the tank has reached to approximately 305 psig.

A 120V-50/60 cy alarm bell and pressure switch shall also be included to signal pressure in excess of 325 psig or below 275 psig.

3.10.1.5 Safety Relief Valves

The primary relief shall be a 3" safety pop valve set at 350 psig.

Secondary relief shall be furnished by a bleed type relief valve set to start bleeding at 340 psig to furnish self-refrigeration in case of temporary mechanical refrigeration shut-down.

3.10.1.6 Vaporizer

Two (2) electrically operated vaporizers shall be provided. They shall be constructed of the same materials and provided with the same insulation as the storage tank.

Each evaporator unit shall be capable of producing 450 lbs/hr of carbon dioxide gas from liquid at 300 psig and at that rate shall not require more the 25 amps at 480 volts.

Each vaporizer shall have a 1-1/2" liquid inlet connection, a 1-1/2" vapor outlet connection, and a purge valve for easy removal of accumulated impurities.

The safety controls for each vaporizer shall be as follows:

a. A 450 psig safety relief valve

b. A fuse in control circuit for coil protection

3.11 Ammonia Recovery System (Tag No. AS-1)

.1 The ammonia recovery system shall consist of the following equipment:

Reboiler
Preheater
Distillation Column
Instruments and Controls
Condenser
Distillate Collection Tank
Piping and valves
Pumps

The ammonia recovery system from the outlet of the feed tank (TK-4) to the inlet to the regenerant day tank (TK-6) shall be the product of a single manufacturer, who shall assume full responsibility for the design, operation and performance of the system. The system shall be fully instrumented and supplied with a self contained instrument and control panel conforming to the general requirement of Section 17A - Instrumentation. In addition, alarm functions as specified herein shall be displayed on the main annunciator panel.

3.11.2 Process Description

Waste ammonia filtrate from the ammonia feed tank (TK 4) will be pumped by an ammonia recovery system feed pump through a preheater into a distillation column of the sieve tray type. The concentrated ammonia vapor from the top of the distillation column will be condensed in a condenser and discharged by gravity into a collection tank. A distillate pump will deliver distillate to the ammonia regenerant day tank (TK 6) and can also serve to reflux distillate to improve the operating efficiency of the system.

The bottom liquor from the distillation column will flow by gravity to the reboiler, where a portion of the flow is vaporized to serve as heat input into the distillation column. Excess liquor flows over a waste weir and is pumped through the shell of the preheater to final disposal by discharge into Hawk Run.

3.11.3 Design Condition

The ammonia recovery system shall have the capacity to treat 30,000 gallons per day of 1.5 percent by weight ammonia solution saturated with calcium sulfate. Other salts may be present but not in significant quantities. The waste liquor discharged to Hawk Run shall not contain more than 50 mg/l of ammonia. The recovered ammonia solution shall contain not less than 15 percent by weight of ammonia as NH_3.

The ammonia recovery system will be supplied with the following services:

Cooling water - 200 gpm at 85°F max.
Steam - 31,200 lb per day at 10 psig
Service water - 5 gpm at 60 psi
Electric power - 100 amp 480 V 3 ph 60 cy
Compressed air - instrument operation only

3.11.4 Instrumentation and Controls

All instrumentation and controls, accessories and appurtenances necessary to provide for safe, efficient and continuous operation of the Ammonia Recovery System shall be supplied with the equipment.

Instrumentation shall consist of, but not be limited to the following:

3.11.4.1 Flow Controls:

.1 Discharge of ammonia liquor feed pump by preset flow rate.

.2 Reflux from distillate collection tank to distillation column by preset flow rate.

.3 Cooling water to condenser by preset temperature of condensed liquid.

.4 Steam to reboiler by preset temperature of vapor return to distillation column.

.5 Discharge of waste water pump by level in reboiler.

3.11.4.2 Level Control:

.1 Shut down of column feed pump by low level in feed tank TK 4.

.2 Maintaining a liquid level in the reboiler, necessary that the steam heating coils are always submerged by the liquid level.

3.11.4.3 Pressure Control:

.1 A pressure indicator at top vapor space of the column.

.2 A differential pressure indicator between top and bottom of column which upon reaching a preset level overrides the steam flow control valve of the reboiler.

3.11.4.4 Temperature:

.1 Temperature indication of liquid feed to preheater.

.2 Temperature indication of liquid feed from preheater.

.3 Temperature indication of vapor space above top tray.

.4 Temperature indication of vapor space above middle tray.

.5 Temperature indication of vapor space below bottom tray.

.6 Temperature indication of condensed vapor from condenser and which from a preset level, controls the rate of cooling water to the condenser.

.7 Temperature indication of vapor from reboiler which from a preset level controls the rate of steam admitted to the reboiler.

.8 Temperature indication of waste stream from reboiler.

.9 Temperature indication of waste stream discharged from preheater.

Alarms shall be installed on Annunciator Panel. Both pressure and level alarms will activate window with inscription: "Ammonia Recovery." For list of abbreviations see Specification Section 17A, INSTRUMENTATION, of this Specification.

3.12 Compressed Air Systems, Compressors and Blowers

3.12.1 Design Conditions

3.12.1.1 High Pressure Air System (Tag No. CM-1 & TK-12)

The high pressure air system shall consist of an intake filter, a compressor, a receiver, a hydropneumatic tank, an air drier and all necessary piping and fittings.

The compressor shall have a capacity of 20 cfm of air at a pressure of 100 psig.

The compressor shall be double stage, single acting receiver mounted type. It shall be driven by an electric motor of not less than 5 hp. The motor shall be connected to the compressor by means of an adjustable multiple V-belt drive complete with belt guards. The receiver shall be of the horizontal type and shall have a capacity of not less than 80 gallons. It shall be of ASME National Board approved construction and rated

at 200 psig working pressure. It shall be equipped with inspection openings, ASME safety valve, drain valve, and pressure gauge.

The compressor shall be started and stopped automatically on demand by means of a pressure activated control. The intake filter, motor, compressor and controls shall be mounted on the receiver and shall be factory piped and wired to function as a self-contained unit. The compressor shall be set on a vibration adsorbent base.

The intake filter and silencers shall be of the replaceable cartridge type. Bourdon-type gages shall be provided on the compressor discharge and on the receiver. They shall have a range of 0 to 200 psig and a minimum dial diameter of 2 inches. The pressure switch shall be "Furnas" or approved equal.

The air filter dryer shall be sized to handle the output of the compressor. It shall be of the cartridge and housing type. The housing shall consist of a cast-iron base and cover with a steel shell and post. The housing shall have a water collection capacity of not less than three (3) pints.

The filter cartridge shall have a rating of 25 microns and shall be made of wool fiber.

The hydropneumatic tank shall be of the horizontal type. The tank shall be designed for 100 lb working pressure and shall be manufactured in accordance with ASME code for pressure vessels. The tank shall be fitted with a safety valve, water guage glass, manhole in one head, and tapped opening for water, air line and drain connections.

Pneumatic Tank Controls shall operate the service water pump and a solenoid valve on the high pressure air line to accurately maintain the correct air pressure in the tank at all times. The pump shall start as the liquid level reaches a predetermined minimum. It shall be locked in until the depth of water reaches a predetermined upper level. The pump shall then be stopped by a float or electrode operated switch. After each pumping cycle, the control unit shall rebalance the air cushion by operating the air line solenoid valve if necessary.

3.12.1.2 Low Pressure Air System (Tag No. BL-2)

The low-pressure air system (BL-2) shall supply 500 scfm air at 8 psig to gravity filters FT-1, FT-2 and FT-3.

The blower shall be of the lobe heavy duty type with inlet and discharge connections to match 125 lb standard ASA flanges. Each blower shall be constructed from close grained cast iron and shall have a replaceable intake filter located on its inlet connection. The blowers shall be either directly connected to the driving motors, or connected by means of a guard protected V-belt drive. Motor, blower and drive shall be mounted on a single baseplate.

All bearings and gears shall be pressure lubricated, with adequate seals to prevent entrance of oil into the air stream.

3.13 Bulk Solids Conveyor (Tag No. BE-1)

3.13.1 Bulk Solids Conveyor

3.13.1.1 Design Condition

The bulk solids conveyor shall be capable of conveying 2 tons per hour of calcium sulfate solids containing 50% moisture, a horizontal distance of 35 feet and a vertical rise of 12 feet. The conveyor shall operate at a speed of 12 feet per minute.

3.13.1.2 Construction

The conveyor shall consist of an endless driven conveying element confined in a totally enclosed casing, moving material in a solid column at the same speed as the conveying element. The conveying element shall be made up of simple one piece detachable links of chain with integral center pull flights supporting the column of material at the bottom and two sides. The flight pattern shall consist of three U shaped flights followed by a web type flight. The conveyor shall contain a 1 HP drive unit and an idler wheel for the return chain. The conveyor shall contain two feed sections chutes located in the horizontal run and a front end discharge shute located at the top of the vertical rise section. The conveyor shall contain inspection doors at the drive and idler pulley and a clean out panel in the curve transition section. The conveyor shall be dust proof and product contamination proof.

3.13.1.3 Materials of Construction

The conveyor shall be constructed of materials compatible to the product conveyed. The enclosed casing shall be constructed of abrasion resistant materials.

3.14 Cooling Tower (Tag No. CT-1)

3.14.1 Design Conditions

The Cooling Tower shall be an induced draft, vertical discharge, crossflow type, packaged as a complete unit.

The tower shall be of adequate capacity to cool a minimum 200 gpm from 105°F to 85°F at a 78°F wet bulb.

Casing shall be of 3/8" corrugated asbestos cement board with lapped joints. Louvers shall be corrugated asbestos cement board of sufficient thickness to prevent sagging and shall be slip fit. Redwood of adequate structural strength may be used in lieu of asbestos board.

All bolts, nuts and washer shall be of heavy plated nonrusting steel or shall be of stainless steel.

Basin shall be of minimum 12 gal. steel bottom and sides, self cleaning, with depressed center section. Basin shall be complete with cleanout, drain, suction screen, anti-cavitation device and mechanically operated automatic makeup water valve.

Fill shall be non corrosive poly vinyl chloride or redwood. Maximum allowable draft loss shall be 0.2 of 1% of the water circulated.

Fan shall have min. of 4 cast aluminum blades and cast iron hub or cast aluminum hub. Each blade shall be individually adjustable. Drive shall be thru parallel shaft, helical gear reduction unit.

Accessories shall include but shall not be limited to fan guard, steel ladder, steel handrail and air inlet screens.

3.15 Chemical Precipitator (Tag No. CP-1 & 2)

3.15.1 Design Conditions

The Chemical Precipitator shall be a vertical tank with cone bottom and dished head top. The tank shall be of 15,000 gallon volume. The tank shall be designed to react 5,000 lb. ammonia sulfate, 350 lb. free ammonia, 3,000 lb.

calcium hydroxide, all in 91,000 lb. water. The product formed will be 6% calcium sulfate and excess lime slurry in a 2% aqueous ammonia solution. The vessel shall be designed to contain 2% aqueous ammonia at ambient temperatures.

3.15.2 Construction

The vessel shall be 12 ft. in diameter with a 16½ ft. straight side. The cone bottom shall contain a 120° included angle and a discharge nozzle. The dished head shall support an agitator as described below. The dished head shall contain nozzles and manhole as shown on Burns and Roe Drawing No. 2106. The precipitators shall contain four baffles, each located 90° apart. The baffles shall be mounted on the interior wall of the precipitator.

3.15.3 Agitator

The precipitator shall contain an agitator. The agitator shall be of the top entering type and shall be supported by the top head. The agitator shall be driven by a 5 hp, 230/460 volt 3 phase motor. The agitator shaft shall be 3½ inch in diameter and extend 228 inches below the mounting flange. A 55 inch diameter, 4 blade axial flow turbine shall be mounted on the agitator shaft.

3.15.4 Materials of Construction

The chemical precipitator and baffles shall be constructed of carbon steel conforming to ASTM-A283.

3.15.5 Pumps

Slurry Pumps, P-16A and P16B shall be furnished as described in Section 15B, Process Pumps.

3.16 Product Water Storage Tank (Tag No. TK-1)

3.16.1 Description of Service

The Product Water Storage Tank shall be a vertical water storage tank with a pitched roof. The tank shall be designed for the storage of potable water.

3.16.2 Design

The product water storage tank shall store 180,000 gallons potable water at ambient temperature. The tank shall be 40 ft. in diameter with a wall height of 20 ft. The tank shall have a pitched roof with a slope of 1:12. Vents, nozzles, manholes and ladder shall be as shown on Burns and Roe Drawing, No. 2106. Foundation shall be constructed as specified in Section 2G - Sand Fill Under Water Tanks and Section 3A - Concrete.

3.16.3 Material of Construction

The product water storage tank shall be constructed of carbon steel conforming to ASTM - A283. The tank shall be coated as specified in Section 9 - Finish Painting and Coatings.

3.17 Backwash Water Storage Tank (Tag No. 11)

3.17.1 Description of Service

The Backwash Water Storage Tank shall be a vertical water storage tank with a pitched roof. The tank shall be designed for the storage of dirty filter backwash water for recovery purposes.

3.17.2 Design

The backwash water storage tank shall store 40,000 gallons water at ambient temperatures. The tank shall be 20 ft. in diameter and 17 ft. straight wall height. The tank shall have a pitched roof with a slope of 1:12. Vents, nozzles, manholes and ladder shall be as shown on Burns and Roe Drawing No. 2106. Foundations shall be constructed as specified in Section 2G Sand Fill Under Water Tanks and Section 3A - Concrete.

3.17.3 Materials of Construction

The backwash water storage tank shall be constructed of carbon steel conforming to ASTM- A-283. The tank shall be coated as specified in Section 9 - Finish Painting and Coatings.

3.18 Regenerant Day Tank (Tag No. TK-6)

3.18.1 Description of Service

The Regenerant Day Tank shall be a vertical tank for mixing and storing 8% aqueous ammonia solution.

3.18.2 Design Conditions

The Regenerant Day Tank shall store 5,000 gallons 8% aqueous ammonia solution at ambient temperature. The tank shall be 8 ft. diameter and 13 ft. straight height. The ends of the tank shall be constructed with dished heads. Vents, nozzles and manholes shall be as shown on Burns and Roe Drawing No. 2106.

3.18.3 Mixing Nozzle

The ammonia mixing nozzle shall be a ejector type jet pump. The ejector shall pump 10 gpm liquid ammonia when supplied with 70 gpm water at an inlet pressure of 70psig and a discharge head of 15 ft. The ejector shall have a 1 inch suction and discharge connection; and a 3/4 inch inlet connection. The ejector shall be constructed of polyvinyl chloride. The ejector shall be Penberthy Model 163P or approved equal.

3.18.4 Materials of Construction

The regenerant day tank shall be constructed of carbon steel conforming to ASTM-A283. The tank shall be coated as specified in Section 9 - Finish Painting and Coatings.

3.19 Portable Resin Loading Tank (Tag No. TK-13)

3.19.1 Description of Service

The Portable Resin Loading Tank and auxilaries shall be an open vertical tank mounted on a dolly. The system is used to load the ion exchange resin into the ion exchange vessels by hydraulic means.

3.19.2 Design

The tank shall be an open top tank with a cone bottom. The tank shall be 4 ft. in diameter with a 3 ft. side wall. The tank shall be mounted on a dolly. The tank shall contain

hose racks and piping as shown on Burns and Roe Drawing No. 2107 and as specified in Section 15C - Piping Systems.

3.19.3 Water Eductor

The tank discharge shall be piped as shown on the plans with a water eductor. The eductor shall have a 2 inch suction and discharge. The eductor shall have a discharge head of 40 ft. water head when supplied with 56 gpm water at 50 psig suction pressure. The eductor shall be a Pemberthy Ejector #166A or approved equal.

3.19.4 Materials of Construction

The portable resin loading tank shall be constructed of carbon steel conforming to ASTM-A283. The tank shall be coated as specified in Section 9 - Finish Paint and Coatings.

3.20 Tank Structures

All exterior tank structures shall be designed for dead, live, wind and snow loads in accordance with the requirements of Section 3.2 of AWWA Specification D-100.

All other interior tank structures shall be designed in accordance with Section 9 of AWWA Specification D-100.

Plate sections shall be carbon steel conforming to the requirements specified in Sections 2.3 and 2.4 of AWWA Specification D-100, or to ASTM A283.

Sturctural sections and shapes shall conform to the requirements of Section 2.5 of AWWA Specification D-100 or to ASTM A36.

All tank structures shall be of welded construction. Welding shall be in strict accordance with Section 8, Welding, of AWWA Specification D-100.

4.0 INSTALLATION

All equipment and systems shall be installed in accordance with all codes and standards noted and with the approved vendor drawings. Each piece of equipment shall be accurately located as shown in the drawings. The equipment shall be perfectly plumb and level. Where pitch is indicated for piping, slope shall be accurately maintained.

Contractor shall comply with the requirements for piping installation as required in accordance with Specification Section 15C, PIPING SYSTEMS, and for electrical equipment alignment requirements in accordance with Specification Section 16H, MOTORS.

After equipment is accurately aligned it shall be brought to proper elevation by use of metal shims or metal wedges which shall remain in place during grouting and until the grout has thoroughly cured. No grouting less than one inch thick shall be used. Grouting shall be done so that all voids under the equipment baseplate or soleplate are completely filled with grout.

Anchor bolt nuts shall not be finally seated until the grout has thoroughly cured.

Manufacturer's instructions as outlined in Instruction Books or in Instruction Sheets sent with the equipment relating to installation, setting and grouting shall have precedence over this specification wherever they are at variance.

5.0 TESTING

The equipment and systems covered under this section shall be tested by Contractor and approved by Engineer prior to acceptance. Equipment, materials and systems shall be tested to ascertain acceptable operational capability and conformance with specified requirements. Tests shall be applied either to entire systems or to sections consistent with the progress of the Work. Equipment, materials, instruments, and labor required for the tests shall be furnished by Contractor without additional cost to Owner.

6.0 INFORMATION TO BE SUBMITTED

The following information and data shall be submitted for approval within 60 days after award of contract.

6.1 Drawings

Contractor shall submit to Engineer for approval, and shall secure same before fabrication or manufacture, copies of drawings showing complete and detailed layouts of all equipment to be furnished.

Section 15B

Process Pumps

DIVISION 15

SECTION 15B

PROCESS PUMPS

1.0 SCOPE

This Specification Section covers furnishing, installing start-up and testing of process pumps all as indicated on the drawings and described in the specification.

2.0 GENERAL

2.1 Work to be Provided

The Work to be provided under this specification shall include the following:

.1 Two (2) Raw Water Pumps (P-1A & P-1B)

.2 One (1) Lime Slurry Transfer Pump (P-10)

.3 Two (2) Lime Slurry Feed Pumps (P-11 & P-12)

.4 Two (2) Coagulant Aid Feed Pumps (P-13 & P-22)

.5 One (1) Backwash Water Sump Pump (P-15)

.6 Two (2) Chemical Slurry Pumps (P-16A & 16B)

.7 One (1) Spent Regenerant Pump (P-17)

.8 One (1) Fresh Regenerant Pump (P-18)

.9 One (1) Rinse Water Pump (P-21)

.10 One (1) Filter Backwash Pump (P-23)

.11 One (1) Backwash Water Transfer Pump (P-24)

.12 One (1) Cooling Water Pump (P-27)

.13 One (1) Fire Pump (P-28)

.14 One (1) Service Water Pump (P-29)

2.2 Work by Others

The following work is included in other Sections.

.1 Concrete foundations and anchor bolts, Section 3A - Concrete.

.2 Main piping to and from pump suction and discharge connections, Section 15C - Piping Systems.

.3 Motor starters and external wiring; Section 16D - Insulated Wire and Cable, Section 16H - Motors and Section 16I - Motor Control Centers, Motor Controls, Motor Starters and Motor Disconnect Switches.

2.3 Codes and Standards

The Work shall conform to the latest edition and latest addenda thereto, as of date of award, of the following codes and standards:

.1 American National Standards Institute

.2 American Society for Testing and Materials

.3 American Society of Mechanical Engineers

.4 Institute of Electrical and Electronic Engineers

.5 Hydraulic Institute

.6 American Institute of Steel Construction

.7 American Welding Society

.8 National Electric Manufacturers Association

.9 National Board of Fire Underwriters

.10 Underwriters Laboratories, Inc.

.11 Factory Mutual Insurance Companies

.12 Commonwealth of Pennsylvania Codes and Regulations

3.0 DETAILED REQUIREMENTS

3.1 Design Conditions

Design conditions for each pump shall be as specified in Table 1 - Design Conditions.

3.2 Materials of Construction

Materials of Construction shall be as specified in Table 2 - Materials of Construction.

3.3 Description of Pumps

.1 Vertical centrifugal sump pump, volute casing, open single suction impeller, sealed bearing housing cast with motor support, pipe column, cover plates and strainers.

Raw Water (Tag No. P-1A and P-1B)
Back Water Sump (Tag No. P-15)

.2 Horizontal centrifugal pump, single stage, open impeller, direct connected, frame mounted, volute casing.

Lime Slurry Transfer (Tag No. P-10)
Lime Slurry Feed (Tag No. P-12)
Chemical Slurry (Tag No. P-16A and P-16B)

.3 Horizontal centrifugal pump, single stage, enclosed impeller, closed couple, volute casing.

Spent Regenerant (Tag No. P-17)
Fresh Regenerant (Tag No. P-18)
Backwash Water Transfer (Tag No. P-24)
Cooling Water (Tag No. P-27)

.4 Horizontal centrifugal pump, single stage, closed impeller, direct connected, frame mounted, volute casing.
Rinse Water (Tag No. P-21)

.5 Horizontal centrifugal pump, single staged, enclosed impeller, frame mounted, volute casing.

Filter Backwash (Tag No. P-23)
Service Water (Tag No. P-29)

.6 Single head, diaphragm metering pump, eccentric-type adjustable stroke assembly.

Coagulant Aid Feed (Tag No. P-13 and P-22)

.7 Duplex positive displacement, hydraulic actuated, diaphragm metering pump.

Lime Slurry Feed Pump (Tag No. P-12)

.8 a. Horizontal centrifugal, double suction, single stage, split casing and combined bed plate.

b. Complete set of fire fittings including; discharge tee relief valve tee, relief valve, suction and discharge pressure gauges and open waste-water cone.

c. Diesel engine, complete with battery rack and batteries, trickle charger and control panel.

d. Complete fuel supply system including; 100 gal. storage tank, piping, valves, gauges, hand pump and gravity feed tank.

e. The fire pump, including driver and all accessories described herein shall conform to the requirements for High Pressure Fire Pumps of the following codes and standards:

National Board of Fire Underwriters
Underwriters' Laboratories, Inc.
Factory Mutual Insurance Companies

Fire (Tag No. P-28)

3.2 Materials

Materials used shall be in accordance with the requirements specified in Table 1.

3.3 Design Conditions

Design conditions for each pump shall be as specified in Table 2.

3.4 Guarantee

Contractor shall guarantee that the equipment will perform in accordance with this specification and Table 1 and 2 and shall meet the following specific performance requirements:

.1 Design conditions herein specified.

.2 Horsepower shall not exceed guaranteed rating at design capacity and head.

.3 Available NPSH at design capacity and head.

.4 Guaranteed efficiency at design capacity and head.

.5 Pumps and motors shall operate smoothly without undue rumble, noise, vibration or other effects detrimental to safe and efficient operation over the entire operating range from minimum flow to design flow in accordance with the pump characteristic curves and other performance data.

.6 All pumps shall be suitable for parallel operation with similar pumps in the system.

.7 Similar parts of like duty pumps shall be interchangeable.

3.5 Construction Features

3.5.1 Pumps

Pump characteristic curve shall be of the continuously rising type from design flow to shut-off head.

Pump bearings shall be grease or oil lubricated.

3.5.2 Impellers and all rotating parts shall be hydraulically and dynamically balanced and shall be fastened to the shaft in such a manner that the connection will withstand the maximum torque or forces that may occur under all operating conditions.

Each pump shall be provided with means of supporting pump components during dismantling, removal or installation.

Where materials are specified herein, the intention is to set forth the minimum acceptable grade or type of material as a means of insuring comparable offerings from the individual Vendors. It is expected that the Vendor shall review all such material suggestions and shall provide a material which is suitable for the intended service where the specified conditions indicate that a better grade of material is required.

Shaft shall be of ample size to transmit full driver output and shall be provided with suitable non-ferrous metal deflectors to keep any leakage from contact with the bearings. Packing box shaft sleeves shall be sealed at either the inner or outer end, and the end of the shaft sleeve assembly shall extend beyond the outer face of packing gland. Shaft sleeves shall be field replaceable. If heavy nuts are used, they shall be of material equal in corrosion resistance to the shaft sleeves.

3.5.3 Diaphragm Metering Pumps

The diaphragm metering pumps shall be a positive displacement hydraulic actuated diaphragm pump driven by a standard foot mounted motor. Double ball type valves shall be provided on the suction and discharge, including a reversible seat and a replaceable ball guide. Each valve shall be removable without disconnection of any piping and capable of disassembly by hand. The hydraulic reservoir and gear reduction lubrication system shall be totally separate. The hydraulic system shall be positively vented on each stroke of the pump and no internal adjustable valves shall be required. The pump shall be dry lift self-priming and capable of indefinite operation without process fluid. An auto-electric capacity adjustment mechanism, having a built in 0 to 100% ratio control, shall respond to a current type signal. Capacity control shall be 0 to 100% with delivery to be repeatable within plus or minus 1% accuracy over a 25:1 range. In order to minimize shook loading on the long slurry discharge line, an accumulator shall be provided on a leg of the main discharge line.

3.6 Motors

Motors shall be of sufficient size for the duty to be performed. In sizing the motors, the Vendor shall select motors which will not exceed the nominal nameplate rating when the driven equipment is operating as specified.

3.6.1 Voltage Ratings

Alternating current motors sized from 1/2 to 200 horsepower shall be rated 460 volts, 3 phase 60 Hz. Motors sized 1/3 horsepower and smaller shall be rated 115 volts, single phase 60 Hz.

3.6.2 Enclosures

Unless otherwise specified, indoor motors shall have open drip-proof enclosures and all outdoor or agitator or pump motors shall have totally enclosed, fan cooled enclosures.

3.6.3 Insulation

Motors shall have Class B insulation with a minimum 1.15 service factor. Insulation shall have special treatment to assure added protection against moderate amounts of moisture, light acid conditions, and a conducting dust unless the Manufacturer's standard Class B construction incorporates this protection.

3.6.4 Temperature Ratings

Open drip-proof and weather protected type II motors shall have a continuous duty classification based on a 50C temperature rise, as measured by the thermometer method, in a 40c ambient temperature.

Totally enclosed fan cooled motors shall have a continuous duty classification based on a 55c temperature rise, as measured by the thermometer method, in a 40c ambient temperature.

3.6.5 Bearings

Bearings shall be of the anti-friction type and shall be capable of adequately supporting all weights and taking all thrusts imposed by the driven equipment. Bearings shall have a guaranteed operating life of 15 to 20 years.

3.6.6 Operating Conditions

Motors shall have torque characteristics suitable for the driven load, and shall have sufficient torque to start fully loaded and accelerate to rated speed with only 80% of rated voltage at the motor terminals. Motors shall have a safe stall time equal or greater than the accelerating time under the worst voltage conditions specified. In sizing motors, no portion of the service factor above 1.00 shall be used in continuous operation of the motor at any point of the curves.

3.6.7 Couplings

Vertical type motors shall be provided with motor coupling for adjustment of pump impeller running clearances. Horizontal, frame mounted pump shall be provided with flexible coupling for connecting pump and motor shafts.

3.6.8 Terminal Boxes

Terminal boxes shall be of the split type and shall be one trade size larger than the standard for the motor frame size. Separate terminal boxes shall be furnished for each accessory.

3.6.9 Nameplates

Each motor shall be furnished with a nameplate in accordance with NEMA standards. Nameplates shall include the service factor and class of insulation.

3.7 Painting and Nameplates

3.7.1 Painting

All exterior surfaces of the equipment, except finished areas, shall be thoroughly cleaned by sand-blasting or wire brushing to remove all scale, weld splatter and foreign matter. These surfaces then shall be given one (1) shop coat of corrosion resistant paint before shipment.

3.7.2 Cleaning and Protection

.1 All finished surfaces shall be cleaned and protected against corrosion during shipment and storage without the application of paint. All connections shall be protected by covers or wood guards to prevent damage during shipment.

.2 A water-soluble, rust-inhibiting coating, subject to Engineer's approval shall be applied to internal steel surfaces for corrosion protection during shipment and storage.

.3 The cleanliness of the equipment furnished shall be such that it is smooth and free of all foreign matter such as scale, sand, blisters, weld splatter, metal chips and shavings, oil, grease, organic matter, and surface and superficial rust.

.4 Machined surfaces and bearings shall be protected against entrance of dirt, dust, moisture, or other deleterious elements. All surfaces which may be subject to corrosion or oxidation shall be protected in accordance with Vendor's standard.

3.7.3 Nameplates

A corrosion resistant nameplate shall be attached at an easily accessible point on each pump, and shall be stamped with the following information:

.1 Manufacturer's name

.2 Manufacturer's shop order number

.3 Manufacturer's serial number

.4 Date of manufacture

.5 Operating data

a. Capacity, gpm

b. Total dynamic head, feet

c. Specific gravity of liquid

d. Speed, rpm

4.0 INSTALLATION

4.1 Erection

Contractor shall provide himself with all the certified drawings and descriptive literature concerning the particular items of equipment to ensure proper erection procedures as outlined by the manufacturer and approved by Engineer.

4.2 Foundation and Anchorage

Where foundations or anchorage must be provided for equipment, Contractor will be solely responsible for alignment, elevations and preparation of said foundation or anchorage in accordance with Owner approved certified Vendor drawings.

5.0 TESTING

5.1 Shop Tests

.1 All pumps shall be given hydrostatic and other standard shop tests.

.2 One pump of similar kind shall be given a shop running test. Test data taken during this test shall be tabulated and computed in accordance with the Hydraulic Institute Test Code and complete pump performance curve shall be plotted and submitted to Engineer for approval.

.3 Motors shall be tested in accordance with ANSI Standard C50.20 and shall include the following:

High potential test
Current at no load
Current with locked motor
Inspection of bearings

Certified copies of test reports shall be submitted to Engineer for approval.

5.2 Field Acceptance Tests

.1 Full load running tests shall be conducted by Contractor after installation.

.2 Tests shall be run in accordance in the Hydraulic Institute Test Code.

.3 Contractor shall make arrangements for observation of tests by Owner's representative.

6.0 INFORMATION TO BE SUBMITTED

6.1 With Bid

.1 Sufficient information and detail shall be submitted with the bid to permit full understanding and evaluation of equipment offered.

.2 The technical information and data sheets included in the bid form shall be submitted completely filled out by Bidder. After acceptance this data shall become part of the Specification for this equipment.

.3 Outline drawing of each pump and motor.

.4 Bidder shall provide a description of its quality control and inspection department and that of major subcontractors.

6.2 After Award

The following information and data shall be submitted within the time indicated.

6.2.1 Drawings

a. Certified outline dimensional drawings including foundation requirements and electrical connections.	30 Days After Award
b. Cross-sectional drawings with complete parts list.	45 Days After Award
c. Certified performance test curves.	10 Days After Shop Test

6.2.2 Manuals

Installation, operating and maintenance manuals	30 Days Before Shipment

6.2.3 Spare Parts

List of recommended spare parts, complete with individual prices.	30 Days After Approval of Drawings

TABLE 1

DESIGN CONDITIONS

Pump		Fluid		Spec.	Visc.	Design		Head		Avail.		
Name	No.	Name	pH	Grav.	CPS	Temp.	Cap.	Dynamic	Shut off	NPSH	Speed	H.P.
Raw Water	P-1A P-1B	Acid Mine Drainage	2.5 4.0	1.00	1.20	50°F to 56°F	250 GPM	180 Ft.	220 Ft.	25 Ft.	1750 RPM	25
Lime Slurry Transfer	P-10	10% Lime Slurry	11.00 to 12.00	1.06	1.0	140°F to 170°F	26 GPM	40 Ft.	50 Ft.	25 Ft.	1750 RPM	3/4
Lime Slurry Feed	P-11	4% Lime Slurry	11.00 to 12.00	1.02	1.0	Ambient	300GPH	280Ft.	200 psig	25 ft.	1750 RPM	1
Lime Slurry Feed	P-12	10% Lime Slurry	11.00 to 12.00	1.05	1.50	Ambient	90 GPM	50 Ft.	60 Ft.	25 Ft.	1750 RPM	3
Coagulant Aid	P-13	Coagulant Solution	Varies with Different Coagulant Solutions			Ambient	20 GPM	280 Ft.		25 Ft.	1750 RPM	1/4
Backwash Water Sump	P-15	Water	7.0 to 9.0	1.0	1.0	Ambient	500 GPM	40 Ft.	50 Ft.	25 Ft.	1750 RPM	10
Chemical Slurry	P-16A P-16B	6% Calcium Sulfate Slurry	12.0 to 14.0	1.05	1.50	Ambient	25 GPM	230 Ft.	280 Ft.	25 Ft.	1750 RPM	7½

TABLE 1

DESIGN CONDITIONS

Pump Name	No.	Fluid Name	pH	Spec. Grav.	Visc. CPS	Design Temp.	Design Cap	Head Dynamic	Head Shut off	Avail. NPSH	Speed	H.P.
Spent Regenerent	P-17	8% Ammonium Sulfate or Acid Mine Water	2.5 to 9.0	1.0	1.0	Ambient	300 GPM	35 Ft.	42 Ft.	25 Ft.	1750	5
Fresh Regerent	P-18	8% Aq. Ammonia	12.0 to 14.0	1.0	1.0	Ambient	300 GPM	35 Ft.	42 Ft.	20 Ft.	1750 RPM	5
Rinse Water	* P-21	Water	7.0 - 9.0	1.0	1.0	Ambient	250 GPM	180 Ft.	220 Ft.	25 Ft.	1750 RPM	25
Coagulant Aid Feed	P-22	Coagulant Solution	Varies with Different Coagulant Solutions			Ambient	20 GPH	280 Ft.	200 PSIG	25 Ft.	1750 RPM	1/4
Filter Backwash	P-23	Water	7.0 - 9.0	1.0	1.0	Ambient	1000 GPM	60 Ft.	75 Ft.	25 Ft.	1750 RPM	25
Backwash Water Transfer	P-24	Water	7.0 - 9.0	1.0	1.0	Ambient	50 GPM	30 Ft.	37 Ft.	25 Ft.	1750 RPM	3/4
Cooling Water	P-27	Water	7.0 - 9.0	1.0	1.0	Ambient	200 GPM	50 Ft.	60 Ft.	25 Ft.	1750 RPM	5

* Performance curve of P-21 must match performance curve of P-1A and P-1B.

TABLE 1

DESIGN CONDITIONS

Pump		Fluid		Spec.	Visc.	Design		Head		Avail.		
Name	No.	Name	pH	Grav.	CPS	Temp.	Cap.	Dynamic	Shut off	NPSH	Speed	H.P.
Fire	P-28	Water	7.0 - 9.0	1.0	1.0	Ambient	500 GPM	230 Ft.	280 Ft.	25 Ft.	1750 RPM	-
Service Water	P-29	Water	7.0 - 9.0	1.0	1.0	Ambient	100 GPM	200 Ft.	240 Ft.	25 Ft.	3500 RPM	10 HP

TABLE 2

MATERIALS OF CONSTRUCTION

Part Name \ Pump No.	P-1A P-1B	P-17	P-18	P-27 P-23 P-15	P-24 P-21 P-29	P-28	P-11 P-13 P-22	P-10 P-12	P-16A P-16B
Casing	316		d	d		AS STANDARD WITH MANUFACTURER SUBJECT TO APPROVAL BY ENGINEER	AS STANDARD WITH MANUFACTURER SUBJECT TO APPROVAL BY ENGINEER	d	
Impeller: with Key, Washer and nut	316		d	d				d	
Shaft	316	SAE 1112		SAE 1112				SAE 4150	
Seals	-	-		-				Rubber	
Ball Bearings	Steel	Steel		Steel				Steel	
Bearing Housing	d	d		d				d	
Frame	-	d		d				d	
Grease and Oil Fittings	Steel	Steel		Steel				Steel	
Packing: Gland	0	-		-				-	
" Stuffing Box	0	a		a				c	

Legend

a. Die formed, white metal, graphite, long fibe-asbestos
b. Flame hardened to approx: 500 brinell thru stuffing box
c. Die formed, Mira impregnated, long fibre blue African Asbestos
d. Cast Iron ASTM A 278 Class 25 and ASTM A-48 Class 25
316 Stainless steel ASTM 316 (wrought) ASTM A296 Grade CF-8M (cast)

Section 15C

Piping Systems

DIVISION 15

SECTION 15C

PIPING SYSTEMS

1.0 SCOPE

This Specification Section includes furnishing, installation, erection and testing of the process piping systems all as indicated on the drawings and described in the specification.

2.0 GENERAL

The piping systems shall include all piping, fittings, flanges, gaskets, bolting and joint connections, valves, hangers, supports, insulation and all appurtenances required to provide complete functional and operational piping systems.

2.1 Work to be Provided

The Work to be provided under this specification shall include the following systems:

	System	System Designation	Piping Classification	Color Code
.1	Backwash Water	BW	C	Dark Green
.2	Cooling Water	CW	C	Tan
.3	Compressed Air	CA	B	Galv. Un-painted
.4	Fire Water	FW	D	Red
.5	Filter Scouring Air	FA	C	Aluminum & Black Stripes
.6	Rinse Water	SW	C	Aluminum
.7	Regenerent Liquid	RL	F	Lt.Yellow
.8	Spent Regenerent	SR	A & C	Grey
.9	Service Water	XW	C	Lt.Green
.10	Carbon Dioxide	CD	E	Orange
.11	Ammonia Supply	AS	E	Yellow

	System	System Designation	Piping Classification	Color Code
.12	Blowdown Sludge	BS	C	None
.13	Coagulant Solution	CS	C	None
.14	Lime Slurry	LS	F	Black
.15	Resin Sluice	RS	C	Black with white band
.16	Raw Water	RW	A	Brown
.17	Process Water	PW	A & G	White
.18	Vents	VT	As shown	None
.19	Drains	DR	As shown	None
.20	Waste Water	WW	C	Dk.Blue
.21	Potable Cold Water	PCW	C	None
.22	Regenerant Liquid & Carbon Dioxide	RL-CD	H	Orange & Black Stripes

2.2 Codes and Standards

The Work shall conform to the latest edition and the latest addenda thereto, as of the date of award, of the following codes and standards:

.1 American National Standards Institute

A13.1 Identification of Piping Systems

A40.8 National Plumbing Code

B1.1 Unified Screwed Threads

B2.1 Pipe Threads (except dryseal)

B2.4 Hose Coupling Screw Threads

B16.1 Cast Iron Flanges and Flanged Fittings, 25, 125, 250 and 800 lbs.

B16.3 Malleable-Iron Screwed Fittings, 150 and 300 lb.

B16.4 Cast-Iron Screwed Fittings, 125 and 250 lb.

B16.5 Steel Pipe Flanges and Flanged Fittings

B16.9 Wrought Steel Buttwelding Fittings

B16.10 Face-to-Face and End-to-End Dimensions of Ferrous Valves

B16.11 Forged Steel Fittings, Socket-Welding and Threaded

B16.20 Ring Joint Gaskets & Grooves for Steel Pipe Flanges

B16.21 Non-Metallic Gaskets for Pipe Flanges

B16.25 Buttwelding Ends for Pipes, Valves, Flanges and Fittings

B18.1 Small Solid Rivets

B18.2.1 Square and Hex Bolts and Screws, Including Hex Cap Screws and Lag Screws

B18.2.2 Square and Hex Nuts

B31.1 Code for Pressure Piping

.2 American Society for Testing Materials

A48 Gray Iron Castings

A53 Welded and Seamless Steel Pipe

A126 Gray Cast Iron Castings for Valves, Flanges, and Pipe Fittings

A181 Forged or Rolled Steel Pipe Flanges, Forged Fittings, and Valves and Parts for General Service

A403 Factory-Made Wrought Austenitic Steel Welding Fittings

A449 Quenched and Tempered Steel Bolts and Studs

B241 Aluminum Seamless Pipe

B361 Factory-Made Wrought Aluminum and Aluminum Alloy Welded Fittings

D1785 Poly Vinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80 and 120.

.3 Standards of the Pipe Fabrication Institute

ES1 End Preparation and Machined Backing Rings for Butt Welds

ES3 Linear Tolerances, Bending Radii, Minimum Tangents

ES4 Standard Practice, Shop Hydrostatic Testing of Fabricated Pipe

ES5 Standard Practice, Cleaning Fabricated Piping

ES13 Classification of Shop Testing, Inspection and Cleaning

.4 Steel Structures Painting Council

SSPC-SP8 Pickling

.5 American Water Works Association

C-203 AWWA Standard for Coal-Tar Enamel Protective Coatings for Steel Water Pipe

.6 National Board of Fire Underwriters

20 Centrifugal Fire Pumps

24 Outside Protection

3.0 DETAILED REQUIREMENTS

3.1 Design Conditions

Design temperatures and pressures for all systems are:

	Design Temp.	Design Press.
CD - Carbon Dioxide	100°F	300 Psig
AS - Ammonia Supply	100°F	250 Psig
All other systems	100°F	150 Psig

3.2 Piping Classification and Materials

Piping systems are classified by the material of construction, and are identified on the drawings as a suffix to the pipe size.

3.2.1 Class A (PVC)

3.2.1.1 Pipe

Polyvinylchloride, ASTM D-1785, Schedule 80, Class 1120 or 1220, Type I, Grade I.

3.2.1.2 Fittings

Polyvinylchloride, Schedule 80, socket-type, Class 1120 or 1220, Type I, Grade I, and 150 lb. socket-type flanges.

3.2.1.3 Valves

Diaphragm: 125 lb. cast iron, rubber lined, ethylene-propylene copolymer diaphragm, Saunders Patent type

Butterfly: 125 lb. cast iron body, stainless steel disc and shaft, rubber liner, bubble tight shut-off, Continental Double R/L.

Check: 175 lb W.O.G., cast iron body rubber lined, stainless steel interior working parts, Darling No. 22 HC-RL.

Gate: 150 lb. cast iron body, rubber lined, stainless steel interior working parts, O.S.&Y. Darling No. 12 RL.

Remarks: All power operated valves are to be supplied complete with operator, limit stops, and limit switch contacts. Valve operators must open and close valves no faster than 5 seconds.

3.2.1.4 Gaskets

Buna Rubber

3.2.2 Class A (Glass-Fiber Reinforced Plastic)

3.2.2.1 Pipe

ASTM D2310, Class II, Type 1

3.2.2.2 Fittings

Socket-type, to match pipe, tapered adhesive connections and 150 lb. socket-type flanges.

3.2.2.3 Valves

Same as for Class A (PVC) See 3.2.1.3

3.2.2.4 Gaskets

Same as for Class A (PVC) See 3.2.1.4

3.2.3 Class A (Coated Carbon Steel)

3.2.3.1 Pipe

ASTM A-53, Grade B, Schedule 5, with ethylene copolymer coating bonded to all surfaces. Coating to be minimum 30 mils thick. Coating to be spark tested for defects by manufacturer.

3.2.3.2 Fittings

To match pipe, 150 lb. flanged, and 150 lb. grooved with grooved mechanical couplings. 150 lb. flare-type mating flanges. Fittings, flanges and couplings to be coated with ethylene copolymer in accordance with pipe manufacturer's recommendations. Coatings to be spark-tested for defects by manufacturer.

3.2.3.3 Valves

Same as for Class A (PVC) See 3.2.1.3

3.2.3.4 Gaskets

Same as for Class A (PVC) See 3.2.1.4

3.2.4 Class B

3.2.4.1 Pipe

Seamless Carbon Steel, ASTM A-53-Gr.B, Sch. 40

3.2.4.2 Fittings

Malleable Iron ASTM A197, 300 lb WSP, Screwed

3.2.4.3 Gaskets

White Compressible asbestos not graphited

Remarks: Pipe and fittings to be galvanized.

3.2.4.4 Valves

3" and less,

Gate: Bronze, 200 lb, I.S.R.S. Scrd. Crane 424

Globe: Bronze, 200 lb. I.S.R.S. Scrd. Crane 212-P

Check: Bronze, 200 lb, Swing Scrd. Crane 36

3.2.5 Class C

3.2.5.1 Pipe, Above Ground

Seamless carbon steel ASTM A-53 Gr. B, Sch. 40

3.2.5.2 Pipe, Buried

2-1/2" and less - ASTM A-53 Gr. B. Sch. 40

3" and over - Asbestos - Cement, Cl. 150

3.2.5.3 Fittings, Above Ground

2-1/2" and less - 300 lb. Malleable Iron, Scrd.

3" and over - Wrought steel, butt-weld, Sch. 40, and 150 lb. Forged Steel Weld Neck flanges.

3.2.5.4 Fittings, Buried

2-1/2" and less - 300 lb. Malleable Iron. Scrd.

3" and over - Class 150, Cast Iron, ring right bell ends to match pipe

3.2.5.5 Gaskets

Flanges: White compressible asbestos - not graphited

Bell Enos: Rubber, ring-type

Remarks: Exterior surface of underground steel pipe and fittings to be tar coated and wrapped in accordance with AWWA C203

3.2.5.6 Valves

2-1/2" and less

Gate: IBBM, 125 lb. Scrd. Crane No. 490

Globe: IBBM, 150 lb. Scrd. Crane No. 314-1/2P

Check: Brass, 125 lb. Scrd. Crane No. 34

3" and over

Gate: IBBM, 125 lb, Flgd. O.S.&Y Crane 465-1/2

Globe IBBM, 125 lb. Flgd. O.S.&Y Crane 351

Check: Iron body, brass trimmed 125 lb. Flgd. Crane 373

Butterfly: 125 lb. cast iron body, aluminum bronze disc, rubber lined, bubble tight shutoff, Continental Double R/L

Diaphragm: 125 lb. cast iron, ethylene-propylene copolymer diaphragm, Saunders Patent type.

Remarks: Exterior surface of underground Steel pipe and fittings to be tar coated and wrapped in accordance with AWWA C203

3.2.6 Class D

3.2.6.1 Pipe, Above Ground

Seamless carbon steel ASTM A-53 Gr. B. Sch. 40

3.2.6.2 Pipe, Buried

Asbestos - Cement Cl. 150

3.2.6.3 Fitting, Above Ground

Wrought steel butt-weld Sch. 40 and 150 lb. Forged Steel Weld Neck Flanges

3.2.6.4 Fittings, Buried

Class 150, Cast-iron ring-tight bell ends to match pipe.

Gaskets

White compressible asbestos, not graphited

3.2.6.5 Valves

6"

Above ground: IBBM, 125 lb. OS&Y Flgd, Crane 467

Buried: IBBM, 125 lb. N.R.S. Hub-end for Cl. 150 Asbestos cement pipe, Crane 462-1/1

Indicator Post: Crane No. 510

Fire Hydrants: Darling B-50B, Size 4, with two (2) 2-1/2" Hose nozzles. Hydrant end to match pipe.

Remarks: Exterior surface of underground fittings to be tar coated and wrapped in accordance with AWWA C-203.

3.2.7 Class E

3.2.7.1 Pipe

Seamless Carbon Steel, ASTM A-53 Gr. B. Sch. 80

3.2.7.2 Fittings 2" and less

3000 lb forged steel, socket-weld, and 300 lb. forged steel weld-neck flanges

3.2.7.3 Valves 2" and less

Ammonia Supply (AS):

Globe: 300 lb. All Iron. Scrd. Crane 1504

Check: 300 lb. All Iron, Scrd. Crane 1507-1/2

Carbon Dioxide (CD):

Globe: 600 lb. forged steel, stainless steel trim, Crane No. 3624-X

Check: 600 lb. forged steel, stainless steel trim, Screwed, Crane No. 3674-X

Remarks: Exterior surface of underground pipe and fittings to be tar coated and wrapped in accordance with AWWA C-203.

3.2.8 Class F

3.2.8.1 Pipe

Seamless Carbon Steel, ASTM A-53 Gr. B. Sch. 40

3.2.8.2 Fittings: 2" and less

Malleable Iron, ASTM A-197, 300 lb. WSP, Screwed

2-1/2" and over

Wrought Carbon Steel Butt-weld Sch. 40 and 150 lb. Forged Steel Weld Neck Flanges.

3.2.8.3 Gaskets

White compressible asbestos, not graphited

3.2.8.4 Valves

2" and less

Gate: All iron, 150 lb, I.S.R.S. Scrd. Crane 488

Globe: All iron, 150 lb. Scrd. Crane 355-1/2

Check: Malleable iron, 1000 W.O.G. Scrd. Crane 346-1/2
2-1/2" and over

Diaphragm: 125 lb. cast iron, ethylene - propylene copolymer diaphragm, Saunders Patent type

Gate: All iron, 125 lb. O.S.&Y. Flgd. Crane 475-1/2

Globe: All iron, 125 lb. O.S.&Y. Flgd. Crane 351-1/4

Check: All iron, 125 lb. Flgd. Crane 373-1/2

Diaphragm: 125 lb. cast iron, ethylene - propylene copolymer diaphragm, Saunders Patent type

3.2.9 Class G

3.2.9.1 Pipe

Seamless carbon steel ASTM A-53 Gr. B. Sch. 40

3.2.9.2 Fittings

Wrought steel butt-weld Sch. 40 and 150 lb. Forged Steel weld-neck flanges

3.2.9.3 Valves

Gate: Cast steel, 150 lb. O.S.&Y. Flgd. Crane 47XR

Butterfly: 150 lb. Cast Iron Body, stainless steel disc and shaft, neoprene liner, bubble tight shut-off, Continental Double R/L

Remarks: Interior surfaces of all pipe and fittings to be tar coated; exterior surfaces of all underground pipe and fittings to be tar coated and wrapped. All in accordance with AWWA C-203.

3.2.10 Class H

3.2.10.1 Pipe

Seamless Aluminum-Alloy ASTM B-241-68 Alloy No. 6061-T6

3.2.10.2 Fittings

Factory-Made Wrought Aluminum and Aluminum-Alloy Welded Fittings ASTM B361-64 Alloy No. WP6061-B-241

3.2.10.3 Valves

Butterfly 150 lb. Cast Iron Body, Stainless steel disc and shaft, neoprene liner, bubble tight shutoff, Continental Double R/L

3.3 Piping Accessories

3.3.1 Valved Hose Connection

Brass with leather disc, Crane No. 58

3.3.2 Flexible Hose

1 section, 50 feet long, 3/4" PVC, 100 psi rating

1 section, 20 feet long, 1" PVC 100 psi rating

2 sections, 10 feet long each, 1" transparent plastic, 100 psi rating

1 section, 10 feet long, 2" PVC, 100 psi rating

1 section, 50 feet long, 2" PVC, 100 psi rating

3.3.3 Quick Disconnect Couplings:

Self-sealing type, steel, Aeroquip series 5600,

3.3.4 Strainers:

Iron body, monel screen, 125 lb. screwed, Crane No. 990-1/2

3.3.5 Cam-Type Quick Coupler Adapter:

4" Cast iron, female NPT thread, Dover OPW 633-A

3.3.6 Breather Valve:

4" Stainless steel vent valve, set at 1/2 oz. pressure and vacuum, Varec Fig. 2000

3.3.7 Automatic Vent Valve:

Stainless steel body, stainless steel working parts, 125 lb working pressure, 3/4" female NPT inlet and outlet, 33 CFM capacity. Valve to be used for venting vessel during filling. Armstrong No. 21 AR

3.3.8 Carbon Dioxide Diffuser:

.1 Diffuser shall have a capacity of 100 SCFM of carbon dioxide and shall be 36 inches long x 3 inches in diameter with 1/2 inch I.P.S. male pipe connection. Diffuser shall be constructed of sintered porous stainless steel, Grade 316L. Porosity shall be 1 to 3 microns.

Diffuser shall be supplied with a cartridge type prefilter complete with filter housing. Filter shall be capable of filtering particulate matter to 0.9 microns.

3.3.9 Insulation

All portions of outdoor piping systems which are located above ground or in valve pits shall be covered with preformed 25% magnesia insulation in the following thicknesses:

Pipe Size	Insulation Thickness
1" through 6"	1"
8" and 10"	1-1/2"

All insulation shall be jacketed with a 45 lb. asphalt-saturated and coated asbestos felt weatherproof covering. Jacket shall be secured by corrosion - resistant metal bands and sealed with asphalted lap cement.

3.4 Construction Features

.1 The Piping Classifications and Materials specified are the minimum required. Contractor may substitute the next heavier schedule or series if designated material is not commercially available, but only upon express permission of Engineer.

.2 All underground steel pipe, fittings, valves, and similar items shall be externally coated in accordance with AWWA Standard C-203, "AWWA Standard for Coal Tar Enamel Protective Coatings for Steel Water Pipes". Exterior coating shall include a bonded asbestos felt wrapper, externally wrapped with kraft paper. Unless otherwise noted, all connections shall have a bitumastic coating of thickness equal to the precoated pipe and wrapped, before backfill is placed.

.3 All underground piping consisting of asbestos-cement pipe and cast iron fittings shall be provided with concrete thrust blocks at all changes of direction, end of runs, and back of all branches.

.4 Alloy and carbon steel bolts shall have heavy hexagon heads and be in accordance with USAS B18.2; threading shall be in accordance with USAS 18.1, Class 2A.

.5 All bolts studs shall be threaded full length and in accordance with USAS B1.1, Class 2A.

.6 All nuts to be heavy semi-finished hexagonal and in accordance with USAS B18.2; threading shall be in accordance with USAS B1.1, Class 2B.

.7 The carbon content in flange material A105 shall not exceed 0.35 percent.

.8 In all cases, where one flange is flat face, the raised face of the matching flange shall be removed so that the flanges are flat face. Ring type gasket shall be used on all raised face flanges and full gaskets shall be used on all flat faced flanges.

4.0 INSTALLATION

4.1 Fabrication

.1 All piping shall be fabricated in accordance with the requirements of the ANSI Code for Pressure Piping, Pipe Fabrication Institute Standards, and other reference specifications listed herein and on the Drawings.

.2 The piping shall be fabricated of new materials and shall be of schedules and/or dimensions as called for herein.

.3 Steam and condensate piping shall be cut short the full calculated amount of thermal expansion from 70° F to the maximum operating temperature, and cold pull the lines into place.

.4 All pipe shall have the manufacturer's private identifying mark stencilled, stamped, or rolled into the surface in accordance with ASTM Specifications.

.5 All straight pipe shall be truly so. All bends and offsets shall be made true to radius and be free from wrinkles and buckles.

.6 Contractor shall take proper precaution to guard against the development of cracks and wrinkles in the fabrication of pipe upon which any bending or forming operation is performed, and if these defects do develop, the pipe shall be discarded as unacceptable.

.7 All free ends of steel pipe lines and fabricated pipe assemblies shall be properly prepared for the particular type of line joint, as specified herein or detailed on the Contract Drawings.

.8 All lines or sections requiring heat treatment, stress relieving, not bending or forming shall be shop fabricated, as far as practicable.

.9 Contractor shall verify all dimensions in the field before erection and all interferences shall be properly cleared.

Piping runs shown on the drawings shall be followed as closely as possible, except for minor adjustments to avoid architectural and structural features. If major relocations are required, they shall be approved by Engineer.

.10 Pipe bends that may be made in the field shall have a minimum radius equal to five times the nominal pipe radius.

.11 All piping shall be supported in such a manner as to eliminate excessive vibration and sway. Contractor shall design, furnish and install all hangers, supports, anchors and miscellaneous steel braces, etc., to properly support all piping subject to the approval of Engineer.

.12 Piping shall be made up in such a manner with sufficient flanged connections, in addition to those shown on the drawings, to facilitate dismantling of piping and equipment.

.13 Contractor shall submit to Engineer, for approval, any and all changes which occur in the field.

.14 All pipes that run through concrete or masonry floors or walls are to be routed through pipe sleeves or connect to embedded spools.

.15 Unless otherwise indicated, no allowance has been made for welded joints or gaskets.

.16 All weld elbows are long radius unless otherwise noted. All flanged elbows are short radius unless otherwise noted.

.17 All instrumentation is shown diagrammatically.

.18 Contractor shall be responsible for all connections to equipment according to certified manufacturer's drawings. Connections on the drawings are approximate.

.19 Low points of lines shall be provided with drains and drain valves.

.20 High points of lines shall be provided with vents and vent valves.

.21 Steam and drain lines shall be pitched downward in direction of flow so they will have positive drainage in both hot and cold positions, unless otherwise shown or noted.

.22 All vent lines shall be located so the discharge will not be injurious to personnel. Vent lines shall be sloped upward in direction of flow unless otherwise noted.

.23 Where two or more runs are parallel, piping shall be grouped in an orderly manner.

.24 All open hubs or pipe must be covered upon installation with removable plugs to prevent debris from entering until piping is complete.

.25 Tubing shall be run in such a manner as to eliminate pockets and to facilitate dismantling of equipment.

.26 Horizontal tubing runs, for flow and level measuring devices, shall be sloped not less than 1" drop in elevation for each linear foot run.

.27 All runs of instrument tubing shall be run from the connection at the higher elevation to the connection at the lower elevation in a continuous downward slope to permit venting of entrapped air.

.28 All primary tubing shall be 1/2" O.D. unless otherwise indicated.

.29 All tubing shown is strictly diagrammatic and shall be run in the field approximately as shown.

.30 All tubing bends that may be made in the field shall have a minimum radius as set by the manufacturer's standard. No tube shall be bent by hand without the use of a jig.

.31 Any locally mounted instrument not specifically located on this or other drawings shall be located in the field to suit, with accessibility being the determining factor.

4.2 Fittings

Fittings for all pipe lines, unless otherwise specified or noted, shall conform dimensionally, and be rated in accordance with the applicable ANSI Standards previously listed. The fittings shall be fabricated of materials and schedules as called for hereon.

Unless otherwise shown, specified, or required, fittings used in pipe lines 2" nominal size or smaller shall be screwed or socket welding type; and on pipe lines 2-1/2" in size or larger, fittings and joints shall be flanged end or butt welded type, as specified in the Material Specification Schedule for Piping Systems, herein.

4.3 Bolting

All bolts, bolt studs, and nuts 1/2" and up to, and including 1" in diameter, shall be threaded in accordance with the ANSI Standard B1.1 for the coarse thread series and with Class 3 fit in conformance with ANSI B1.1 for sizes above 1".

All carbon steel nuts shall be semi-finished, hexagenal in shape, conforming to standard serial designation USAS B18.2.2.

4.4 Gaskets

The type and material for gaskets to be used with the various flanged joints shall be as specified for the individual class of service as noted in Material Specification Schedule for Piping Systems.

4.5 Valves

All valves, as indicated on the drawings, or as otherwise approved, shall be furnished, delivered and installed by Contractor. Valves shall conform to requirements in Paragraph 3.2 of this Specification Section.

Valves shall be the first grade line of acceptable manufacturers. All valves of the same size, type and rating shall be the products of one manufacturer. Valves shall be provided with permanent metallic tags on which the identifying number, as given on the drawings, is engraved, and the tag shall be attached to the valve handwheel.

All power operated valves are to be supplied complete with operator, limit stops, and limit switch contacts. Valve operator must open and close valve no faster than 5 seconds.

All valves shall be installed in such manner as to make them readily accessible for operation. Where necessary for proper operation, chains, floor stands and stem extensions shall be furnished and installed by Contractor.

4.6 Thermometers, Pressure Gauges, Traps, etc.

Contractor shall install all thermometers, thermometer wells, pressure gauges, traps, strainers and miscellaneous specialties and items as specified in this section and Section 17A, INSTRUMENTATION of theSpecification and as shown on the drawings.

4.7 Joints

.1 Welded Joints

For welded joints see Section 13-D, "WELDING AND NON-DESTRUCTIVE TESTING" of this specification.

.2 Flanged Joints

Unless otherwise specified, carbon steel pipe flanges and flanged fittings shall be furnished faced and drilled and shall conform to ANSI Standard B16.5. The respective pressure

rating series and style of facing to be used shall be as specified in the Material Specification Schedule for Piping Systems.

Unless otherwise noted, flanges for cast iron pipe and fittings shall be furnished faced and drilled in accordance with ANSI Standard B16.1.

Flanges shall be installed so that bolt holes straddle the horizontal and vertical centerlines unless otherwise noted.

.3 Screwed Joints

The threads of all screwed joints shall conform to ANSI Standard for taper pipe threads ANSI B2.1. Screwed joints shall be made perfectly tight with a mixture of graphite and oil, or other approved compound, and applied with a brush to the male pipe threads only, and in no case to the unthreaded portion of the pipe or fitting.

4.8 Hanger and Anchor Connections

Contractor shall provide properly designed steel lugs, brackets, etc., welded to the pipe for hanger support and anchor connections.

4.9 Fabrication of Steel Pipe Assemblies

4.9.1 Bending

Bending may be performed either hot or cold, at the option of Contractor, unless the method is specified by Engineer, and so noted on the individual shop sketches, within the following limitations:

ASTM A53 Grade B pipe shall not be cold bent,

ASTM A53 furnace lap-welded or furnace butt-welded pipe shall not be bent either hot or cold.

Unless the method of bending is specified by Engineer and specifically indicated on the individual sketches, bends may be made cold on a bending machine or on a bending table. The method of cold bending (free or on dies) and the necessity for sand filling shall be determined by the tolerance specified for wrinkles, ovality, and stretch.

4.9.2 Cleaning

Contractor shall clean, preserve and control the quality of the internal surface of the piping system, including the distribution piping, valves, branches and accessories.

The cleaning shall be accomplished by mechanical cleaning, alkaline or degreasing solutions, or other non-corrosive means or by a combination of these, or other approved, means. Solvents shall be compatible with materials in the system. Mechanical cleaning may consist of scrubbing with a non-shedding bristle (or wire brushing on unlined piping only). Wiping with rags or cloth is forbidden.

The potable cold water piping (PCW) shall be disinfected, after hydro-testing, in accordance with the National Plumbing Code ANSI A40.8, Chapter 10, Paragraph 10.9.

All internal surfaces with which hydraulic fluids may be in contact shall be free of metallic particles, burrs and organic materials when viewed under a strong white light. No corrosion or corrosion products shall be visible. The surfaces shall be inspected visually for presence of moisture and foreign material such as corrosion, burrs, oil, grease and other foreign material. A flashlight, borescope or other method shall be used, as required, to examine internal surfaces. If any moisture, scale, dirt or corrosion is visible, the system shall be recleaned.

5.0 TESTING

5.1 Piping Systems

Each of the systems shall be pressure tested in accordance with ANSI B31.3 "Code for Pressure Piping - Power Piping" and as specified below. However, the test pressure shall not exceed the maximum test pressure of any of the system components. The test pressure shall be held long enough to inspect all joints or for a minimum of 10 minutes.

Hydrostatic Test Pressure:

CD	Carbon Dioxide	450 psig
AS	Ammonia Supply	375 psig
All other systems		225 psig

In addition to the requirements noted above, the following requirements shall also apply:

5.1.1 Compressed Air System

This system shall be air tested to 125 psig long enough to apply a soap bubble test and inspect all joints or for a minimum of 10 minutes.

5.1.2 Fire Protection System

This system shall be hydrostatically tested in accordance with the requirements specified in NBFU No. 24, Chapter 9, paragraph 99.

5.2 Equipment

All equipment testing shall be in accordance with the requirements specified in the specification section for each piece of equipment.

6.0 INFORMATION TO BE SUBMITTED

The following information and data shall be submitted:

6.1 Drawings

Drawings shall show in detail any proposed departures from the Contract Drawings within 30 days after award of contract.

6.2 Fire Protection System Certification

Contractor shall submit a written certificate within 5 days after completion of system installation certifying that the work has been performed in accordance with the Specification.

Section 15D

Plumbing

DIVISION 15

SECTION 15D

PLUMBING

1.0 SCOPE

This Specification Section includes the furnishing, installation and testing of all plumbing, piping, and valves and accessories, all as indicated on the drawings and described in the specification.

2.0 GENERAL

2.1 Work to be Provided

In general, the Work consists of but is not necessarily limited to the following:

.1 Sanitary drainage systems

.2 Floor and equipment drains

.3 Hot and cold water piping

.4 Fuel oil piping

.5 Fixtures

.6 Insulation

.7 Installation and testing

2.2 Work by Others

The following work is included in Section 15C - Piping Systems:

.1 Piping systems required to provide complete function and operation of the process plant.

2.3 Codes and Standards

The Work shall conform to the latest edition and latest addenda thereto, as of date of award, of the following codes and standards.

.1 Federal Specifications

HH-I-552	Insulation, Pipe Covering, Thermal, and Insulation Blanket, Thermal, Pipe Covering
HH-I-562	Insulation, Thermal, Mineral Wool, Block or Board and Pipe Insulation (Molded Type)
HH-I-567	Insulation; Pipe, Laminated - Felt (for temperature between 40° and 212°F.) (With Conservation Provision)
OO-C-566	Dispenser, Drinking-Water, Mechanically Cooled
QQ-L-156	Lead; Calking
TT-P-91	Paint, Rubber-Base, for Concrete Floors
WW-H-171	Hangers and Supports, Pipe
WW-P-541	Plumbing Fixtures, Land Use

.2 American National Standards Institute

A40.1	Cast Iron Soil Pipe and Fittings
A40.8	National Plumbing Code
B2.1	Pipe Threads (Except Dryseal)
B16.3	Malleable-Iron Screwed Fittings, 150 lb. and 300 lb.
B16.12	Cast Iron Threaded Drainage Fittings

.3 American Society for Testing and Materials

A53	Welded and Seamless Steel Pipe
A74	Cast Iron Soil Pipe and Fittings
A120	Black and Hot-Dipped Zinc Coated (Galvanized) Welded and Seamless Pipe for Ordinary Uses

.4 American Water Works Association

C203	Coal-Tar Enamel Protective Coating for Steel Water Pipe

.5 National Fire Protection Association

No. 31	Installation of Oil Burning Equipment

2.4 Intent and Arrangements

.1 It is the intent that drawings and specifications are in accordance with current plumbing codes. If, in any instance, local codes are at variance, Contractor shall follow local exceptions and notify Engineer in writing.

The arrangement of the equipment and piping of the plumbing and plumbing systems are shown on the drawings. The drawings are schematic and Contractor shall furnish all offsets, fittings or accessories necessary for a complete and acceptable installation, and in accordance with all Code requirements. Water and drainage piping shall be extended 5 feet outside the building where it shall be temporarily capped or plugged. Utilities shall be installed below the frost line. Contractor shall be responsible for the proper fitting of materials and equipment in each building as indicated without substantial alterations. If actual field conditions, or if selection of equipment, necessitates a departure from the actual layout of the drawings or intent of the specification, Contractor shall receive the approval of such departure by Engineer in writing prior to the start of installation.

3.0 DETAILED REQUIREMENTS

3.1 Materials

3.1.1 Domestic (Potable) Water Piping & Valves

.1 Piping 1 inch and smaller shall be Type K hard drawn copper tubing with wrought copper or cast brass solder fittings. Solder shall be 95-5 type. All threaded nipples for use with copper tubing shall be IPS brass. Steel nipples or ferrous fittings shall not be permitted in copper tubing.

.2 Piping over 1 inch in size shall be galvanized steel conforming to ASTM A53, Grade B, schedule 40. Fittings shall be 300 pound malleable iron screwed type conforming to ANSI B16.3. Exterior surface of steel pipe and fittings encased in concrete or buried underground shall be tar coated and wrapped in accordance with AWWA C-203.

.3 Valves 2" and smaller shall be bronze valves. Gate valves shall be used on all locations except where otherwise indicated on the drawings. Gate valve shall be Crane No. 431, globe shall be Crane No. 7, and check valves shall be Crane No. 34 or equal, as approved by Engineer. All bronze valves shall have screwed ends using proper adaptors for copper tubing. Solder end valves will not be permitted.

3.1.2 Soil, Waste, Drain and Vent Piping

.1 Underground soil, waste, drainpipe, and fittings shall be extra heavy bell-and-spigot cast iron conforming to ANSI A40.1 or ASTM A74.

.2 Above ground soil, waste, drainpipe and vents shall be standard weight cast iron pipe and fittings conforming to ANSI A40.1 or ASTM A74 where line sizes are 3" or larger; and shall be galvanized steel pipe, standard weight ASTM A120, and galvanized cast iron screwed drainage fittings where line sizes are less than 3 inches.

.3 All joints in cast iron pipes and fittings shall be made with packed oakum and molten lead and shall be caulked thoroughly to insure gas tight joints. Lead used shall conform to Federal Specification QQ-L-156, Type I, or equal approved by Engineer.

.4 Threaded joints shall have American National taper-screw threads conforming to ANSI B2.1, with graphite and oil compound applied to the male thread. Connections between threaded pipe and soil pipe shall be similar, and the threaded pipe shall have a ring or half coupling screwed on to form a spigot end.

.5 Changes in pipe size in soil, waste, and drain lines shall be made with reducing fittings or recessed reducers. All changes in direction shall be made by the appropriate use of 45-degree wyes, long or short-sweep 1/4 bends, 1/6, 1/8 or 1/16 bends, or by a combination of those or equivalent may be used in drainage lines only where the direction of flow is from horizontal to vertical. Short sweeps not less than 3 inches in diameter may be used where the change in direction of flow is either from horizontal to vertical or from vertical to horizontal and may be used for making necessary offsets between the ceiling and the next floor above.

.6 Slip joints will be permitted only in trap seals or on the inlet side of the traps. Tucker or hub drainage fittings shall be used for making union connections wherever practicable. The use of long screws and bushings is prohibited.

3.1.3 Clean-Out Plugs and Test Tees

.1 Cleanouts shall be the same size as the pipe except that clean-out plugs larger than 4 inches will not be required. Clean-outs installed in connection with cast-iron hub-and-spigot pipe shall consist of a long-sweep 1/4 bend or one or two 1/8 bends extended to an easily accessible place, or where indicated on the drawings. An extra-heavy cast-brass ferrule with countersunk trap screw cover shall be caulked into the hub of the fitting and shall be flush with the floor. Where cleanouts in connection with threaded pipe are indicated and are accessible, they shall be cast-iron drainage T-pattern 90-degree branch fittings with extra-heavy brass screw plugs of the same size as the pipe up to and including 4 inches. Test tees with cast-iron clean-out plugs shall be on each building drain outside the building.

3.1.4 Floor Drains

Floor drains shall be minimum 3 inches in size of cast iron, with integral clamping ring. Floor drains shall conform to requirements of Federal Specification WW-P-541, Type 216.

3.1.5 Pipe Sleeves

Pipe sleeves shall be of cast-iron, wrought iron, or steel standard weight pipe, properly secured in place, with approximately 1/4 inch space between pipe (insulated where required) and enclosing sleeve. Pipe sleeves shall be provided for all pipe passing through walls and floors below

finished grade. Space between pipe and sleeve shall be filled with oakum and caulked on both ends with elastic cement. Sleeves on outside walls below and above grade or in floor, shall be U.S. 26 gauge galvanized steel pipe. Sleeves in partitions shall be zinc coated sheet steel having a nominal weight of not less than 0.906 pound per square foot.

3.1.6 Pipe Hangers

Hangers shall conform to Federal Specification WW-H-171. Insert shall permit adjustment of the bolt in one horizontal direction and shall be installed before the concrete is poured. The inserts shall be malleable-iron, or prefabricated steel, and shall be of a type to receive a machine bolt head or nut after installation.

3.1.7 Fuel Oil Piping and Fittings

Fuel oil piping shall be black steel conforming to ASTM A120. Fittings shall be malleable iron screwed type conforming to ANSI B16.3, or equal approved by Engineer.

3.1.8 Insulation

.1 Wool-felt pipe covering shall conform to Federal Specification HH-I-567, shall be not less than 3/4 inch in thickness, shall be a sectional removable type lined with asphalt-saturated asbestos paper, and shall be constructed of either solid wool felt or preshrunk indented wool felt. Pipe covering in concealed spaces shall be finished with one coat of paint conforming to Federal Specification TT-P-91. Where space does not permit the installation of sectional covering on pipes in wall chases, the chase shall be packed full of mineral wool, 35 percent magnesia, or asbestos. Valves and fittings, except unions and flanges, shall be covered with magnesia cement or mineral wool cement of the same thickness as the pipe covering. Wool felt, mineral-wool pipe covering. Wool felt, mineral-wool pipe covering, and plastic insulation on valves and fittings shall be jacketed with cotton sheeting, weighing not less than 3.5 ounces per yard of 37-1/2 inch width, pasted neatly to the material.

.2 Mineral-wool pipe covering shall conform to Federal Specification HH-I-562, Type II, Class 1 3/4 inch thick, with jackets and bands as specified for wool-felt covering, or Federal Specification HH-I-552, Type I, Class A. Valves and fittings, except unions and flanges, shall be covered with magnesia cement or mineral wool cement of the same thickness as the pipe covering. Wool felt, mineral-wool pipe covering, and plastic insulation on valves and fittings shall be jacketed with cotton sheeting, weighing not less than 3.5 ounces per yard of 37-1/2 inch width, pasted neatly to the material.

3.1.9 Lime Pit

Lime pit shall be of carbon steel with ceramic stoneware finish on interior surface and shall be Model 401, Style B, 18" x 24" with extension Style BE, as manufactured by Maurice A. Knight Co., Akron, Ohio, or equal approved by Engineer.

3.1.10 Plumbing Fixtures

Plumbing fixtures shall be of the types indicated on the drawings and as hereinafter described. Fixture fittings shall be those regularly furnished by the manufacturer of the fixture. Supply and waste fittings shall be chromium plated. Shut off valves shall be provided and installed on each plumbing fixture and equipment supply line.

.1 Water closets shall be American-Standard, "Glenco" F-2495, vitreous china, or equal approved by Engineer, syphon jet action toilet, wall hung, elongated bowl, 1-½ inch top spud; with Sloan "Royal" or equal approved by Engineer, flush valve with screwdriver stop and vacuum breakers and open front black olsonite or moulded rubber seat, less cover.

.2 Urinals shall be American-Standard "Washbrook", or equal approved by Engineer, wall mounted vitreous china washout urinal with extended shields, integral flush spreader, 3/4 inch top spud, 2 inch back threaded outlet; one inch Sloan "Royal" flush valve, or equal approved by Engineer, wtih screwdriver stop and vacuum breaker.

.3 Lavatories shall be American-Standard "Regalyn" P-4867-30, 19 inch x 17 inch, or equal approved by Engineer, acid resisting enameled cast iron, equipped with concealed wall brackets, 3/8 inch supply lines from wall with loose key angle stops and 1-¼ inch "P" trap with plug cleanout.

.4 Corner lavatory shall be American-Standard "Minette" F-451-30, 16-¼ inch by 11 inch, or equal approved by Engineer, vitreous china, equipped with wall hangers, 3/8 inch supply lines from wall, Heritage N2001 trim and 1-¼ inch "P" trap with plug cleanout.

.5 Service sink shall be American-Standard "Argo" P-7705, 22 inch x 18 inch, or equal approved by Engineer, acid resisting enamel cast iron sink with integral back and chrome plated rim guard bolted to rim, chrome plated rough

brass combination supply fitting with hose and spout, pail hook, and ½ inch quick compression metal-level handle valves, standard P or S Trap, trap cleanout and strainer; wall hangers with auxiliary backing plates for embedding in masonry.

.6 Kitchen sink shall be Kohler of Kohler "Cymbria" Model K-5569-A 42 inch by 25 inch with 18-3/4 inch x 18 inch x 8 inch deep bowl, or equal approved by Engineer, acid resisting white enamel cast iron sink with right hand drain based, K-7765 supply fitting, K-8801 Duostrainer and K-9000 1-½ inch "P" trap with plug cleanout. Cabinet to match sink shall be Kohler of Kohler "Lyon" No. 8133-L 42 inch by 24 inch white enamel furniture steel complete with drawers and doors.

.7 Shower unit shall be American-Standard N1140 concealed type having-Aquaseal compression valves with ½ inch pipe union couplings, bent arm, escutcheon and N1301 ball joint adjustable flow shower head or equal approved by Engineer.

.8 Electric water cooler shall be wall mounted pressure type unit, complying with the requirements of Federal Specification OO-C-566, Type 1, Size 5, or equal approved by Engineer. Unit shall have a capacity of not less than six (6) gallons per hour of cooled (50 degrees) drinking water based on 80 degrees F supply and shall be fan-cooled and complete with 1/5 H.P, 115 volt, single phase, 60 Hertz hermetically sealed condensing unit. Cabinet shall be heavy gauge cold rolled phosphatized steel with gray baked enamel finish. Top shall be contoured polished stainless steel with removable drain grid. Bubbler shall be angle stream chrome plated brass with mouth guard. Push button shall have self-regulating valves. Unit shall be installed in accordance with manufacturer's instructions.

3.2 Painting

Exterior surfaces of piping to be installed in or through concrete floor fill or buried underground shall be given one coat of acid-resisting paint have a bituminous base. Finish painting of exposed pipe, pipe covering, hangers, supports, and other iron work shall conform to Specification Section 9A FINISH PAINTING.

3.3 Identification of Piping

All water piping exposed or concealed in accessible

pipe spaces shall be provided with color bands and legends adjacent to all valves and at sufficiently frequent intervals to identify the lines. Color code shall be of type selected by Owner. Pipe identification bands shall identify the lines by name, color code and directional flow.

3.4 Defective Work

If inspection or test shows defects, such defective work or material shall be replaced and inspection and tests repeated. Repairs to piping shall be made with new material. No caulking of screwed joints or holes will be acceptable.

3.5 Cleaning and Adjusting

At the completion of the Work, all parts of the installation shall be thoroughly cleaned. All pipe, valves, and fittings shall be cleaned of grease, metal cuttings, and sludge which may have accumulated by operation of the system for testing. Valves and other parts of the Work shall be adjusted for quiet operation.

4.0 INSTALLATION

4.1 General

.1 All plumbing shall be installed in strict accordance with the requirements specified in ANSI A40.8, NATIONAL PLUMBING CODE.

.2 All fuel oil piping shall be installed in strict accordance with the requirements specified in Chapter 3 of NFPA No. 31, INSTALLATION OF OIL BURNING EQUIPMENT.

.3 Overhead piping shall be concealed (where possible) in suspended ceiling. Wall piping for fixtures adjacent to pipe chases, and risers shown in chases shall be concealed in chases. Elsewhere the piping may be exposed.

4.2 Cleaning and Protection of Pipe

Before being placed in position, pipe and fittings shall be carefully cleaned. All pipe shall be maintained in a clean condition.

4.3 Excavation, Trenching and Backfilling

Trenches for underground pipe lines shall be excavated

to the required depths. The bottom of trenches shall be tamped hard and graded to secure the required slope. Bell holes shall be excavated so that pipe will rest on solid ground for its entire length. Sewer and water pipes shall be laid in separate trenches, except where otherwise noted on the drawings. Wherever a sewer line crosses above a sanitary water line below ground, the sewer line shall be encased in concrete for a distance of at least 3 feet on each side of the crossing point or for a distance shown on the drawings. After pipe lines have been tested, inspected and approved by Engineer, and the legal authorities, forms shall be removed and the excavation shall be cleared of truck and debris, and backfilled. Material for backfilling shall consist of the excavation, or borrow of sand, gravel or other materials approved by Engineer, and shall be free of truck lumber or other debris. Backfill shall be placed in horizontal layers not exceeding 9 inches in thickness and properly moistened. Each layer shall be compacted in accordance with the method specified in another section of these specifications. Backfill shall be brought to a suitable elevation above grade to provide for anticipated settlement and shrinkage.

4.4 Drainage and Vent Piping

.1 Horizontal soil and waste pipes shall be given a grade of 1/3 inch per foot where possible, but in no case, less than 1/8 inch per foot. Horizontal waste lines receiving the discharge from two or more fixtures shall be provided with end vents, unless separate venting of fixture is noted.

.2 All main vertical soil and waste stacks shall be extended full size to the roof lines and above, except where otherwise specifically indicated. Where permissible and practicable, two or more vent pipes shall be connected and extended as one pipe through the roof.

.3 The connection point of a circuit vent pipe from any fixture, or line of fixtures, to a vent line serving other fixtures shall be at least four feet above the floor on which the fixtures are located, to prevent the use of any vent line as a waste.

.4 A cleanout shall be installed at the foot of each soil and waste line, at changes in direction in lines, and where indicated on the drawings and specified herein.

4.5 Protection to Fixtures, Materials and Equipment

Pipe openings shall be closed with caps or plugs

during installation. Fixtures and equipment shall be tightly covered and protected against dirt, water and chemical or mechanical injury. Upon completion of all work, the fixtures, materials and equipment shall be cleaned thoroughly and delivered in a satisfactory condition to the Owner.

4.6 Joints

4.6.1 Bell and Spigot Joints

.1 Bell and spigot joints for sanitary piping, or between sanitary piping and threaded piping or caulking ferrules, shall be firmly packed with braided or twisted hemp or oakum gaskets of the best commercial grade and shall allow for not less than one inch depth of lead. Each bell joint shall contain not less than 12 oz. of fine soft pig lead for each inch of diameter of the pipe. Gaskets shall not project into the base of the finished joint. After the gaskets are placed, the joints shall be cleaned and the remaining space filled at one pouring with lead which shall be caulked in a manner to insure a tight joint without overstraining the iron of the bells. After the caulking, the lead shall be practically flush with the face of the bells. The lead shall contain not less than 99.7 percent pure lead.

.2 Joints in the cast iron pipe for drain systems shall have pure asbestos rope packing filled to one-half the bell and be leaded as specified hereinbefore for sanitary piping.

.3 Bell and spigot pipe under pressure shall be laid with the bell pointing in the direction of flow; other pipe shall be laid with bell pointing up-grade. Pipe shall be graded carefully and shall be supported firmly and uniformly at its proper elevation and grade. Adjacent lengths of pipe shall be adjusted with reference to each other; blocking or wedging between hub and spigot will not be permitted. Spigots shall be adjusted in the bells so as to give a uniform space all around and, if any pipe does not allow sufficient space for proper caulking, it shall be replaced by one of the proper dimensions. Open ends of pipe at the end of each day's work shall be closed by a watertight plug.

4.6.2 Screw and Solder Joints

.1 Threaded joints shall be tapered standard pipe threads conforming to ANSI B1.1. Screw joints shall be made with a suitable lubricant, such as graphite and oil compound, applied on the male threads only. Threads shall be full cut and not more than three threads on the pipe shall remain ex-

posed. Threaded pipe and tubing shall be cut accurately and shall be worked into place without springing or forcing. Where outlets for fixtures are indicated or specified for fixture equipment, the lines shall be extended not less than 6 inches above the floor and capped or plugged. Proper provision shall be made for the expansion and contraction of all pipes and tubing lines. Pipe and fittings shall be free from fins and burrs. Copper tubing shall be cut with square ends. All burrs and fins shall be removed. Tubing shall be handled and protected carefully and all tubing that is cut, dented, or otherwise damaged shall be replaced with new tubing. End of tubing and fittings shall be cleaned and inserted in the fittings to their full depth. Stems and washers of solder-joint type valves shall be removsd before soldering. All changes in sizes of tubing and pipe shall be made with reducing fittings or recessed reducers.

.2 Unions shall be provided at all equipment connections, control valves and specialties such as meters, filters, separators, etc., or where required for ready disconnecting of the piping system, whether or not indicated on the drawings. On ferrous pipe, 2½ inches in size and smaller, unions shall be 150 lb. WSP, zinc-coated malleable iron, ground-joint type; on pipe 3" in size and larger, disconnect joints shall be made with 150 lb. WSP zinc-coated cast iron flange unions with 1/16" thick gaskets made of the best quality rubber or cloth inserted rubber.

4.7 Hangers and Supports

.1 Pipes above ground shall be adequately supported by means of hangers, or by wall or floor clamps. Hangers shall be of a standard type suitable for the conditions of installation. Horizontal runs of screwed piping or tubing shall be supported at intervals not exceeding the following distances:

Pipe Size	Hanger Spacing
1/2 inch	8 feet 0 inches
3/4 inch and 1 inch	10 feet 0 inches
1-1/4 inch 1-1/2 inch and 2 inch	16 feet 0 inches

.2 Horizontal runs of soil pipe shall be supported at each branch junction, at each change in line direction and at not more than 5-foot intervals between these points.

.3 Vertical lines shall be supported at their bases. Vertical lines shall have intermediate supports spaced not over 20 diameters, nor more than 20 feet apart.

.4 Hangers and supports shall be installed at dimensions not to exceed the maximum limits, and at intervals to keep the pipe in alignment and to carry the weight of the pipe and contents.

4.8 Air Chambers

All piping connections to fixtures shall be provided with an air chamber of the full size of the pipe and at least 12 inches long.

4.9 Pipe Sleeves

Pipe sleeves shall be provided where pipes and tubing for any system pass through masonry or concrete walls, floors, and partitions. Sleeves shall be held securely in proper position and location before and during construction.

All sleeves shall be of sufficient length to pass through entire thickness of wall, partitions or slabs. Sleeve in floor slabs shall extend 1 to 2 inches above the finished floor. Space between pipe and tubing and sleeve shall be firmly jacketed and made watertight with oakum and caulked on both ends of sleeve with elastic cement.

4.10 Floor, Wall and Ceiling Plate

Uncovered exposed pipes, where passing through floors, finished ceiling, shall be fitted with chromium-plated or nickel-plated cast iron or steel plate. Plates shall be large enough to completely close the hole around the pipes and shall be square, octagonal or round, with the least dimension not less than 1-1/2 inches larger than diameter of the pipe. Plates shall be secured in an approved manner. All plates shall be of the same type and shall be approved by Engineer before installation.

4.11 Fixture Connections

.1 Fixtures shall be supported and fastened in an approved and satisfactory manner. Where secured to masonry walls, fixtures shall be fastened with bronze bolts or machine screws in lead or corrosion-resisting metal, sleeve-type anchorage unit or with bronze expansion bolts. Expansion bolts shall be 1/4 inch bronze with 20 threads to the inch and of sufficient length to extend at least 3 inches into solid or filled masonry, and shall be fitted with loose tubing or sleeves of proper length to bring expansion sleeve in the masonry wall. Inserts shall be installed flush with the finished wall and shall be completely concealed when the fixtures are installed.

.2 Connections between earthenware of fixtures and flanges in soil pipe shall be made gas and watertight, with a one-piece special welded asbestos or plastic gasket. Any bulk material, including putty and plastics shall not be used as gaskets. Floor flanges shall be caulked into position. Floor drains shall be secured in a watertight manner. Bolts shall be not less than 1/4 inch in diameter and shall be equipped with chromium plated nuts and washers. Fixtures with outlet flanges shall be set the proper distance from floor or walls to make a first-class joint with the closet-setting compound or gasket and fixture used. No fixture shall be set in place until Engineer has examined and approved each flange.

4.12 Insulation

.1 After the piping has been cleaned and satisfactory tests have been completed, wool-felt or mineral-wool pipe covering shall be installed on all hot-water and cold-water lines. Insulation for cold-water lines shall have a vapor barrier to prevent sweating. The covering shall be neatly finished where pipe hangers occur and shall be continuous through walls and floors. Pipe covering shall be installed in strict conformance with the recommendations of the manufacturer. In concealed spaces, impregnated-mineral-wool covering and wool-felt covering shall be banded at intervals of not less chan 18 inches with lacquered-steel bands 3/4 inch wide. Covering on concealed fittings shall be held secure with two bands at each elbow and valve and three bands at each tee. Branches in partitions to individual fixtures may be without covering when necessary. Sizing and finish painting shall conform to Specification Section 9A, FINISH PAINTING. Where the fixture supplies drop from exposed piping overhead, the covering on the vertical pipes shall stop 6 feet above the floor. The end of the covering shall be fitted with a metal pipe-covering protector, and the covering shall be supported with a ceiling plate secured by means of a set-screw.

4.13 Sterilization

After the fixtures are installed and connected, the potable water systems shall be sterilized for a minimum of 24 hours in strict accordance with the requirements specified in Chapter 10, paragraph 10.9 of ANSI A40.8, National Plumbing Code. The system shall then be flushed until the chlorine content of the water is not more than the exterior service mains. All valves, cocks and regulators in the systems shall be operated during the sterilization period so that they too will be sterilized.

5.0 TESTING

5.1 Drainage and Venting System

The piping of the drainage and venting system shall be tested with water or air.

5.1.1 Water Test

Water tests shall be applied to the drainage and venting system either in its entirety or in sections. If the test is applied to the entire system, all openings in the piping shall be tightly closed except the 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 tightly plugged, and each section shall be filled with water and tested with at least a 10-foot head of water. In testing successive sections, at least the upper 10 feet of the next preceding section shall be tested so that each joint or pipe in the building except the uppermost 10 feet of the system has been submitted to a test of 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 15 minutes before the inspection starts; the system shall then be tight at all joints.

5.1.2 Air Test

If tests are made with air, a pressure of not less than 5 pounds per square inch shall be applied with a force pump and maintained at least 15 minutes without leakage. A mercury-column gauge shall be used in making the air test.

5.1.3 Final Test

When the smoke test is employed, the smoke shall be produced by a smoke machine, and a pressure equal to 1-inch

water column shall be maintained for 15 minutes before starting inspection. When the peppermint test is preferred, 2 ounces of peppermint shall be introduced into each line or stack. Defects discovered shall be eliminated by resetting the fixtures and equipment with new gaskets.

5.2 Water System

Upon completion of the roughing-in and before setting fixtures, the entire cold-water piping systems shall be tested at a hydrostatic pressure of not less than 100 pounds per square inch gauge, and proved tight at this pressure for not less than 30 minutes in order to permit inspection of all joints. Where a portion of the water-piping system is to be concealed before completion, this portion shall be tested separately in a manner described for the entire system.

5.3 Fuel Oil System

After installation and before being covered, fuel oil piping shall be tested for leaks. Piping shall be tested with air pressure, at not less than 1-½ times the maximum working pressure but not less than 5 pounds per square inch at the highest point in the system. The test shall be made so as not to impose a pressure of more than ten pounds per square inch on the tank. The test shall be maintained for at least 30 minutes or for sufficient time to complete visual inspection of all joints and connections. In lieu of a pressure test, suction lines may be tested under a vacuum of not less than 20 inches of mercury maintained for at least 30 minutes.

6.0 INFORMATION TO BE SUBMITTED

The following information and data shall be submitted:

6.1 Drawings

Contractor shall submit complete Drawings or"tear sheets" for all fixtures, piping, valves and materials specified, and piping diagrams for all systems within 30 days after award of contract.

6.2 Test Reports

Approved test reports, including test data shall be forwarded to Engineer within 3 days of completion of each of the tests.

Section 15E

Heating

DIVISION 15

SECTION 15E

HEATING

1.0 SCOPE

This Specification Section includes the furnishing, installation and testing of the heating systems complete with all components and accessories all as indicated on the drawings and described in the specification.

2.0 GENERAL

2.1 Work to be Provided

.1 Steam heating system in Treatment Plant Building.

.2 Hot water heating system in Treatment Plant Building.

.3 Electric heating system in Pump House.

2.2 Work by Others

The furnishing, installing, testing and placing in operation, of the following processing equipment is included in Section 15A - Mechanical Equipment.

.1 Carbon Dioxide System Refrigeration Unit

.2 Carbon Dioxide System Vaporizer

.3 Ammonia Recovery System Steam Heat

.4 Ammonia Recovery System Cooling Water

.5 Cooling Tower

2.3 Codes and Standards

The Work shall conform to the latest edition and latest addenda thereto, as of date of award, of the following codes and standards:

.1 American National Standards Institute
B36.1 Welded and Seamless Steel Pipe

.2 American Society of Heating, Refrigerating and Air Conditioning Engineers

Handbook of Fundamentals

Heating, Ventilating and Air Conditioning Guide and Data Book (2 Volumes)

.3 American Society of Mechanical Engineers Boiler and Pressure Vessel Code

Section I - Power Boilers
Section IV - Heating Boilers
Section VIII - Unfired Pressure Vessels
Section IX - Welding Qualifications

.4 Commonwealth of Pennsylvania Codes and Regulations

3.0 DETAILED REQUIREMENTS

3.1 Design Conditions

3.1.1 System No. 1 - Steam (15 psi) Treatment Plant Building

Requirements (at peak load)	Min. Pounds of Steam/HR (15 psi)
Ammonia Process	1,320
Domestic Hot Water	25
Air Conditioning Heating Coil	227

3.1.2 System No. 2 - Hot Water (200°F) Treatment Plant Building

All building heating requirements shall be supplied from one (1) package type, low pressure hot water boiler, located in Boiler Room inside the building.

The heating system shall maintain the following minimum temperatures:

Area	Min. Temp.	Type of Heating Units	Min. Total Output Rating, BTU/HR.
Machine Shop	75°F	Convectors	30,600
Electrical Equipment Room	75°F	"	3,000
First Aid Room	75°F	"	7,900
Locker Room & Toilet	75°F	"	3,600

Area	Min. Temp.	Type of Heating Units	Min. Total Output Rating, BTU/HR.
Lobby	75°F	Convectors	16,100
Vestibule	65°F	"	20,500
Office	75°F	"	5,700
Secretary	75°F	"	1,050
Lunch Room	75°F	"	12,800
Chemical Laboratory	75°F	"	31,700
Tank and Pump Area	65°F	Unit Heaters	156,600
Ammonia System Area	65°F	Heating & Ventilating Unit Unit Heaters	297,300 65,000

Above conditions based on outside air temperature 0°F (DB)-Winter

3.1.3 System No. 3 - Electric Heating - Pump House

Requirements

The Pump House shall be heated to 40°F DB(min) by means of six (6) electric unit heaters, thermostatically controlled.

3.2 Description of Systems

3.2.1 System No. 1 - Steam

The steam boiler shall supply steam to the following:

Reboiler Ammonia Process
Domestic Water (internal coil in boiler)
Air Conditioning Unit (steam coil)
Condensate shall be returned from system as shown on the drawings.

3.2. System No. 2 - Hot Water

The hot water boiler shall supply two (2) zones:

Zone No. 1 - All convectors.

Zone No. 2 - All unit heaters, and Heating & Ventilating Unit

Type of System: Closed system, 2 pipes and circulating pumps.

Supply Temperature: 200°F (constant).

Return Temperature: 180°F (average).

3.2.3 System No. 3 - Electric

Six (6) electric unit heaters shall be provided in the Pump House, each unit having a rating of 5 kw with adequate overload protection. Three(3) room type thermostats, each providing on-off control for two unit heaters, shall be installed as indicated on Dwg. 3103.

3.3 Equipment

3.3.1 Boilers

Boilers shall be low pressure, packaged units factory insulated complete with combination oil/gas burner units. The boilers shall be a type approved by the "American Gas Association" and shall be constructed and tested in accordance with the provisions of Section IV of the ASME Boiler and Pressure Vessel Code and be stamped with the required ASME symbol. Boilers shall be Cleaver-Brooks Model CB 15-50, or equal approved by Engineer.

Net ratings for the boiler shall be I-B-R approved. The maximum boiler working pressure shall be 15 psi and each individual section shall be pressure tested at the factory in accordance with ASME test procedures.

The boiler shall be capable of stable controlled operation at 80 percent efficiency from 30 percent to 100 percent of firing rating. The boilers shall be installed, started and adjusted by manufacturer's service.

The complete packaged boilers shall be approved as a unit by Underwriters' Laboratories and shall bear the Underwriters' label. Hot water boiler shall have "Airtrol" boiler fitting.

Initially the boilers shall operate on No. 2 fuel oil, supplied from an underground fuel oil tank, located outside of building as shown on drawings. Provisions shall be made to operate in future, on gas with minimum revision to

equipment provided. In this respect the burners shall be provided with gas burner rings and tappings for simple, quick conversion to gas firing.

3.3.1.1 Boiler Ratings

a. Steam Boiler:

Rated capacity (Min. output)	1,725 lbs steam/hr @ 15 psig
EDR steam gross	6,970 sq ft
Light Oil (140,000 BTU/gal)	15 Gal/hr
Gas (800 BTU/cu. ft -mixed gas)	2615 cu. ft/hr (average)
Stack as required for final draft operation	

b. Hot Water Boiler:

Rated capacity (Min output)	1,674,000 BTU/hr
EDR water gross	11,150 sq ft
Light oil (140,000 BTU/gal)	15 Gal/hr
Gas (800 BTU/cu. ft - mixed gas)	2,615 cu. ft/hr (average)
Stack as required for final draft operation	

3.3.1.2 Boiler Breechings and Stacks

Boiler breechings and stacks shall be fabricated from not less than No. 10 U. S. gauge black steel, shall be of all welded construction and reinforced, if required. Stacks shall be of stub venturi design adequate for the boiler on which installed. Suitable cleanouts shall be provided which will permit cleaning the entire smoke connection without

dismantling. A barometric damper shall be provided in each flue.

3.3.2 Boiler Controls

Boiler controls shall be provided for oil firing initially (gas future) and shall be boiler manufacturer's standards and shall include flame failure protection. Controls shall be panel mounted in accordance with manufacturer's standards. Controls shall conform to the following:

a. Steam Boiler

-Protection:

The boiler shall have a low water cutoff as an integral part of the boiler feedwater control. It shall be wired into the burner control circuit to prevent burner operation if the boiler water falls below a safe level.

-Steam pressure control:

The steam pressure controls which regulate burner operation shall be mounted near the water column. The burner operation shall be on full modulated principle.

b. Hot Water Boiler

Limit control:

Cut-in $205^{o}F$

Cut-out $215^{o}F$

Modulating control (full modulation control)

Set point $200^{o}F$

Low fire $205^{o}F$

High fire $200^{o}F$

Temperature controls which regulate burner operation shall be mounted on the unit with temperature sensing elements located adjacent to the hot water outlet.

3.3.3 Convectors

Convectors shall be self-standing enclosure Trane Co. Type SFK or equal approved by Engineer, of the capacities specified on Table 1 - page 15E-7a. Each convector shall be furnished with a manually operated tight closing damper.

3.3.4 Unit Heaters

Unit heaters shall be Trane Co. horizontal type with adjustable louvers, or equal approved by Engineer, with capacity as indicated below and based on 200°F entering water temperature, 20°F temperature drop 70°F entering air temperature and 110°F (max) leaving air temperature.

Unit heaters shall provide required distance of throw at mounting height indicated on design drawings, approved by Engineers.

Area Served	Quant.	HP(Min)	Min. Btu h/unit
Tank and Pump Room	3 (UH-4,5 & 7) 1 (UH-6)	1/8	36,500 47,500
Ammonia System	2 (UH-2 & 3)	1/8	32,500

Each unit heater shall be equipped with gate valves for supply and return, Balance Valve, Aquastat, manual vent and drain pipe capped.

3.3.5 Expansion Tank

A horizontal compression tank shall be provided of minimum 80 gallons capacity, dimension 20" x 63" length, equipped with "Airtrol Tank Fitting," Bell and Gossett number ATF-18 or equal approved by Engineer.

3.3.6 Pumps

Hot water circulating pumps, one for each zone, (located in Boiler Room) shall be close coupled, with mechanical seal and shall be Aurora or equal approved by Engineer, as follows:

Zone No. 1 - 14 GPM; 25 ft head;
1750 RPM; 1/2 hp motor

TABLE I

CONVECTORS - HOT WATER - 190°F AVERAGE WATER TEMP.
20°F TEMP DROP SLOPING TOP CABINET, FREE-STANDING,
WITH STANDARD INLET OPENING

Room No.	Function	Temp °F	Room Heat Loss Btu/hr.	Dimension Length	Height	Depth	No. of each	Convector Capacity Btu/Hr.	Total Heat Output Btu/Hr.
1	Machine Shop	75	31,000	48"	32"	6"	2	8,800	17,600
				40"	32"	6"	2	7,300	14,600
2	Elec. Equip.	75	2,840	28"	32"	4"	1	3,200	3,200
3	First Aid Rm.	75	9,330	56"	32"	6"	1	10,400	10,400
4	Locker Room	75	3,340	32"	32"	4"	1	3,700	3,700
5	Lobby	75	16,930	48"	32"	6"	2	8,800	17,600
6	Vestibule	65	35,830	36"	32"	10"	4	9,200	36,800
7	Office	75	6,130	56"	32"	4"	1	6,800	6,800
8	Secretary Rm	75	960	20"	20"	4"	1	1,800	1,800
9	Lunch Room	75	13,480	56"	32"	4"	2	6,800	13,600
10	Chemical Lab	75	34,200	48"	32"	6"	4	8,800	35,200
	Total Heat Loss		154,040 Btu/hr					Btu/Hr Installed	161,300 Btu/hr

Zone No. 2 - 55 GPM; 25 ft head;
1750 RPM; 3/4 hp motor

3.3.7 Feedwater Pumps

One pump in operation and one pump standby shall be "AURORA" Model D4, or equal approved by Engineer.

7.9 GPM; 20 psig
1750 RPM; 1/4 hp motor

Both pumps shall be located in Boiler Room below feedwater tank.

3.3.8 Domestic Hot Water Circulating Pump

Pump shall be "Bell and Gossett Company," Booster Bronze Pump type or equal approved by Engineer.

Size Number "75"

Pipe Size 3/4" flanged

1/12 HP motor (115/60/1 current)

3.3.9 Internal Boiler Heating Coil

An internal domestic hot water coil shall be provided and shall have 20.5 sq ft surface area. Coil shall be copper and shall be installed in the steam boiler with easy access flange plate for maintenance purposes.

3.3.10 Domestic Water Storage Tank

Tank shall be galvanized steel having 100 gallon capacity and equipped with all accessories shown on drawings.

3.3.11 Fuel Oil Storage Tank

Tank shall be installed below grade shown on drawings, of minimum 5,000 gal. capacity and shall provide a storage for approximately 2 weeks at maximum consumption at peak load.

The tank shall be API approved with National Board of Fire Underwriters' label attached. All seams shall be shop coated outside with a rust inhibiting paint applied on clean

surfaces and shall be coated externally with a heavy coat of black asphaltum before placing underground. A 16 inch manhole shall be provided and shall be installed with suitable lugs for attachment of cathodic protection. Tank shall be provided with "hold down" device.

3.3.12 Electric Unit Heaters

Each heater shall be "Markel" Model No. 1505 or equal approved by Engineer, and shall meet the following requirements:

280 CFM: 56°F Temp. Rise: 25 ft throw:
Thermostat setting at 45°F

3.3.13 Heating and Ventilating Unit

Refer to Section 15F, Air Conditioning and Ventilating.

3.4 Materials

3.4.1 Piping

All piping 2 inches in size and smaller shall be hard copper, type "L". Fittings shall be wrought copper, cast brass, or wrought brass with soldered joints. All pipes 2-1/2 inches in size and larger shall be carbon steel with screwed ends.

Overhead piping shall be concealed, where possible, in suspended ceiling.

Flexible connections or couplings shall be installed on piping connected to pump and other equipment where required to absorb expansion and contraction.

Piping and accessories to and from all heating coils shall be provided and installed in conformity with piping recommendation in Trane catalog DS-385.

3.4.2 Hangers

Materials used in the fabrication and erection of hangers, supports and accessories shall be the best of their respective kinds for the intended use, and shall be the first

grade line of a manufacturer regularly engaged in the production of such equipment. Hangers of the same type shall be the product of a single manufacturer. Hangers shall be such as to adequately support the piping free of sway, vibration or sag. Hangers shall be spaced in accordance with the hanger manufacturer's printed instructions.

3.4.3 Check,Gate and Globe Valves

Valves 2 inches in diameter and smaller shall be bronze. Valves 2-1/2 inches in diameter and larger shall be cast iron with screwed ends.

3.4.4 Relief Valves

Relief valves shall be provided in strict accordance with American Society of Mechanical Engineers, Boiler and Pressure Vessel Code.

Relief valves shall have settings with proper margin above normal operating pressure in system. The aggregate relieving capacity of the relief valves shall not be less than that required by the above code.

3.4.5 Reducing Valve

Compressed air reducing valve for pneumatic control shall be "Johnson" or equal approved by Engineer.

3.4.6 Instruments

Thermometers shall be dial type 4-1/2 inches diameter plus or minus one degree accuracy, white face with black markings, graduated in 2-degree increments. Thermometers are to be adjustable and repairable of a type approved by Engineer.

Pressure gauges shall be dial type 4-1/2 inch diameter, white face with black markings. The gauge range shall be such that full scale reading shall be not less than the design pressure of the system. Accuracy of indication shall

be within 1/2 percent of full scale range. A suitable shut-off cock shall be installed in the line to each gauge.

3.4.7 Insulation

Piping insulation shall conform to requirements in the latest issue of ASHRAE Handbook of Fundamentals, Chapter 18 (Thermal Insulation and Water Vapor Barrier) and the following:

Hot water heating piping (200^{o}F supply and 180^{o}F return) shall be insulated with molded fiberglass 1/2-inch thick with white jacket, "Owens - Corning," low pressure pipe insulation or equal approved by the engineers. the "K" factor shall be 0.24 BTU/sq ft/in./hr/^{o}F at 75 mean temperature

Installation shall conform to manufacturer's published recommendations on application procedures. Fittings and valves shall be insulated with molded fiberglass or hydraulic setting cement, off-white color when dry, finished with a pasted-on application of standard weight white canvas.

Domestic hot water supply pipe, domestic hot water storage tank and feedwater storage tank shall be insulated with a min. of one-inch thickness (0.25k factor fiberglass) PF-615 as manufactured by "Owens-Corning" or equal approved by Engineers.

Installation shall conform to manufacturer's published recommendation on application procedure for indoor heated equipment.

3.5 Control Systems

Control systems shall be as specified hereinafter and as manufactured by Johnson Service Company, Honeywell or equal approved by Engineer.

All major components of the system such as temperature, pressure and other sensor/transmitter devices, electric instruments, and all other related control devices shall be the product of a single manufacturer.

Any additional control that may be required as determined by examination of the drawings and specifications or by

test of the system after installation, shall be furnished and installed as required at no additional cost to Owner. The entire systems shall be installed with all work done in strict accordance with the control equipment manufacturer's instruction.

3.6 Sequence of Operation

.1 Hot water system shall operate only when outdoor air temperature is below 60°F. The hot water temperature at the outlet of boiler shall be thermostatically controlled at 200°F. The hot water temperature in each zone supply pipe shall be modulated by means of a three-way mixing valve, thermostatically controlled between 200° and 100°F as the outside temperature varies from 0° to 60°F. The unit heater fans shall be controlled(on-off) by room thermostats. A supplementary control of air room temperature is available locally by modulating the dampers of convectors (Zone No. 1).

.2 Steam system shall operate continuously (24-hours a day) as required by ammonia process.

.3 Electric unit heaters in Pump House shall operate on an off-on cycle controlled by room thermostats.

3.7 Painting

Uninsulated piping, pipe hangers and other ferrous metal accessories installed outside finished rooms or spaces, and not requiring finish painting, shall be thoroughly cleaned and given one coat of asphalt varnish. Factory finished items need not be painted. All other insulated and exposed surfaces of equipment and materials shall be cleaned, primed and finish painted as specified in Specification Section 9A, FINISH PAINTING.

3.8 Cleaning of Boilers and Piping

.1 After hydrostatic tests have been completed, and prior to performing operating tests, the boilers and piping shall be thoroughly cleaned of foreign materials. Wherever possible, water-contacted surfaces shall be wire brushed to remove loose scale material.

.2 The steam boiler shall be filled with a cleaning solution recommended by the manufacturer and operated at approxi-

mately 3 to 5 pounds per square inch gauge pressure for a period of 24 to 48 hours, exhausting steam to atmosphere.

.3 The hot water boiler shall be filled with a cleaning solution recommended by the manufacturer and operated at approximately 200°F for a period of 4 to 5 hours, circulating the cleaning solution through the entire system.

.4 Chemicals used for cleaning shall be thoroughly dissolved in the water before being placed in the boilers. After the cleaning periods, the boilers and piping, as applicable, shall be allowed to cool, be completely drained and thoroughly flushed with clean water to remove all cleaning solution.

4.0 INSTALLATION

4.1 Boilers

Manufacturer's instructions as outlined in its instruction manuals or instruction sheets sent with the boilers relating to installation shall be complied with in all respects. Boilers shall be accurately located as shown on the drawings, shall be set perfectly plumb and level.

Contractor shall comply with the requirements specified for electrical equipment in the applicable electrical specifications included under DIVISION 16, ELECTRICAL of this specification.

4.2 Piping and Appurtenances

Pipe shall be accurately cut to measurements established at the building, and shall be worked into place without springing or forcing, properly clearing all windows, doors, and other openings.

Piping shall have burs removed by reaming and shall be so installed as to permit free expansion and contraction without damage to joints or hangers. Changes in direction shall be made with fittings except that bending of pipe will be permitted provided a hydraulic pipe bender is used. Bent pipe showing kinks, wrinkles, or other malformations will not be acceptable.

Piping connections to equipment shall be in accordance with details shown on the drawings, or as directed by Engineer. Open ends of pipe lines or equipment shall be properly capped or plugged during installation to keep dirt or other foreign material out of the system.

5.0 TESTING

After heating systems have been installed and prior to the application of insulation, a preliminary test of the piping systems using compressed air at 50 psi shall be made prior to the hydrostatic test hereinafter specified. This test makes it possible to break all joints that may leak and re-make them while still dry, without having to drain the piping systems of water. Soap suds shall be applied to all joints to indicate leakage. All leaks disclosed shall be repaired prior to continuing further testing.

5.1 Hydrostatic Tests

The steam and hot water heating systems shall be hydrostatically tested at a pressure of at least 1-1/2 times the intended operating pressure, for a minimum of 2 hours to preclude any possibility of leaks. All leaks disclosed shall be repaired prior to conducting operating tests.

5.2 Operating Tests

Upon completion and prior to acceptance of the installation, Contractor shall subject the heating systems (steam, water and electric) to such operating tests as may be required to demonstrate satisfactory functional and operating efficiency. Operating tests shall cover a period of 24 to 48 hours for each system. All indicating instruments shall be read at half-hour intervals unless otherwise directed by Engineer. Contractor shall furnish all instruments, test equipment and test personnel required for the tests. Owner will furnish necessary fuel, water and electricity.

6.0 INFORMATION TO BE SUBMITTED

The following information and data shall be submitted:

6.1 Drawings

Contractor shall submit drawings showing equipment and installation information with specific details as to arrangement, dimensions, capacities and foundation and installation requirements. Drawings shall also include sizes and details of piping, hangers, valves and other required accessories within 30 days after award of contract.

6.2 Wiring Diagrams

Contractor shall submit control and electrical wiring diagrams for each of the heating systems within 30 days after award of contract.

6.3 Instruction Manuals

Contractor shall submit instruction manuals for the boilers, burners and electric heaters within 5 days prior to installation.

Section 15F

Air Conditioning and Ventilating

DIVISION 15

SECTION 15F

AIR CONDITIONING AND VENTILATING

1.0 SCOPE

This Specification Section includes furnishing, installing, balancing and testing the air conditioning and ventilating systems complete with all components and accessories all as indicated on the drawings and described in the specification.

2.0 GENERAL

2.1 Work to be Provided

The Work consists of furnishing, installing, balancing and testing the air conditioning and ventilating systems.

2.2 Work by Others

The furnishing, installing testing and placing in operation, of the following processing equipment is included in Section 15A - Mechanical Equipment.

.1 Carbon Dioxide System Refrigeration Unit

.2 Carbon Dioxide System Vaporizer

.3 Ammonia Recovery System Steam Heat

.4 Ammonia Recovery System Cooling Water

.5 Cooling Tower

2.3 Codes and Standards

The Work shall conform to the latest edition and latest addenda thereto, as of date of award, of the following codes and standards:

.1 American Society of Heating, Refrigerating and Air Conditioning Engineers

Handbook of Fundamentals

Heating, Ventilating and Air Conditioning Guide and Data Book (2 Volumes)

.2 Air Moving and Conditioning Association, Inc.
Bulletin No. 210 - Test Code for Air Moving Devices

.3 National Fire Protection Association

90A - Air Conditioning and Ventilating Systems

.4 Commonwealth of Pennsylvania Codes and Regulations

3.0 DETAILED REQUIREMENTS

3.1 General Description of Systems

The drawings indicate the extent and general arrangement of the air conditioning and ventilating systems. Contractor shall be responsible for the proper installation of these systems without violation of applicable codes, standards or specification requirements. If any departures from the drawings are deemed necessary by Contractor, details of such departures and the reasons therefore shall be submitted as soon as practicable to Engineer for approval. No such changes shall be made by Contractor without prior written approval of Engineer. Equipment and ductwork arrangements shall provide adequate and acceptable clearness for entry, servicing and maintenance.

3.2 Materials

All materials shall be newly fabricated and of first grade quality. Mechanical equipment shall be of the best quality for the intended service and shall be essentially the standard product of a reputable manufacturer. All rotating parts (fans, belts, pulleys, gears and similar items) located so that personnel may come in contact therewith shall be fully enclosed or properly guarded.

3.3 Design Description

3.3.1 Air Conditioning Unit

.1 Unit shall consist of the following two (2) sections:

a) A Trane Model #8 Vertical Climate Changer, or approved equal draw-thru type with a medium capacity filter and mixing box supplying a minimum of 3880 cfm of air @ 1-1/4 inch (W.G.) external static pressure adequately service connected to;

b) A separate air cooled condensing unit, Trane Model #RA-2004, or equal approved by Engineer.

.2 Supply unit shall be furnished with non freeze type steam heating coils, centrifugal fan, motor, V-belt drive, face and by-pass dampers, filter and mixing box with throwaway low velocity filters and direct expansion cooling coils, all contained in an insulated vertical rust proof casing complete with drains, all controls and access panels.

.3 Condensing unit shall contain an adequate condenser-compressor with vertical air discharge fan, V-belt drives and motors all within a sheet metal housing suitable for outdoor installation. Compressor shall be of the hermetic type.

3.3.2 Heating and Ventilating Unit

.1 Unit shall be a Trane Company model T-6 "Torrivent", or approved equal, draw-through type consisting of a V-type filter box, face and bypass proportioning damper, type W series 8 hot water heating coil, centrifugal fan with V-belt drive, motor, adjustable base, and vibration mounts all contained in an insulated min. 16 gauge sheet metal rust proof casing complete with drain, controls and access panels.

.2 All structural steel required for the support of complete unit shall be provided and installed by contractor.

3.3. 3 Roof Exhaust Units

.1 Units shall be belt driven centrifugal roof exhaust fans. The wheel shall be aluminum of the backward-inclined, non-overloading design. The wheel shall be statically and dynamically balanced. Housing shall be molded shock-resistant and sound-absorbing bonded reinforced fiber-glass or approved equal. The units shall have a molded venturi type inlet and outlet with cadmium plated air flow guides.

.2 Motors shall be in accordance with Section 16H, MOTORS of this specification. Motors for all exhaust fans shall be 2-speed, to provide 50% of rated cfm capacity at the lower speed.

.3 Each roof exhauster shall have a balanced gravity type damper arranged to open when fan operates and close when fan stops.

.4 Exhaust fans shall be those manufactured by Swartwout Manufacturing Co. or equal approved by Engineer.

3.4 Design Conditions

3.4.1 Air Conditioning Unit

Units shall satisfy the following design conditions:

Total Btu/hr	-	213,000
Total Sensible Heat	-	143,000 Btu/Hr
Total Latent Heat	-	70,000 Btu/hr
Outside Air	-	95^{o}F DB & 75^{o}F WB
Inside Design	-	75^{o}F DB & 50% RH
Recirculated Air	-	1080 cfm
Total Air	-	3880 cfm (minimum)
Steam (heating coil)	-	15 psig (227,000 Btu/ hr)
Electrical current	-	440/60/3

3.4.2 Heating and Ventilating Unit

Unit shall satisfy the following design conditions:

Air Capacity (Total)	-	3,500 cfm (min.)
External Static Pressure (inches water gauge)	-	3/8 inches (w.g.)
Outside Air (winter)	-	0^{o}F
Inside Design (winter)	-	65^{o}F
Recirculated Air	-	None
Coil Capacity (min)	-	297, 300 btu/hr
Hot water inlet temperature	-	200^{o}F
Hot water return temperature	-	180^{o}F
Hot Water Flow Rate (min)	-	30 gpm
Fan Motor H.P. (min.)	-	1½ H.P.

3.4.3 Ventilating Units

Exhaust fans shall satisfy the following design conditions:

Fan No.	Area Served	Quantity	Min.Capacity Min.External Static Pressure	Minimum Motor HP
EF-2 & EF-4	Tank and Pump Room	2	4000 cfm (ea.) @ 1/8" w.g.	1/2
EF-3	Ammonia System Room	1	7000 cfm @ 1/8" w.g.	3/4
EF-1	Machine Shop	1	1800 cfm @ 1/8 w.g.	1/6
EF-7	Locker Room and Toilet	1	650 cfm @ 1/4" w.g.	1/12
EF-5	Lunch Room	1	500 cfm @ 1/4" w.g.	1/12
EF-6	Chemical Laboratory	1	1050 cfm @ 3/8" w.g.	1/6

3.5 Controls

.1 Control systems shall be as specified hereinafter and as manufactured by Johnson Service Company, Honeywell or equal approved by Engineer.

All major components of the system such as temperature, pressure and other sensor/transmitter devices, electric instruments, and all other related control devices shall be the product of a single manufacturer.

Any additional control that may be required as determined by examination of the drawings and specifications or by test of the system after installation, shall be furnished and installed as required at no additional cost to Owner. The entire systems shall be installed with all work done in strict accordance with the control equipment manufacturer's instruction.

.2 For the office air conditioning contractor shall provide a remote room thermostat located on the south wall in office. Thermostat shall be pneumatic modulating type with a temperature range of approximately 55°F to 85°F and an adjustable differential range of 1½ to 6°F. Thermostat shall be provided with a silver

bronze finished backing cover of the locking type and a temperature indicator. Thermostat shall be Minneapolis-Honeywell or equal approved by Engineer.

.3 Contractor shall provide air conditioning unit with fan off-cool switch. Unit shall be arranged to supply at least a two step cooling capacity.

.4 Contractor shall provide an automatic method to permit operation at any temperatures down to zero degrees F for the air-cooled condensing unit located outside the building.

.5 Contractor shall provide air dampers which shall be positioned by piston damper operators controlled by the pneumatic thermostat. A pilot positioner shall modulate the stroke of the operator in precise relation to pilot pressure changes from the thermostat.

Damper operator shall be Johnson Service Co. Piston Damper Operator D-251, with Polot Positioner D-265, or equal approved by Engineer.

.6 Contractor shall provide for the Tank and Pump Room Heating and Ventilating unit all controls and accessories shown on design drawings and as required for a complete control system.

.7 Contractor shall provide all pressure gauges and thermometers indicated on the drawings, and as required for complete installation. Pressure gauges shall be of the bourdon tube type, suitable in all respects for the intended service, and shall have a gauge shut-off valve. Thermometers shall be of the industrial type employing mercury.

3.6 Sequence of Operation

.1 Air Conditioning Unit

The outdoor air damper shall close and the return air damper shall open when the A/C unit fan is turned off.

The space thermostat shall perform the following functions on a split range basis: On a rise in roon temperature it shall modulate the return and max. outside air dampers to increase the proportion of outside air, providing the outside air temperture is below 75°F as determined by the temperature controller

with its sensing bulb in the minimum outside air duct. On a further rise in room temperature, it shall actuate the refrigeration compressor in two separate stages. On a drop in room temperature, it shall reverse the above operations and finally, it shall modulate the steam valve toward an open position, admitting steam to the heating coil.

A low limit temperature controller, with its sensing bulb in the fan discharge duct, shall prevent the discharge temperature from dropping below its set point ($50^{\circ}F$) by restricting the flow of instrument air to the room thermostat.

A temperature controller, with its sensing element in the minimum outside air duct, shall operate through a relay to close the maximum outside air damper and open the return air damper whenever the outside air temperature is above its set point ($75^{\circ}F$).

.2 Heating and Ventilating Unit

The outdoor air damper shall open when the Heating and Ventilating unit is manually turned on. The room thermostat shall modulate the face and by-pass dampers to satisfy the thermostat setting.

A freezestat shall turn off fan and shut outside air damper when a temperature of $40^{\circ}F$, or below, is sensed leaving the hot water coil.

3.7 Dampers

3.7.1 Manual Dampers

Dampers shall be furnished and installed where indicated on the drawings and as shall be required for balancing

the system. Dampers shall be opposed-blade type for throttling operation and parallel-blade type for two (2) position operation. Each damper shall be provided with a suitable adjustment quadrant, indicating and locking device. All dampers shall be provided with shafts and bearings so designed and mounted that the position of the damper within the duct shall be clearly indicated from the outside of the duct, and the exposed portion of the activating mechanism of the damper can be manually operated without the use of special tools. Where operators occur in finished areas of building, they shall be chromium plated with all exposed edges rounded. On insulated ducts the damper operator and indicator shall extend beyond the insulation and covering and shall have bearings and quadrants on pads finished flush with insulation, if splitter dampers cannot be provided with operating quadrants, they shall be provided with a positioning rod pivoted to the leading edge of the splitter damper, passing in a substantially air tight bushing, through the side of the duct and arranged so that the position of the splitter damper may be adjusted, indicated and secured from this point. No damper blade shall be longer than 48 inches; dampers for ducts less than 14 inches high shall have a single leaf. Materials for dampers shall be two gauges heavier than that used for ductwork in which it is installed. Dampers shall be free of flutter, rattling, vibration and distortion and shall be reinforced where necessary.

3.7.2 Automatic Dampers

Automatic dampers shall be factory fabricated louvered units. Those to be installed in the air conditioning duct systems, shall be of substantially air tight construction and shall be felted. They shall be of the two (2) position type or opposed blade type as indicated on design drawings interlocked with the operation of the system which they serve.

3.7.3 Fire Dampers

Fire dampers of suitable type, if required by applicable codes, shall be provided in accordance with National Fire Protection Association Code 90A. Construction and installation shall be as illustrated in the code, and fusible links shall be designed to melt at a temperature

approximately 50°F in excess of the maximum temperature normally encountered.

3.7.4 Supply Volume Dampers

Supply volume dampers shall be of the opposed-blade type, shall be standard catalog products, and shall be furnished and installed behind all supply grilles and ceiling outlets. Each volume damper behind a wall outlet shall consist of a metal frame containing a number of vanes, individually adjustable so as to control both the distribution of air over the face of the outlet, and volume of air delivered to the space. The design of the dampers shall be such that there will be no rattling or vibration when the system is in operation.

3.8 Ductwork, Hangers and Access Doors

3.8.1 Ductwork

.1 Ductwork indicated on the drawings, specified or required for the proper and continuous service of the air conditioning and ventilating systems shall be constructed and installed in a first class workmanlike manner, and in accordance with the specifications and with the requirements of all public authorities and Fire Insurance Rating Organization having jurisdiction.

.2 All sheet metal used in the construction of ductwork shall be the best grade galvanized steel except that for all-weather exposed materials such as outside dampers and ducts, intake ducts, casings or housing to the first connection indoors or to the first fan material shall be aluminum and shall conform to the requirements specified herein. Ductwork shall be assembled in a neat and workmanlike manner, and shall be of the sizes shown on the drawings.

.3 Gauges, seams, reinforcements and construction to be used in ductwork shall be in accordance with the requirements specified in the ASHRAE Heating, Ventilating and Air Conditioning Guide and Data Books.

3.8.2 Hangers

All ducts shall be adequately supported from the building structure by fastening hangers with approved long screws, expansion shields, or bolts. Ducts shall be completely free of vibration. Hangers shall be spaced not more than 4 feet on centers with a hanger no farther than 1 foot on each side of any change in direction or louver damper. The hangers shall be 3/8 inch diameter threaded rods for ductwork up to 46 inches in width. Wider ducts shall be supported by 1-½ inch by 1-½ inch by 3/16 inch galvanized steel angle supports rigidly fastened to the duct reinforcement. Perforated band or wire shall not be used for supporting ductwork.

3.8.3 Access Doors

Contractor shall provide adequately sized and located access doors in all ducts so that filters, control louvers, dampers, fire dampers, temperature sensing elements and other devices requiring direct accessibility for cleaning, servicing or adjustment shall be directly accessible. In addition, access doors shall be installed in all ducts to provide clearance for internal duct cleanout. Access doors shall be hinged on the air upstream side and shall provide swinging clearance from adjacent equipment. Doors shall have a felt or plastic strip around all edges, adequately spaced and designed hinges and cam locks to provide air tight door closure. Where access doors are placed or indicated in an insulated section of duct or casings, they shall be of double panel construction with not less than 1 inch of approved insulation inserted between the panels.

3.8.4 Flexible Connections

All suction and discharge connections to fans or unit equipment shall be made with 15 ounce woven asbestos canvas which shall not be installed taut. Flexible connections shall be held in place by 2 inch by 1/8 inch galvanized steel band drawn together with 1/4 inch diameter bolts. Location and lengths of the connections shall be such as to allow for ease of replacement. All flexible connections shall be bridged with a braided copper strap soldered to metal on each side of the connection.

3.9 Ceiling Outlets, Registers and Grilles

3.9.1 Ceiling Outlets

Ceiling air diffusers shall be provided where indicated on the drawings. Outlets shall be designed to operate without noticeable drafts or noise and to distribute the air uniformly over the horizontal cross-sectional area served. They shall be sized in accordance with the date shown on the drawings and with the manufacturers' certified tests and recommendations. Diffusers shall be furnished complete with equalizing grids, volume controllers, anti-smudge rings and necessary baffles. Anti-smudge rings need not be furnished where outlets are mounted on exposed ductwork. Ceiling diffusers shall be fully adjustable after installation through all air patterns from horizontal to vertical, without the use of any special equipment or tools. All exposed diffusers shall have a baked metal-escent aluminum finish. Registers, grilles and diffusers shall be the standard product of Tuttle and Bailey, General Air Products Co., or equal approved by Engineer.

3.9.2 Wall Type Air Supply Registers

Wall type air supply registers shall be provided where indicated on the drawings. Registers shall be of the type with horizontal and vertical adjustable vanes for obtaining the desired air distribution. Supply registers shall be of the sizes indicated and shall be equipped with an opposed blade volume controller, regulated by a removable key operator. Each register shall be given a rust-inhibiting primer and a finish coat of lacquer. Registers shall be Tuttle and Bailey T647 or T557, or equal approved by Engineer.

3.9.3 Refrigerant Piping and Accessories

Piping shall be copper tubing type "K". Fittings shall be wrought copper, silver brazed.

Drier shall be silica gel replaceable core type Sporlan or approved equal, sized for compressor capacity with three valve bypass for liquid line.

Shutoff valves shall be balanced action packless type for lines 1-1/8 inch O.D. or smaller, and bronze valves with bolted bonnets, repackable under pressure for lines over 1-1/8" O.D.

All piping systems and accessories shall conform to the requirements of the latest issues of all ASHRAE Guide and Data Books and Carrier Co. System Design Manuals.

3.10 Insulation

Fresh air duct from intake to mixing plenum, all ductwork and equipment, if not factory insulated, accessories of air conditioning system installed in non-air conditioned spaces, all ductwork within suspended ceilings and refrigerant lines between air conditioning unit and air cooled condenser shall be insulated as hereinafter specified.

3.10.1 Duct Insulation

Insulation shall be 1 inch thick, 3/4 pound density, flexible blanket fiber glass insulation ("k" factor 0.24 at 75^{o}F) with a factory applied flame retardant, foil-scrim-kraft vapor barrier of 0.0025 inch embossed aluminum foil facing, or equal approved by Engineer. The insulating material shall be held in place by welded pins and speed washers, spaced on not more than 12 inch centers or by means of galvanized steel wire and corner angles. If wires are used to hold the insulation in place, the corners of the insulation shall be adequately protected against injury. Insulation shall be finished with a cover of metal or suitable material for painting to provide a neat appearance.

Ductwork in concealed spaces shall have an integral factory applied fire resistant vapor barrier of aluminum base facing equal in flame resistance to the insulator. During erection, a vapor barrier of not less than 4 inch wide vapor-barrier tape shall be used to seal all joints. All joints and breaks in facings shall be sealed with vapor-barrier tapes or mastic glass fiber tape set in mastic, centered over the tape.

3.10.2 Pipe Insulation

Refrigerant lines shall be covered with fiber glass blanket or molded type insulation (maximum "k" factor 0.24 at 75°F mean temperature) with a fire retardant vapor barrier jacket. Additional jacketing of corrugated aluminum, with 3" overlapped joints and longitudinal seam along bottom shall be provided for weatherproofing of outdoor lines. Where possible, the suction and liquid lines shall be run together and insulated as a single line.

Steam piping shall be insulated as specified in Section 15E, HEATING of this specification.

4.0 INSTALLATION

.1 Contractor shall be responsible for the complete installation and placing in operating condition all equipment and systems specified in this section of the specification.

.2 Contractor shall start-up and operate all systems for the purpose of checking leakage, removing excessive noise or vibration, balancing, adjustment of control valves, and other miscellaneous equipment requiring adjustment and general operational performance. Prior to start-up and testing, all systems shall be thoroughly cleaned of foreign matter.

.3 Contractor shall balance out all distributing systems. All outlets shall deliver the required quantities of air shown on the drawings and with a throw range to cover required area. Contractor shall, at its own expense, rectify all unbalanced ducts, inadequate quantity of air delivery and/or throw, where such exist in the judgment of Owner or its authorized representative.

.4 Contractor shall correct, at its own expense, any leakage, excessive noise, or vibration on piping and ductwork,or faulty operation of equipment which develops or occurs during the start-up and test period.

.5 After air distribution is balanced, Contractor shall indicate by an arrow painted on the duct at each damper, the operating position for each damper.

5.0 TESTING

.1 After the installation is complete, Contractor shall conduct a performance test on all installed equipment.

.2 Contractor shall see that the air conditioning and ventilating systems operate in accordance with the requirements of this specification. Tests shall be performed in the presence of Owner or its authorized representative. Contractor shall furnish all instruments and personnel required for the tests.

.3 An approved test report shall be forwarded to Engineer upon completion of tests.

6.0 INFORMATION TO BE SUBMITTED

The following information and data shall be submitted:

6.1 Drawings

Contractor shall submit drawings and/or descriptive data for fans, air conditioning unit, dampers, grilles, regulators, ductstats and other commercial items. Drawings shall include equipment and installation information with specific details as to arrangement, dimensions, capacity and installation requirements. Submit certified curves for all fans and motors, and a detail drawing of refrigeration piping showing pipe routing and all details including connection to equipment. Drawings to be submitted for approval within 30 days after award of contract.

6.2 Test Report

Contractor shall submit test report, within 5 days after completion of test, which shall include, but not be limited, to the following:

Air distribution system

Fans: Size, type, speed (rpm), static pressure (WG) air quantity (cfm), power (motor)

Air Outlets and Inlets: Size, velocity (fpm), throw, air quantities (cfm)

Coils: Size, face velocity (fpm), entering and leaving temperatures, (dry bulb and wet bulb) heating medium

Control Settings: Actual on-site setting of all controls and other similar items shall be provided in the form of a typed tabulated list, indicating type of control, location, setting and function.

6.3 Instruction Manuals

Contractor shall submit instruction manuals for installing, maintaining and operating all equipment and systems specified 5 days prior to installation.