BONNEVILLE
POWER ADMINISTRATION

Melvin R. Sampson Coho Hatchery Engineer-Procure-Construct Project

The Confederated Tribes and Bands of the Yakama Nation

Technical Specifications
90% Submittal
Volume 1B
(Divisions 23 – 44)

Volume 1B
Technical Specifications

McMILLEN JACOBS ASSOCIATES

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MELVIN R. SAMPSON COHO HATCHERY
TECHNICAL SPECIFICATIONS

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SECTION 23 00 00 – HEATING, VENTILATION, AND AIR CONDITIONING, GENERAL

PART 1 -- GENERAL

1.1 ALTERNATES

A. Take cognizance of any change required in this work which may be a direct result of any alternate bid item listed and include the price deemed necessary to meet the requirements of the respective alternate.

1.2 BIDDING

A. The Contractor shall provide labor, materials, equipment, items, articles, operations and methods listed, shown, scheduled, or mentioned on the drawings, and/or specified, including all incidentals required for their completion.

B. The Contractor shall refer to the General part of these specifications, such as Instructions to Bidders, Special Conditions and DIVISION 1 for restrictions covering time that work can be performed in certain areas, noisy and dusty operations, sequence of work, access to restricted areas and similar types of work and operations.

1.3 SUBSTITUTIONS

A. Most items in this Division are eligible for substitution in accordance with the General Conditions and Supplements thereto. Where a proprietary specification is written for a particular item, then only that item may be used.

B. When the Engineer deems it necessary, to assure satisfactory installation and compatibility with other equipment, piping, ductwork, electrical provisions and other appurtenances, the Contractor shall prepare scale drawings of the substitute item showing proposed location, connections, relation to other equipment and other pertinent data such as maintenance space requirements, electrical requirements, height and weight. Drawings must receive Engineer's approval before the substitution is made.

C. It is the Contractor's responsibility that the substitute item shall fit into the space allocated and that the item can be installed and function as intended. Should changes in the work of any Contractor become necessary as a result of any substitute item under this Division, such changes shall be arranged and paid for by this Contractor.

D. Capacities of substitute items shall not be less than that of the specified item.

E. The performance of the factory representative and supplier on past work will be a consideration in the approval process of substitute items.

F. The final decision as to acceptability rests with the Engineer.

1.4 CODES, REGULATIONS AND PERMITS

A. All materials and equipment shall be new, approved by the governing authority, and be in new, undamaged condition when installed.

B. Comply with the International Mechanical Code, National Fire Protection Association

Fire Codes, State of Idaho Plumbing Code (Uniform Plumbing Code – latest approved edition), International Building Code, and all other applicable Federal, State, County and City codes, regulations and ordinances. Comply with DIVISION 16 and all codes referenced therein for any and all electrical work accomplished under this Division or by this Contractor.

C. Arrange for and obtain all permits and approvals required for the execution of the work.

1.5 INTENT OF DRAWINGS

A. Pipe or duct risers and other diagrams are schematic only and not to scale. They are intended only to indicate sizes or relative arrangement of pipe and equipment shown elsewhere in plan view.

B. Some items defined in these specifications may not actually be required in this work scope. This fact does not render the remaining specifications null, nor does it relieve the contractor from complying with these specifications as they apply to the work defined in the project documents.

1.6 WORKMANSHIP

A. Work shall be accomplished by workmen skilled in the particular trade, in conformance with best practices and to meet all applicable codes.

B. This Contractor shall replace materials or equipment not properly installed or finished, without increase in payment received.

1.7 RESPONSIBILITY

A. The Contractor is responsible for installation of a satisfactory and complete piece of work in accordance with true intent of the drawings and specifications.

B. Consult all drawings for the project to predetermine that the work and equipment will fit as planned.

C. The location of piping, ducts, equipment, etc., shall be checked to ensure clearance from openings, structural members, cabinets, lights, outlets, and equipment having fixed locations. This shall be accomplished prior to fabrication of pipe or ducts.

D. If, at any time, and in any case, changes in location of piping, ducts, equipment, etc., becomes necessary due to existing obstacles or installation of other trades shown on any of the project drawings and such conflict could have been avoided by proper coordination between trades or proper pre-planning of work, such required changes shall be made by the Contractor at no extra cost. These changes are to be recorded on the record drawings.

E. This Contractor is responsible to provide all incidental electrical interconnections, control wiring, etc., which are necessary for system completion and which are not specifically shown or otherwise indicated on the electrical drawings or specified in DIVISION 26.

F. All electrical work incidental to or accomplished under this Division shall comply with all requirements of DIVISION 26.

1.8 WARRANTY

A. Contractor shall guarantee the installation under his scope of work free from defects of workmanship and materials for a period of one year after the date of substantial completion and promptly remedy any defects developing during this period without charge. Contractor must assume responsibility for all expenses incurred to repair or replace his work as well as work of other trades that may be affected by this replacement.

B. Under certain circumstances, phasing will require particular pieces of equipment to be started up prior to the Substantial Completion Date. Contractor to assume responsibility for operation of this equipment and be cognizant of warranty to owner shall still be provided for the full one-year duration after Substantial Completion.

1.9 DELIVERY AND STORAGE OF MATERIALS

A. Make provisions for introduction into the building of equipment furnished under this Division. Refer to DIVISION I for additional provisions to allow equipment passage into the building.

A. All materials shall be protected from damage and from weather. Cover, enclose and protect all stored materials and preserve in new, clean condition. Keep all openings in pipe, ductwork and equipment closed with caps and covers. All materials shall be elevated above the ground or floor during storage.

C. All materials and products installed shall be new and shall be in new and undamaged condition. Materials that are rusted, weathered or otherwise depleted in condition shall not be installed.

1.10 MANUFACTURER'S DIRECTIONS

A. Manufactured materials and equipment shall be applied, installed, connected, erected, used, cleaned and conditioned as directed by the manufacturer unless noted otherwise herein or on the drawings.

B. Certain items of equipment, as noted herein, shall be checked out, started and put into service by factory representatives.

1.11 CUTTING, PATCHING, REPAIRING

A. Cutting, patching and repairing required by the work of this Division shall be the responsibility of this Contractor.

B. Work shall be performed in accordance with DIVISION 1 of these specifications.

C. The performance of this work shall not weaken the structural integrity of the building.

D. Any abrasion or disfigurement of the finished work or any portion of the building where any such abrasion or disfigurement is caused by the activities of the Contractor shall be repaired and neatly refinished to match the adjacent work.

1.12 OPENINGS IN DUCTS

A. Openings in ducts shall be kept closed during progress of work.

B. The Contractor is required to clean new systems found dirty to the satisfaction of the Engineer at no additional cost.

1.13 CLEANUP

A. Upon completion of work, remove materials, scraps, etc., relative to this work and leave the premises in a clean and orderly condition. This applies equally to finished, unfinished and concealed spaces.

B. Clean equipment of dirt and debris.

1.14 SAMPLES

A. The Contractor shall submit actual production samples on any material or equipment requested if, in the Engineer's opinion, it is necessary in order to determine the quality, workmanship, operation, etc. of the item.

B. Samples will be returned to the Contractor. Approved samples may be used on the job.

C. Costs incurred in providing and returning samples will be the responsibility of the Contractor.

1.15 TEMPORARY SERVICES

A. See DIVISION 1 - GENERAL REQUIREMENTS for Temporary Facilities.

1.16 FIRE PROTECTION

A. Metallic pipe, duct and other penetrations of all fire partitions, walls and floors shall be effectively fire-stopped to equal the fire rating of the floor or partition using materials and methods UL approved and tested to meet all conditions of ASTME E119, UL 1479 and ASTME 814 tests. One such material is Carborundum bulk "Fiberfrax" fiber packing for filling the annual space between pipe and sleeve or hole and Fiberfrax LDS moldable caulking for sealing in the fiber packing. Other acceptable materials are Dow Corning 3-6548 Silicon RTV foam firestop system, General Electric 'Pensil' 851 system or U.S.G. fire code compound and Thermafire.

B. PVC pipe, duct penetrations to be fire stopped same as metallic penetrations with the addition of an intumescent wrap to effectively close the hole if PVC vaporizes.

C. Construction of permanent bracing, framing, roof curbs and platforms or other structures which utilize wood construction shall be fabricated from fire resistant treated materials or shall be otherwise protected by approved fire resistant materials.

1.17 ACCESS DOORS

A. Where access to valves, dampers, equipment, etc. is required, provide Inryco/Milcor Type "K", "DW", or "M" doors. Access doors required in fire-rated walls or ceilings shall be U.L. approved, similar and equal to Ruskin #APW1. Size of door shall be sufficient to provide proper access to item, if size is not listed on the drawings.

1.18 COMPLETION AND TESTS

A. Complete and test each system as specified. Submit all reports and complete the Project Completion Checklist in PART 3 of this Section. Leave all systems in proper operation.

B. At the time of finalizing the project, a demonstration of all systems shall be performed in the presence of the Owner's designated representative. The Contractor shall demonstrate that the systems perform in the manner described in the specifications and indicated on the drawings.

1.19 OPERATING INSTRUCTIONS

A. The Contractor shall provide qualified personnel to instruct the Owner's maintenance personnel in the operation and maintenance of all the new systems and equipment. In general, the installer of the system may give these instructions. However, some equipment or systems require instruction be given by an authorized agent of the supplier or manufacturer. See the individual Sections of this Division for specific training requirements.

B. Written operation and maintenance instructions, as produced by the manufacturer, shall be provided for all equipment. These instructions shall be bound and submitted as described in this Section.

1.20 RECORD DRAWINGS

A. A separate set of mechanical drawings shall be maintained at the job site at all times and shall be used as record drawings. This set shall be kept up to date with all changes and/or additions in the construction and/or mechanical systems, and shall be delivered to the Engineer at the completion of this job. This set of drawings shall be kept clean and protected at all times.

1.21 GENERAL

A. The literature required to be submitted and approved in order to fulfill the requirements of this Division falls into two general categories. These are the "Brochures of Equipment" and "Submittals."

B. "Submittals" is a general term for informational literature that must be supplied to and approved by the Contractor and the Engineer prior to installing, receiving, or in some instances, even ordering equipment. The normal required types of submittals include shop drawings, manufacturer's literature, installation and operation instructions (from the manufacturer) and wiring diagrams. System reports, such as start-up reports or balancing reports, and the project completion checklist are two forms of submittals that are required after the equipment has been installed and is operational

C. Brochures of Equipment are booklets assembled by the contractor that contain operation, maintenance and repair literature for all equipment installed under the requirements of the project. They will be used by the Owner's personnel as the primary source of information for operating and maintaining the installed systems. As such, they shall exhibit a professional quality, high degree of clarity and durability that will allow their use throughout the useful life of the installed system.

1.22 SUBMITTALS

A. The contractor shall procure all manufacturers' literature and produce or have produced, all drawings, calculations or other data as required by either the Submittal Schedule contained in this Section or as specifically called out in the individual Sections of this Division.

B. Submittal materials shall be complete in every respect and shall clearly indicate equipment features, dimensions, weights, performance characteristics and capacities. Capacity and performance calculations shall be adjusted to indicate actual equipment performance at the project elevation. Literature or drawings that describe more than one model or size of equipment shall be marked with arrows or otherwise clearly inscribed to identify the actual equipment that will be furnished. All options and special parts of features shall also be clearly identified. All submitted materials must be clear, complete and legible. Copies or duplications of poor quality will not be reviewed or accepted.

C. Where specified or otherwise required, proof of equipment compliance with standards or listings by specific agencies (e.g. AGA, ASME, etc.) shall be included in submittal material.

D. Submittals for all equipment shall be routed through and reviewed by the Contractor. The Contractor shall check all submittals for adequate identification, number of copies, correctness and compliance with contract drawings and specifications and apply his stamp of approval. For submittals that are required to be reviewed by the Engineer, a minimum of six copies shall be forwarded for approval after review and approval by the Contractor. These shall be returned and shall be revised and resubmitted until acceptable and approved by the Engineer. A minimum of two copies of each submittal will be retained by the Architect and Engineer. Copies of ALL submittals, including those which are not required to be forwarded for the Engineer's approval, shall be included in the Brochures of Equipment.

E. Submittals may be accepted or rejected by the Engineer in their entirety. Upon rejection of any entire submittal, the entire submittal package shall be resubmitted. No partial approval will be granted for any equipment that is a part of a submittal which has been rejected in its entirety.

F. If the Engineer "Rejects" or asks for "Revise and Resubmit" for any individual item in a particular submittal, then just that individual item shall be re-submitted by the Contractor.

G. Individual submittals may include data for more than one piece of equipment. However, submittal data for equipment specified in different sections of specifications shall not be included in the same submittal package. For example, submittal data for plumbing fixtures specified in Section 22 40 00 shall not be included in the same submittal package as data for pipe hangers as specified in Section 22 05 29.

H. Submittals shall be bound by staples, comb binders or flexible post binders. Three-ring binders shall not be used. Submittals not bound as specified herein shall be rejected and returned without review.

I. Approval of submittals by the Engineer shall not relieve the Contractor from responsibility for deviations from drawings or specifications, nor shall it relieve him from responsibility for errors in shop drawings or other submittal literature.

1.23 SUBMITTAL SCHEDULE

A. The following is an index of the Sections of this Division and a schedule of the submittal data required for each Section. Items marked "c" under each heading for the various submittal forms shall be submitted to the Contractor for review and approval. Items marked "c" and "e" are to be forwarded to the Engineer for review and approval after the Contractor has affixed his approval. All marked items shall be included in the Brochures of Equipment whether or not they require initial forwarding to the Engineer. All submittal literature appearing in the Brochures of Equipment shall be stamped or marked as approved by the Contractor.

B. All submittals required by the schedule shall be checked, revised as necessary, and approved by the Contractor. Submittals, which are required to be forwarded to the Engineer, shall first be reviewed and approved by the Contractor.

C. Submit any additional materials, not found on the Submittal Schedule, as required by the contract drawings or individual Sections of this Division of contract specifications.

1.24 BROCHURES OF EQUIPMENT

A. The Contractor shall prepare and submit three complete Brochures of Equipment. Each shall contain all required submittal data for the construction materials and each piece of equipment installed under this project. The literature required for submittal purposes shall be expanded to include operation and maintenance literature for each piece of equipment. Maintenance information shall be complete in every respect and shall include parts lists and assembly drawings wherever applicable. Manuals, catalogs, etc., shall be new, as supplied by the factory, and not photocopied. The Brochures shall also include a copy of the SUBMITTAL SCHEDULE and a final copy of the project COMPLETION CHECKLIST.

B. All literature shall clearly indicate the equipment it represents and shall be labeled with the equipment identification abbreviation found on the drawings, e.g. EF-1, etc. All information which is not applicable to the particular model and size supplied shall be clearly and neatly crossed out with heavy black marker or other suitable means. This includes dimensional drawings, maintenance information, parts lists, wiring diagrams, etc. Only the information applicable to the particular equipment supplied shall remain and it shall be easy to follow. Booklets not meeting these requirements shall be returned for correction.

C. Binders shall be high quality telescoping post type with slide or lever release, metal hinges, and covered hardboard or rigid plastic covers.

D. Dividers shall be used to separate the literature for equipment supplied under each of the various Sections of this Division. Divider headings shall read the same as the Section title e.g. "22 07 00 PLUMBING INSULATION."

E. Large size drawings or diagrams shall be folded and placed in heavyweight sheets with pockets.

F. The format of the Brochure shall begin with the submittal requirement list at the front as an index sheet. The dividers for each section shall then progress sequentially and the project completion checklist shall be included at the back as the appendix.

G. Authorization for final payment shall not be made prior to final acceptance of the Brochures of Equipment.

1.25 COMPLETION CHECKLIST

A. The following checklist shall be completed by contractor and submitted to A/E before final site visitation or job acceptance is made.

B. Refer to each specific specification section listed for a more complete description of listed test requirements.

MECHANICAL:

SPEC. SECTION	ITEM	DATE	CORRECTED OR COMPLETED BY (NAME OR INITIALS)
230000	Demonstrate to owner that all systems are functioning properly.		
230000	Provide record drawings.		
230000	Provide Brochures of Equipment.		
230593	Provide air balance test report.		
230593	Provide water balance test report.		
230900	Test temperature controls and instruct owner's personnel.		
232300	Test refrigeration system.		
232300	Clean refrigeration system.		
233113	Test, balance & clean low pressure duct.		
233113	Test, balance & clean medium & high pressure duct system.		
233600	Test & balance air terminal units.		
235400	Test and balance electric furnaces.		

236400	Test water chiller.	______________________________
236400	Provide water chiller certification.	______________________________
236400	Provide water chiller instructions to Owner's personnel.	______________________________
238239	Test and balance unit heaters and provide Report	___________________________
233423	Test, balance & clean Power ventilators	_____________________________

Job Name: ____

Location: _________________________

Job#: _______________________________

Contractor: ____

Submitted by: _____________________________________ ____________
Name Date

1.26 SUBSTITUTION REQUEST FORM

A. The following Substitution Request Form shall be completed by Contractor and submitted to A/E for review of equipment or materials prior to bid as defined in sub-section 1.3 of Section 23 00 00.

B. Review of the substitution request form is only for general conformance with the design concept of the project and general compliance with the information given in the contract documents. Any action shown is subject to the requirements of the plans and specifications. Contractor is responsible for: dimensions which shall be confirmed and correlated at the job site, fabrication processes and techniques of construction, coordination of their work with that of all other trades, and the satisfactory performance of the work.

PROJECT: ____

SPECIFIED ITEM: ____
Section Page Paragraph Description/Tag

The undersigned requests consideration of the following:

PROPOSED SUBSTITUTION: ____

<u>Attached</u> data includes product description, specifications, drawings, photographs, performance and test data adequate for evaluation of the request; applicable portions of the data are clearly identified.

<u>Attached</u> data also includes a description of changes to Contract Documents that the proposed substitution will require for its proper installation.

The undersigned certifies that the following paragraphs, unless modified by attachments, are correct:

1. The proposed substitution does not affect dimensions shown on Drawings.

2. The undersigned will pay for changes to the project design, including engineering design, detailing and construction costs caused by the requested substitution.

3. The proposed substitution will have no adverse affect on other trades, the construction schedule, or specified warranty requirements.

4. Maintenance and service parts will be locally available for the proposed substitution.

5. The undersigned further certifies that the performance, capacity, function, appearance and quality of the proposed substitution are equivalent or superior to the specified item.

The undersigned agrees that, if this page is reproduced, the terms and conditions for substitutions found in the Bidding Documents apply to this request.

Submitted by:

____

Name General Contractor (if after award of contract)

____
Signature

____
Firm Name

____
Address

____
City, State, Zip

____
Date

____
Telephone Fax

For use by the A/E

☐ No Exception Taken

☐ Exception Taken, Revise as noted.

☐ Request Denied

☐ Document not submitted per the Contract Documents

By ______________________________

Date ______________________________

Remarks ______________________________

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

- END OF SECTION -

SECTION 23 05 00 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. **This Section includes the following:**

1. Piping materials and installation instructions common to most piping systems
2. Dielectric fittings
3. Mechanical sleeve seals
4. Sleeves
5. Escutcheons
6. Grout
7. HVAC demolition
8. Equipment installation requirements common to equipment sections
9. Concrete bases
10. Supports and anchorages

1.2 DEFINITIONS

A. **Finished Spaces**: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. **Exposed, Interior Installations**: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. **Exposed, Exterior Installations**: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. **Concealed, Interior Installations**: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

E. **Concealed, Exterior Installations**: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.3 SUBMITTALS

A. Welding certificates.

1.4 QUALITY ASSURANCE

A. **Steel Support Welding**: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. **Steel Pipe Welding**: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."

2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. **Electrical Characteristics for HVAC Equipment**: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

PART 2 - PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.

B. **Pipe Threads**: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.2 JOINING MATERIALS

A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

B. **Pipe-Flange Gasket Materials**: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.

C. **Plastic, Pipe-Flange Gasket, Bolts, and Nuts**: Type and material recommended by piping system manufacturer, unless otherwise indicated.

D. **Solder Filler Metals**: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.

E. **Brazing Filler Metals**: AWS A5.8, BCuP Series or BAg1, unless otherwise indicated.

F. **Welding Filler Metals**: Comply with AWS D10.12.

G. **Solvent Cements for Joining Plastic Piping**:

1. CPVC Piping: ASTM F493.

2. PVC Piping: ASTM D2564. Include primer according to ASTM F656.

2.3 DIELECTRIC FITTINGS

A. **Description**: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. **Insulating Material**: Suitable for system fluid, pressure, and temperature.

C. **Dielectric Unions**: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F

D. **Dielectric Flanges**: Factory-fabricated, companion-flange assembly, for 150- or 300-psig (1035) minimum working pressure as required to suit system pressures.

E. **Dielectric Couplings**: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F (107 deg C).

F. **Dielectric Nipples**: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F.

2.4 MECHANICAL SLEEVE SEALS

A. **Description**: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

B. **Sealing Elements**: EDPM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

C. **Pressure Plates**: Stainless Steel. Include two for each sealing element.

D. **Connecting Bolts and Nuts**: Stainless Steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.5 SLEEVES

A. **Galvanized-Steel Sheet**: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

B. **Steel Pipe**: ASTM A53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. **Cast Iron**: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. **Stack Sleeve Fittings**: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with set screws.

E. **Molded PVC**: Permanent, with nailing flange for attaching to wooden forms.

F. **PVC Pipe**: ASTM D1785, Schedule 40.

G. **Molded PE**: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

2.6 ESCUTCHEONS

A. **Description**: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. **One-Piece, Deep-Pattern Type:** Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. **One-Piece, Cast-Brass Type**: With set screw.

1. Finish: Polish chrome-plated.

D. **Split-Casting, Cast-Brass Type**: With concealed hinge and set screw.

1. Finish: Polished chrome-plated.

2.7 GROUT

A. **Description**: ASTM C1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.

2. Design Mix: 5000-psi 28-day compressive strength.

3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 HVAC DEMOLITION

A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.

2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.

3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.

4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.

5. Equipment to Be Removed: Disconnect and cap services and remove equipment.

6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.

7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors.

M. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

N. **Aboveground, Exterior-Wall Pipe Penetrations**: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.

2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.

3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

O. **Underground, Exterior-Wall Pipe Penetrations**: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

P. **Fire-Barrier Penetrations**: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

Q. Verify final equipment locations for roughing-in.

R. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.3 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. **Soldered Joints**: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. **Brazed Joints**: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. **Threaded Joints**: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. **Welded Joints**: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. **Flanged Joints**: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. **Plastic Piping Solvent-Cement Joints**: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F402, for safe-handling practice of cleaners, primers, and solvent cements.

2. CPVC Piping: Join according to ASTM D2846/D2846M Appendix.

3. PVC Pressure Piping: Join schedule number ASTM D1785, PVC pipe and PVC socket fittings according to ASTM D2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D2855.

4. PVC Nonpressure Piping: Join according to ASTM D2855.

J. **Plastic Pressure Piping Gasketed Joints**: Join according to ASTM D3139.

K. **Plastic Nonpressure Piping Gasketed Joints**: Join according to ASTM D3212.

L. **PE Piping Heat-Fusion Joints**: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D2657.

1. Plain-End Pipe and Fittings: Use butt fusion.

2. Plain-End Pipe and Socket Fittings: Use socket fusion.

M. **Fiberglass Bonded Joints**: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.4 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.

2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.6 CONCRETE BASES

A. **Concrete Bases**: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.

2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.

3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.

4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

5. Install anchor bolts to elevations required for proper attachment to supported equipment.

6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Miscellaneous Cast-in-Place Concrete."

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

C. **Field Welding**: Comply with AWS D1.1.

3.8 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.9 GROUTING

A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

- END OF SECTION -

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SECTION 23 05 13 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.2 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.

2. Torque, speed, and horsepower requirements of the load.

3. Ratings and characteristics of supply circuit and required control sequence.

4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS

A. **Duty:** Continuous duty at ambient temperature of 40 deg C and at altitude of 2,000 feet above sea level.

B. **Capacity and Torque Characteristics**: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. **Description**: NEMA MG 1, Design B, medium induction motor.

B. **Efficiency**: Energy efficient, as defined in NEMA MG 1.

C. **Service Factor**: 1.15.

D. **Multispeed Motors**: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.

2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. **Rotor:** Random-wound, squirrel cage.

F. **Bearings**: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. **Temperature Rise**: Match insulation rating.

H. **Insulation**: Class F.

I. **Code Letter Designation**:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.

2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

J. **Enclosure Material**: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. **Motors Used with Reduced-Voltage and Multispeed Controllers**: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. **Motors Used with Variable Frequency Controllers**:

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.

2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.

3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.

4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.

2. Split phase.

3. Capacitor start, inductor run.

4. Capacitor start, capacitor run.

B. **Multispeed Motors**: Variable-torque, permanent-split-capacitor type.

C. **Bearings**: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. **Motors 1/20 HP and Smaller**: Shaded-pole type.

E. **Thermal Protection**: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (NOT USED)

- END OF SECTION -

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SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. **This Section includes Testing, Adjusting, and Balancing (TAB) to produce design objectives for the following**:

1. Air Systems:

    a. Variable-air-volume systems.

    b. Ventilation and exhaust systems.

2. HVAC equipment quantitative-performance settings.

3. Verifying that automatic control devices are functioning properly.

4. Reporting results of activities and procedures specified in this Section.

1.2 SUBMITTALS

A. **Strategies and Procedures Plan**: Within 30 days from Contractor's Notice to Proceed, submit 2 copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.

B. **Certified TAB Reports**: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.

C. Warranties specified in this Section.

1.3 QUALITY ASSURANCE

A. **TAB Firm Qualifications**: Engage a TAB firm certified by AABC, NEBB or TABB or approved by the engineer.

1. The contractor shall submit the name and credentials of the TAB firm for review and approval within 30 days after signing the construction contract.

    a. The TAB firm shall provide qualifications of the firm and of both the individual who is to do the test and balance. Provide proof of completed balancing work on at least five projects of similar size and scope, along with a list of references which may verify qualifications.

    b. Final approval of the TAB firm will be at the Engineer’s discretion, based on the information submitted.

B. **Certification of TAB Reports**: Certify TAB field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.

2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.

C. **TAB Report Forms**: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems." or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."

1.4 PROJECT CONDITIONS

A. **Partial Owner Occupancy**: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.5 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

1. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine Project Record Documents described in Division 01 Section "Project Record Documents."

D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

G. Examine system and equipment test reports.

H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

K. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.

L. Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

M. Examine strainers for clean screens and proper perforations.

N. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

O. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

P. Examine system pumps to ensure absence of entrained air in the suction piping.

Q. Examine equipment for installation and for properly operating safety interlocks and controls.

R. **Examine automatic temperature system components to verify the following**:

1. Dampers, valves, and other controlled devices are operated by the intended controller.

2. Dampers and valves are in the position indicated by the controller.

3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.

4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.

5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.

6. Sensors are located to sense only the intended conditions.

7. Sequence of operation for control modes is according to the Contract Documents.

8. Controller set points are set at indicated values.

9. Interlocked systems are operating.

10. Changeover from heating to cooling mode occurs according to indicated values.

S. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:

1. Permanent electrical power wiring is complete.

2. Hydronic systems are filled, clean, and free of air.

3. Automatic temperature-control systems are operational.

4. Equipment and duct access doors are securely closed.

5. Balance, smoke, and fire dampers are open.

6. Isolating and balancing valves are open and control valves are operational.

7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.

8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

E. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling unit components.

L. Check for proper sealing of air duct system.

3.5 PROCEDURES FOR EXHAUST SYSTEMS SYSTEM AND VENTILATION FAN SYSTEMS.

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure fan static pressures to determine actual static pressure as follows:

    a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.

    b. Measure static pressure directly at the fan outlet or through the flexible connection.

    c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.

    d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

2. Measure static pressure across each component that makes up the system.

3. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.

4. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.

5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.

B. Adjust volume dampers to indicated airflows within specified tolerances.

    1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.

C. Measure inlets without making adjustments.

D. Adjust inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers.

3.6 PROCEDURES FOR MOTORS

A. **Motors, 1/2 HP and Larger**: Test at final balanced conditions and record the following data:

    1. Manufacturer, model, and serial numbers.

    2. Motor horsepower rating.

    3. Motor rpm.

4. Efficiency rating.

5. Nameplate and measured voltage, each phase.

6. Nameplate and measured amperage, each phase.

7. Starter thermal-protection-element rating.

B. **Motors Driven by Variable-Frequency Controllers**: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.7 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record compressor data.

3.8 PROCEDURES FOR TEMPERATURE MEASUREMENTS

A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.

B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

C. Measure outside-air, wet- and dry-bulb temperatures.

3.9 TEMPERATURE-CONTROL VERIFICATION

A. The temperature control system test and report shall be performed by the temperature control contractor.

B. Verify that controllers are calibrated and commissioned.

C. Check transmitter and controller locations and note conditions that would adversely affect control functions.

D. Record controller settings and note variances between set points and actual measurements.

E. Check the operation of limiting controllers (i.e. high- and low-temperature controllers).

F. Check free travel and proper operation of control devices such as damper and valve operators.

G. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.

H. Check the interaction of electrically operated switch transducers.

I. Check the interaction of interlock and lockout systems.

J. Check main control supply-air pressure and observe compressor and dryer operations.

K. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or non-grounded power supply.

L. Note operation of electric actuators using spring return for proper fail-safe operations.

3.10 TOLERANCES

A. **Set HVAC system airflow and water flow rates within the following tolerances**:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 5 to plus 10 percent.

2. Air Outlets and Inlets: 0 to minus 10 percent.

3. Heating-Water Flow Rate: 0 to minus 10 percent.

4. Cooling-Water Flow Rate: 0 to minus 5 percent.

3.11 FINAL REPORT

A. **General:** Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.

1. Include a list of instruments used for procedures, along with proof of calibration.

C. **Final Report Contents**: In addition to certified field report data, include the following:

1. Fan curves.

2. Manufacturers' test data.

3. Field test reports prepared by system and equipment installers.

4. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

D. **General Report Data**: In addition to form titles and entries, include the following data in the final report, as applicable:

1. Title page.
2. Name and address of TAB firm.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB firm who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:
    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.
12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer, type size, and fittings.
14. Notes to explain why certain final data in the body of reports varies from indicated values.
15. Test conditions for fans and pump performance forms including the following:
    a. Settings for outside-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.

g. Settings for supply-air, static-pressure controller.

h. Other system operating conditions that affect performance.

E. **System Diagrams**: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outside, supply, return, and exhaust airflows.

2. Water and steam flow rates.

3. Duct, outlet, and inlet sizes.

4. Pipe and valve sizes and locations.

5. Terminal units.

6. Balancing stations.

7. Position of balancing devices.

3.12 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

- END OF SECTION -

SECTION 23 07 00 - HVAC INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. **Section Includes**:

1. Insulation Materials:

    a. Cellular glass

    b. Flexible elastomeric

    c. Mineral fiber

    d. Polyolefin

    e. Polystyrene

2. Fire-rated insulation systems:

3. Insulating cements

4. Adhesives

5. Mastics

6. Sealants

7. Factory-applied jackets

8. Field-applied fabric-reinforcing mesh

9. Field-applied jackets

10. Tapes

11. Securements

12. Corner angles

1.2 SUBMITTALS

A. **Product Data**: For each type of product indicated.

B. **Shop Drawings**:

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.

2. Detail attachment and covering of heat tracing inside insulation.

3. Detail insulation application at pipe expansion joints for each type of insulation.

4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.

5. Detail removable insulation at piping specialties, equipment connections, and access panels.

6. Detail application of field-applied jackets.

7. Detail application at linkages of control devices.

8. Detail field application for each equipment type.

C. Field quality-control reports.

1.3 QUALITY ASSURANCE

A. **Fire-Test-Response Characteristics**: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Pittsburgh Corning Corporation; Foamglas Super K.

2. Block Insulation: ASTM C552, Type I.

3. Special-Shaped Insulation: ASTM C552, Type III.

4. Board Insulation: ASTM C552, Type IV.

5. Preformed Pipe Insulation without Jacket: Comply with ASTM C552, Type II, Class 1.

6. Preformed Pipe Insulation with Factory-Applied [ASJ-SSL]: Comply with ASTM C552, Type II, Class 2.

7. Factory fabricate shapes according to ASTM C450 and ASTM C585.

G. **Flexible Elastomeric**: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, Type I for tubular materials and Type II for sheet materials.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Aeroflex USA Inc.; Aerocel.

    b. Armacell LLC; AP Armaflex.

H. **Mineral-Fiber Blanket Insulation**: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II and ASTM C1290, Type II with factory-applied vinyl jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. CertainTeed Corp.; Duct Wrap.

    b. Johns Manville; Microlite.

    c. Knauf Insulation; Duct Wrap.

    d. Owens Corning; All-Service Duct Wrap.

I. **High-Temperature, Mineral-Fiber Blanket Insulation**: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type V, without factory-applied jacket.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Johns Manville; HTB 23 Spin-Glas.

b. Owens Corning; High Temperature Flexible Batt Insulations.

J. **Mineral-Fiber Board Insulation**: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied ASJ. For equipment applications, provide insulation with factory-applied AS. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. CertainTeed Corp.; Commercial Board.

b. Fibrex Insulations Inc.; FBX.

c. Johns Manville; 800 Series Spin-Glas.

d. Knauf Insulation; Insulation Board.

e. Owens Corning; Fiberglas 700 Series.

K. **High-Temperature, Mineral-Fiber Board Insulation**: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type III, without factory-applied jacket.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Fibrex Insulations Inc.; FBX.

b. Johns Manville; 1000 Series Spin-Glas.

c. Owens Corning; High Temperature Industrial Board Insulations.

d. Rock Wool Manufacturing Company; Delta Board.

e. Roxul Inc.; Roxul RW.

f. Thermafiber; Thermafiber Industrial Felt.

L. **Mineral-Fiber, Preformed Pipe Insulation**:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Fibrex Insulations Inc.; Coreplus 1200.

b. Johns Manville; Micro-Lok.

c. Knauf Insulation; 1000 Pipe Insulation.

d. Owens Corning; Fiberglas Pipe Insulation.

2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

M. **Mineral-Fiber, Pipe Insulation Wicking System**: Preformed pipe insulation complying with ASTM C547, Type I, Grade A, with absorbent cloth factory applied to the entire inside surface of preformed pipe insulation and extended through the longitudinal joint to outside surface of insulation under insulation jacket. Factory apply a white, polymer, vapor-retarder jacket with self-sealing adhesive tape seam and evaporation holes running continuously along the longitudinal seam, exposing the absorbent cloth.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Knauf Insulation; Permawick Pipe Insulation.

b. Owens Corning; VaporWick Pipe Insulation.

N. **Mineral-Fiber, Pipe and Tank Insulation**: Mineral or glass fibers bonded with a thermosetting resin. Semi-rigid board material with factory-applied (ASJ) complying with ASTM C1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. CertainTeed Corp.; CrimpWrap.

b. Johns Manville; Micro-Flex.

c. Knauf Insulation; Pipe and Tank Insulation.

d. Owens Corning; Fiberglas Pipe and Tank Insulation.

O. **Polyolefin:** Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C534 or ASTM C1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Armacell LLC; Tubolit.

b. Nomaco Inc.; IMCOLOCK, IMCOSHEET, NOMALOCK, and NOMAPLY.

c. RBX Corporation; Therma-cell.

P. **Polystyrene**: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C578, Type IV or Type XIII, except thermal conductivity (k-value) shall not exceed 0.26 Btu x in./h x sq. ft. x deg F after 180 days of aging. Fabricate shapes according to ASTM C450 and ASTM C585.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Dow Chemical Company (The); Styrofoam.

b. Knauf Insulation; Knauf Polystyrene.

2.2 INSULATING CEMENTS

A. **Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement**: Comply with ASTM C449/C449M.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Insulco, Division of MFS, Inc.; SmoothKote.

b. P. K. Insulation Mfg. Co., Inc.; PK No. 127, and Quik-Cote.

c. Rock Wool Manufacturing Company; Delta One Shot.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. **Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive**: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Products, Division of ITW; CP-96.

b. Foster Products Corporation, H.B. Fuller Company; 81-33.

C. **Flexible Elastomeric and Polyolefin Adhesive**: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Aeroflex USA Inc.; Aeroseal.

b. Armacell LCC; 520 Adhesive.

c. Foster Products Corporation, H.B. Fuller Company; 85-75.

d. RBX Corporation; Rubatex Contact Adhesive.

D. **Mineral-Fiber Adhesive**: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Products, Division of ITW; CP-82.

b. Foster Products Corporation, H.B. Fuller Company; 85-20.

E. **Polystyrene Adhesive**: Solvent- or water-based, synthetic resin adhesive with a service temperature range of minus 20 to plus 140 deg F.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Products, Division of ITW; CP-96.

b. Foster Products Corporation, H.B. Fuller Company; 97-13.

F. **ASJ Adhesive, and FSK and PVDC Jacket Adhesive**: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Products, Division of ITW; CP-82.

b. Foster Products Corporation, H.B. Fuller Company; 85-20.

c. ITW TACC, Division of Illinois Tool Works; S-90/80.

d. Marathon Industries, Inc.; 225.

e. Mon-Eco Industries, Inc.; 22-25.

G. **PVC Jacket Adhesive**: Compatible with PVC jacket.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Dow Chemical Company (The); 739, Dow Silicone.

b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.

c. P.I.C. Plastics, Inc.; Welding Adhesive.

d. Red Devil, Inc.; Celulon Ultra Clear.

e. Speedline Corporation; Speedline Vinyl Adhesive.

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.

B. **Vapor-Barrier Mastic**: Water based; suitable for indoor and outdoor use on below ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Childers Products, Division of ITW; CP-35.

   b. Foster Products Corporation, H. B. Fuller Company; 30-90.

   c. ITW TACC, Division of Illinois Tool Works; CB-50.

   d. Marathon Industries, Inc.; 590.

   e. Mon-Eco Industries, Inc.; 55-40.

   f. Vimasco Corporation; 749.

C. **Breather Mastic**: Water based; suitable for indoor and outdoor use on above ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Childers Products, Division of ITW; CP-10.

   b. Foster Products Corporation, H.B. Fuller Company; 35-00.

   c. ITW TACC, Division of Illinois Tool Works; CB-05/15.

   d. Marathon Industries, Inc.; 550.

   e. Mon-Eco Industries, Inc.; 55-50.

   f. Vimasco Corporation; WC-1/WC-5.

2.5 SEALANTS

A. **Joint Sealants**:

1. Joint Sealants for Cellular-Glass Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Childers Products, Division of ITW; CP-76.

   b. Foster Products Corporation, H.B. Fuller Company; 30-45.

c. Pittsburgh Corning Corporation; Pittseal 444.

2. **Joint Sealants for Polystyrene Products**: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Products, Division of ITW; CP-70.

b. Foster Products Corporation, H.B. Fuller Company; 30-45/30-46.

3. Materials shall be compatible with insulation materials, jackets, and substrates.

4. Permanently flexible, elastomeric sealant.

B. **FSK and Metal Jacket Flashing Sealants**:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Products, Division of ITW; CP-76-8.

b. Foster Products Corporation, H.B. Fuller Company; 95-44.

2. Materials shall be compatible with insulation materials, jackets, and substrates.

3. Fire- and water-resistant, flexible, elastomeric sealant.

C. **ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants**:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Products, Division of ITW; CP-76.

2. Materials shall be compatible with insulation materials, jackets, and substrates.

3. Fire- and water-resistant, flexible, elastomeric sealant.

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.

2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.

3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

2.7 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. **PVC Jacket**: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Johns Manville; Zeston.

   b. P.I.C. Plastics, Inc.; FG Series.

   c. Proto PVC Corporation; LoSmoke.

   d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.

3. Color: Color-code jackets based on system.

4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

   a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

5. Factory-fabricated tank heads and tank side panels.

D. **Aluminum Jacket**: Comply with ASTM B209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Childers Products, Division of ITW; Metal Jacketing Systems.

   b. PABCO Metals Corporation; Surefit.

   c. RPR Products, Inc.; Insul-Mate.

2. Sheet and roll stock ready for shop or field sizing.

3. Finish and thickness are indicated in field-applied jacket schedules.

4. Moisture Barrier for Indoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.

5. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.

6. Factory-Fabricated Fitting Covers:

   a. Same material, finish, and thickness as jacket.

   b. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.

   c. Tee covers.

   d. Flange and union covers.

   e. End caps.

   f. Beveled collars.

   g. Valve covers.

   h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. **Self-Adhesive Outdoor Jacket**: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with aluminum-foil facing.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Polyguard; Alumaguard 60.

F. **PVDC Jacket for Indoor Applications**: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E84.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Dow Chemical Company (The), Saran 540 Vapor Retarder Film.

G. **PVDC Jacket for Outdoor Applications**: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E84.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Dow Chemical Company (The), Saran 560 Vapor Retarder Film.

H. **PVDC-SSL Jacket**: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

2.8 TAPES

A. **ASJ Tape**: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.

b. Compac Corp.; 104 and 105.

c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.

d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

B. **FSK Tape**: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.

b. Compac Corp.; 110 and 111.

c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.

d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.

C. **PVC Tape**: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.

b. Compac Corp.; 130.

c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.

d. Venture Tape; 1506 CW NS.

D. **Aluminum-Foil Tape**: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.

    b. Compac Corp.; 120.

    c. Ideal Tape Co., Inc., an American Biltrite Company; 488 AWF.

    d. Venture Tape; 3520 CW.

E. **PVDC Tape for Indoor Applications**: White vapor-retarder PVDC tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Dow Chemical Company (The); Saran 540 Vapor Retarder Tape.

F. **PVDC Tape for Outdoor Applications**: White vapor-retarder PVDC tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Dow Chemical Company (The); Saran 560 Vapor Retarder Tape.

2.9 SECUREMENTS

A. **Aluminum Bands**: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing or closed seal.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Products; Bands.

    b. PABCO Metals Corporation; Bands.

    c. RPR Products, Inc.; Bands.

B. **Insulation Pins and Hangers**:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, and securely in position indicated when self-locking washer is in place. Comply with the following requirements:

    a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series T.

2) GEMCO; Perforated Base.

3) Midwest Fasteners, Inc.; Spindle.

2. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, and securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) GEMCO; Nylon Hangers.

2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.

3. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, and securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series TSA.

2) GEMCO; Press and Peel.

3) Midwest Fasteners, Inc.; Self Stick.

4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) AGM Industries, Inc.; RC-150.

2) GEMCO; R-150.

3) Midwest Fasteners, Inc.; WA-150.

4) Nelson Stud Welding; Speed Clips.

b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

      1) GEMCO.

      2) Midwest Fasteners, Inc.

C. **Staples**: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

D. **Wire**: 0.062-inch soft-annealed, galvanized steel.

   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

      a. C & F Wire.

      b. Childers Products.

      c. PABCO Metals Corporation.

      d. RPR Products, Inc.

2.10 CORNER ANGLES

A. **PVC Corner Angles**: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.

B. **Aluminum Corner Angles**: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B209, Alloy 3003, 3005, 3105 or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 PREPARATION

A. **Surface Preparation**: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that applies to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. **Install insulation with factory-applied jackets as follows**:

1. Draw jacket tight and smooth.

2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.

3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.

5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. **For above ambient services, do not install insulation to the following**:

1. Vibration-control devices.

2. Testing agency labels and stamps.

3. Nameplates and data plates.

4. Manholes.

5. Handholes.

6. Cleanouts.

3.3 PENETRATIONS

A. **Insulation Installation at Roof Penetrations**: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.

4. Seal jacket to roof flashing with flashing sealant.

B. **Insulation Installation at Underground Exterior Wall Penetrations**: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. **Insulation Installation at Aboveground Exterior Wall Penetrations**: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.

4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. **Insulation Installation at Fire-Rated Wall and Partition Penetrations**: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

1. Comply with requirements in Division 07 Section "Penetration Firestopping" Firestopping and fire-resistive joint sealers.

F. **Insulation Installation at Floor Penetrations**:

1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.

2. Pipe: Install insulation continuously through floor penetrations.

3.4 Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

A. **Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels**: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.

2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.

3. Protect exposed corners with secured corner angles.

4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

    a. Do not weld anchor pins to ASME-labeled pressure vessels.

    b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.

    c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.

    d. Do not overcompress insulation during installation.

    e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.

    f. Impale insulation over anchor pins and attach speed washers.

    g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.

6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.

7. Stagger joints between insulation layers at least 3 inches.

8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.

9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.

10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. **Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels**: Install insulation over entire surface of tanks and vessels.

1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.

2. Seal longitudinal seams and end joints.

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. **Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions**:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.

2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.

3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.

4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.

5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.

7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.

2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.

4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 CELLULAR-GLASS INSULATION INSTALLATION

A. **Insulation Installation on Straight Pipes and Tubes**:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.

2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.

3. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches o.c.

4. For insulation with factory-applied jackets on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. **Insulation Installation on Pipe Flanges**:

1. Install preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.

4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. **Insulation Installation on Pipe Fittings and Elbows**:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. **Insulation Installation on Valves and Pipe Specialties**:

1. Install preformed sections of cellular-glass insulation to valve body.

2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

3. Install insulation to flanges as specified for flange insulation application.

3.7 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

A. Seal longitudinal seams and end joints with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. **Insulation Installation on Pipe Flanges**:

1. Install pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.

4. Secure insulation to flanges and seal seams with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. **Insulation Installation on Pipe Fittings and Elbows**:

1. Install mitered sections of pipe insulation.

2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. **Insulation Installation on Valves and Pipe Specialties**:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.

2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

3. Install insulation to flanges as specified for flange insulation application.

4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.8 MINERAL-FIBER INSULATION INSTALLATION

A. **Insulation Installation on Straight Pipes and Tubes**:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.

2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.

3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.

4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. **Insulation Installation on Pipe Flanges**:

1. Install preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.

4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. **Insulation Installation on Pipe Fittings and Elbows**:

1. Install preformed sections of same material as straight segments of pipe insulation when available.

2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. **Insulation Installation on Valves and Pipe Specialties**:

1. Install preformed sections of same material as straight segments of pipe insulation when available.

2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.

3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

4. Install insulation to flanges as specified for flange insulation application.

E. **Blanket Insulation Installation on Ducts and Plenums**: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area.

2. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.

b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

d. Do not overcompress insulation during installation.

e. Impale insulation over pins and attach speed washers.

f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

3. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.

4. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

F. **Board Insulation Installation on Ducts and Plenums**: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area.

2. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.

   b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

   d. Do not overcompress insulation during installation.

   e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

3. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.

4. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

5. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.9 POLYOLEFIN INSULATION INSTALLATION

A. **Insulation Installation on Straight Pipes and Tubes**:

1. Seal split-tube longitudinal seams and end joints with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. **Insulation Installation on Pipe Flanges**:

1. Install pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as pipe insulation.

4. Secure insulation to flanges and seal seams with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. **Insulation Installation on Pipe Fittings and Elbows**:

1. Install mitered sections of polyolefin pipe insulation.

2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. **Insulation Installation on Valves and Pipe Specialties**:

1. Install cut sections of polyolefin pipe and sheet insulation to valve body.

2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

3. Install insulation to flanges as specified for flange insulation application.

4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.10 POLYSTYRENE INSULATION INSTALLATION

A. **Insulation Installation on Straight Pipes and Tubes**:

1. Secure each layer of insulation with tape or bands and tighten bands without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.

2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.

3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. **Insulation Installation on Pipe Flanges**:

1. Install preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch thickness.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polystyrene block insulation of same thickness as pipe insulation.

C. **Insulation Installation on Pipe Fittings and Elbows**:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. **Insulation Installation on Valves and Pipe Specialties**:

1. Install preformed section of polystyrene insulation to valve body.

2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

3. Install insulation to flanges as specified for flange insulation application.

3.11 FIELD-APPLIED JACKET INSTALLATION

A. **Where FSK jackets are indicated, install as follows**:

1. Draw jacket material smooth and tight.

2. Install lap or joint strips with same material as jacket.

3. Secure jacket to insulation with manufacturer's recommended adhesive.

4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.

5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturers recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

C. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

D. **Where PVDC jackets are indicated, install as follows**:

1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.

2. Wrap factory-presized jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.

3. Continuous jacket can be spiral wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.

4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. The 33-1/2-inch-circumference limit allows for 2-inch- overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.

5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.12 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. **Tests and Inspections**:

1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

2. Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.

3. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe,

three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.13 DUCT INSULATION SCHEDULE, GENERAL

A. **Plenums and Ducts Requiring Insulation**:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in nonconditioned space.
4. Indoor, exposed return located in nonconditioned space.
5. Outdoor, concealed supply and return.
6. Outdoor, exposed supply and return.

B. **Items Not Insulated**:

1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.

3.14 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. **Concealed or exposed, Supply Air Duct, Return Air Duct and Outside Air Duct**:

1. Insulation for concealed and round ducts shall be Type 75 fiberglass duct wrap, 2” thick with foil reinforced Kraft jacket.
2. Insulation for exposed rectangular ducts shall be Type 703 rigid fiberglass board, 1-1/2” thick with ASJ25 white Kraft foil laminate facing. Ductwork shall be considered exposed in all cases where it is not enclosed in shafts or is not located above hard or lay-in ceilings.

3.15 ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.

B. **Exposed, Supply Air Duct, Return Air Duct and Outside Air Duct**:

1. Fully adhered foamular extruded polystyrene closed-cell insulation board 1.3 pcf density 2 inch thick, with 0.016” thick aluminum jacketing secured to insulation with 100% coverage adhesive.

3.16 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.

C. **Heat-Exchanger (Water-to-Water for Heating Service) Insulation**: Mineral-fiber pipe and tank, 2 inches.

D. **Heating-Hot-Water Expansion/Compression Tank Insulation**: Mineral-Fiber Pipe and Tank: 1 inch thick.

E. **Heating-Hot-Water Air-Separator Insulation**: Mineral-Fiber Pipe and Tank: 2 inches thick.

3.17 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. **Items Not Insulated**: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.

2. Underground piping.

3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.18 INDOOR PIPING INSULATION SCHEDULE

A. **Heating-Hot-Water Supply and Return, 200 Deg F and below**: Insulation shall be Owens-Corning Fiberglass 25 ASJ/SSL or equal:

Pipe Size	Insulation Thickness
1-1/2” & under	1-1/2”
2” – 4”	2”

5” – 6”	2-1/2”

B. **Chilled Water, above 40 Deg F**: Insulation shall be Owens-Corning Fiberglass 25 ASJ/SSL or equal:

Pipe Size	Insulation Thickness
1-1/2” & under	1-1/2”
2” – 4”	1-1/2”

C. **Refrigerant Suction and Hot-Gas Piping**: Flexible elastomeric, 1-1/2 inch thick.

3.19 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. **Heating-Hot-Water Supply and Return, 200 Deg F and below**: Insulation shall be Insulation shall be Owens-Corning Fiberglass 25 ASJ/SSL or equal:

Pipe Size	Insulation Thickness
1-1/2” & under	1-1/2”
2” – 4”	2”
5” – 6”	2-1/2”

B. **Chilled Water, above 40 Deg F**: Insulation shall be Owens-Corning Fiberglass 25 ASJ/SSL or equal:

Pipe Size	Insulation Thickness
1-1/2” & under	1-1/2”
2”-4”	1-1/2”

C. **Refrigerant Suction and Hot-Gas Piping**: Insulation shall be one of the following:

1. Flexible Elastomeric: 2 inches thick.

3.20 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE

A. Loose-fill insulation, for belowground piping, is specified in Division 33 piping distribution Sections.

B. Chilled Water, All Sizes: Cellular glass, 2 inches thick.

C. Heating-Hot-Water Supply and Return, All Sizes, 200 Deg F and below: Cellular glass, 3 inches thick.

3.21 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. **Ducts and Plenums, Concealed**:

1. None.

D. **Ducts and Plenums, Exposed**:

1. None.

E. **Equipment, Concealed**:

1. None.

F. **Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches**:

1. Hot equipment shall be insulated with Type 700 Series fiberglass board, 2” thick, unfaced with 8-ounce canvas jacket applied with a white adhesive such as Aerbol meeting flame spread and smoke restrictions as listed.

G. **Piping, Concealed**:

1. None.

H. **Piping, Exposed**:

1. Any insulated piping which spans mechanical rooms less than 18” above the floor shall be covered with metal jacket. Jacket material shall be one of the following:

a. Aluminum, embossed, 0.016” thick with stainless steel tie-bands.

b. Stainless steel, smooth surface, 0.010” thick with stainless steel tie bands.

3.22 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. **Piping, Exposed**:

1. Aluminum, embossed, .016” thick with stainless steel tie-bands.

2. Stainless steel, smooth surface, 0.010” thick with stainless steel tie bands.

3. Fittings shall be covered with pre-formed metal jackets.

3.23 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

- END OF SECTION -

SECTION 23 09 00 – INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

1.2 ACTION SUBMITTALS

A. **Product Data**: For each control device indicated.

B. **Shop Drawings**:

1. Schematic flow diagrams.

2. Power, signal, and control wiring diagrams.

3. Details of control panel faces.

4. DDC System Hardware: Wiring diagrams, schematic floor plans, and schematic control diagrams.

5. Control System Software: Schematic diagrams, written descriptions, and points list.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Software and firmware operational documentation.

1.5 QUALITY ASSURANCE

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

PART 2 -- PRODUCTS

2.0 SECTION INCLUDES

1. Materials

2. Communication

3. Operator Workstation

4. Controller Software

5. Building Controllers

6. Advanced Application Controllers

7. Application Specific Controllers

8. Input/Output Interface

9. Power Supplies and Line Filtering

10. Auxiliary Control Devices

11. Wiring and Raceways

12. Fiber Optic Cable System

13. Access Control

2.1 MATERIALS

A. All products used in this project installation shall be new, currently under manufacture, and shall be applied in similar installations for a minimum of two years. This installation shall not be used as a test site for any new products unless explicitly approved by the Owner's Representative in writing. Spare parts shall be available for at least five years after completion of this contract.

2.2 COMMUNICATION

A. All control products provided for this project shall comprise a BACnet internetwork. Communication involving control components (i.e., all types of controllers and Operator Workstations) shall conform to ANSI/ASHRAE Standard 135-2001, BACnet.

B. Each BACnet device shall operate on the BACnet Data Link/Physical layer protocol specified for that device as defined in this section.

C. The Contractor shall provide all communication media, connectors, repeaters, bridges, hubs, switches, and routers necessary for the internetwork.

D. All controllers shall have a communication port for connections with the Operator Workstations using the BACnet Data Link/ Physical layer protocol.

E. A device on the internetwork shall be provided with a 56k-baud modem that will allow for remote Operator Workstation using the BACnet PTP Data Link/ Physical layer protocol. Remote Operator Workstation via this modem shall allow for communication with any and all controllers on this network as described in Paragraph F below.

F. Communication services over the internetwork shall result in operator interface and value passing that is transparent to the internetwork architecture as follows:

1 Connection of an Operator Workstation device to any one controller on the internetwork will allow the operator to interface with all other controllers as if that interface were directly connected to the other controllers. Data, status information, reports, system software, custom programs, etc., for all controllers shall be available for viewing and editing from any one controller on the internetwork.

2 All database values (e.g., objects, software variables, custom program variables) of any one controller shall be readable by any other controller on the internetwork. This value passing shall be automatically performed by a controller when a reference to an object name not located in that controller is entered into the controller's database. An operator/installer shall not be required to set up any communication services to perform internetwork value passing.

G. The time clocks in all controllers shall be automatically synchronized daily. An operator change to the time clock in any controller shall be automatically broadcast to all controllers on the network.

H. **The network shall have the following minimum capacity for future expansion**:

1. Each Building Controller shall have routing capacity for 99 controllers.

2. The Building Controller network shall have capacity for 1000 Building Controllers.

3. The system shall have an overall capacity for 12,500 Building Controller, Advanced Application Controller, and Application Specific Controller input/output objects.

2.3 OPERATOR WORKSTATION

A. Operator Workstation. Furnish one PC-based workstation as shown on the system drawings. Each of these workstations shall be able to access all information in the system. These workstations shall reside on the same Ethernet protocol network as the Building Controllers.

B. Workstation information access shall use the BACnet protocol. Communication shall use the ISO 8802-3 (Ethernet) Data Link/ Physical layer protocol.

C. Hardware. Each operator workstation and custom programming workstation shall consist of the following:

1. Personal Computer. Furnish IBM compatible PCs as shown. The CPU shall be a minimum of an Intel Pentium and operate at a minimum of 1,800 MHz. A minimum of 2 gigabyte of RAM, one CD readable/writeable drive and a 100GB hard disk with a minimum access time of 12 milliseconds shall be provided. A two-button mouse also will be provided. Furnish all required serial (USB), and network communication ports, and all cables for proper system operation. The PC shall have a minimum of a 20" SVGA LCD monitor (1024 x 768 resolution, 32 Bit color).

2. BACnet Interoperability Building Blocks. The workstation shall support the following BIBBs:

Data Sharing	**Alarm & Event**	**Scheduling**	**Trending**	**Device & Network Mgmt.**
DS-RP-A,B	AE-N-A	SCHED-A	T-VMT-A	DM-DDB-A,B
DS-RPM-A	AE-ACK-A		T-ATR-A	DM-DOB-A,B
DS-WP-A	AE-ASUM-A			DM-DCC-A

DS-WPM-A	AE-ESUM-A			DM-TS-A
				DM-UTC-A
				DM-RD-A
				DM-BR-A
				NM-CE-A

D. System Software

1. Operating System. Furnish a concurrent multi-tasking operating system. The operating system also shall support the use of other common software applications that operate under Microsoft Windows. Examples include Microsoft Excel, Microsoft Word, and Microsoft Access. Acceptable operating systems are, Windows XP Pro and Windows 7.

2. System Graphics. The operator workstation software shall be a graphical user interface (GUI). The system shall allow display of up to 10 dynamic and animated graphic screens at once for comparison and monitoring of system status. Provide a method for the operator to easily move between graphic displays and change the size and location of graphic displays on the screen. The system graphics shall be able to be modified while on-line. An operator with the proper password level shall be able to add, delete, or change dynamic objects on a graphic. Dynamic objects shall include analog and binary values, dynamic text, static text, and animation files. Graphics shall have the ability to show animation by shifting image files based on the status of the object.

3. Custom Graphics. Custom graphic files shall be created with the use of a graphics generation package furnished with the system. The graphics generation package shall be a graphically based system that uses the mouse to create and modify graphics. The graphics generation package also shall provide the capability of capturing or converting graphics from other programs such as Visio or AutoCAD.

4. Graphics Library. Furnish a complete library of standard HVAC equipment graphics such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library also shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. The library shall be furnished in a file format compatible with the graphics generation package program. Graphics shall be created by drag-and-drop selection of graphic symbols and drag-and-link with BACnet objects with dynamic and interactive display fields.

5. Multilingual. Software shall be supported in the following languages English, Spanish, French, German, and Chinese.

6. Dynamic Data Exchange (DDE). Software shall support dynamic data sharing with other Windows-based programs for third party add-on functionality e.g. preventative maintenance, tenant billing, etc.

E. System Applications. Each workstation shall provide operator interface and off-line storage of system information. Provide the following applications at each workstation:

1. System Database Save and Restore. Each workstation shall store on the hard disk a copy of the current database of each Building Controller. This database shall be updated whenever an operator initiates a save command.

2. Manual Database Save and Restore. A system operator with the proper password clearance shall be able to save the database from any system panel. The operator shall be able to clear a panel database via the network and may initiate a download of a specified database to any panel in the system from the network.

3. System Configuration. The workstation software shall provide a method of configuring the system. This shall allow for future system changes or additions by users under proper password protection.

4. On-Line Help. Provide a context-sensitive, on-line help system to assist the operator in operating and editing the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.

5. Security. Each operator shall be required to log on to the system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system supervisor shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the functions accessible to viewing and/or changing each system application.

6. System Diagnostics. The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers.

7. Alarm Processing. Any object in the system shall be configurable to alarm in and out of normal state. The operator shall be able to configure the alarm limits, alarm limit differentials, states, and reactions for each object in the system.

8. Alarm Messages. Alarm messages shall use the English language descriptor for the object in alarm, in such a way that the operator will be able to recognize the source, location, and nature of the alarm without relying upon acronyms or other mnemonics.

9. Alarm Reactions. The operator shall be able to determine (by object) what if any actions are to be taken during an alarm. Actions shall include logging, printing, starting programs, displaying messages, dialing out to remote stations, paging, providing audible annunciation.

10. Trend Logs. The operator shall be able to define a custom trend log for any data object in the system. This definition shall include change-of-value digital, change-of-value analog, time interval, start time, and stop time. Trend data shall be sampled and stored on the Building Controller panel, and be archivable on the hard disk and be retrievable for use in spreadsheets and standard database programs.

11. Alarm and Event Log. The operator shall be able to view all system alarms and change of states from any location in the system. Events shall be listed chronologically. An operator with the proper security level may acknowledge and clear alarms.

12. Object and Property Status and Control. Provide a method for the operator to view, and edit if applicable, the status of any object and property in the system. The status shall be available by menu, on graphics, or through custom programs.

13. Clock Synchronization. The real-time clocks in all building control panels and workstations shall be using the BACnet Time Synchronization service. The system also shall be able to automatically synchronize all system clocks daily from any operator-designated device in the system. The system shall automatically adjust for daylight savings and standard time, if applicable.

F. Workstation Applications Editors. Each PC workstation shall support editing of all system applications. Provide editors for each application at the PC workstation. The applications shall be downloaded and executed at one or more of the controller panels.

1. Controller. Provide a full-screen editor for each type of application that shall allow the operator to view and change the configuration, name, control parameters, and setpoints for all controllers.

2. Scheduling. An editor for the scheduling application shall be provided at each workstation. Provide a method of selecting the desired schedule and month. This shall consist of a monthly calendar for each schedule. Exception schedules and holidays shall be shown clearly on the calendar. Provide a method for allowing several related objects to follow a schedule. The start and stop times for each object shall be adjustable from this master schedule.

3. Custom Application Programming. Provide the tools to create, modify, and debug custom application programming. The operator shall be able to create, edit, and download custom programs at the same time that all other system applications are operating. The system shall be fully operable while custom routines are edited, compiled, and downloaded. The programming language shall have the following features:

a. The language shall be English language oriented, be based on the syntax of BASIC, FORTRAN, C, or PASCAL, and allow for free-form programming (i.e., not column-oriented or "fill in the blanks").

b. A full-screen character editor/programming environment shall be provided. The editor shall be cursor/mouse-driven and allow the user to insert, add, modify, and delete custom programming code. It also shall incorporate word processing features such as cut/paste and find/replace.

c. The programming language shall allow independently executing program modules to be developed. Each module shall be able to independently enable and disable other modules.

d. The editor/programming environment shall have a debugging/simulation capability that allows the user to step through the program and observe any intermediate values and/or results. The debugger also shall provide error messages for syntax and execution errors.

e. The programming language shall support conditional statements (IF/THEN/ELSE/ELSE-IF) using compound Boolean (AND, OR, and NOT) and/or relations (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.

f. The programming language shall support floating point arithmetic using the following operators: +, -, /, x, square root, and x-to-the-y-power. The following mathematical functions also shall be provided: natural log, log, trigonometric functions (sine, cosine, etc.), absolute value, and minimum/maximum value from a list of values.

g. The programming language shall have predefined variables that represent time of day, day of the week, month of the year, and the date. Other predefined variables shall provide elapsed time in seconds, minutes, hours, and days. These elapsed time variables shall be able to be reset by the language so that interval-timing functions can be stopped and started within a program. Values from all of the above variables shall be readable by the language so that they can be used in a program for such purposes as IF/THEN comparisons, calculations, etc.

h. The language shall be able to read the values of the variables and use them in programming statement logic, comparisons, and calculations.

i. The programs shall support online changes with the ability to read real time values without exiting the program. Sample programs and syntax help functions shall be resident in the program.

F. Portable Operator's Terminal. Furnish a Portable Operator's Terminal that shall be capable of accessing all system data. This device may be connected to any point/object on the system network or may be connected directly to any controller for programming, setup, and troubleshooting. This device may be connected to any point/object on the system network or it may be connected directly to controllers using the BACnet PTP (Point-To-Point) Data Link/ Physical layer protocol. The terminal shall use the Read (Initiate) and Write (Execute) Services as defined in Clauses 15.5 and 15.8, respectively, of ASHRAE Standard 135-2001, to communicate with BACnet objects in the internetwork. The Portable Operator's Terminal shall be an IBM compatible notebook-style PC including all software and hardware required.

G. REPORT MANAGEMENT

1. The following reporting capability shall be provided at the operator workstation.

2. Reporting:

a. Internal reports built into operator workstation software

b. External reporting via ODBC

3. Internal Reports

a. User definable query reports (support advanced multiple property, multiple object).

b. Reports shall be scheduled for automatic generation by schedule or event.

c. Manual execution to printing/file.

d. Ability to save report in system report folder.

e. Query controller hierarchy.

f. Report to multiple destinations

i. Email

ii. Print

iii. File (text, csv, xml)

iv. Terminal

4. Enterprise Interface

   a. ODBC driver supporting common SQL statements (select, update, insert, where, order by, group by, etc.)

   b. Allow integration to Enterprise software

   c. Shall be capable of being used with third party software that supports ODBC connection such as: Microsoft Access, Excel, Crystal Reports, etc.

   d. All queries shall be real time into live controller network.

   e. Shall be able to both read and write using SQL.

H. Web Browser Interface

1. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Google Chrome™ or Mozilla Firefox™.

2. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the BAS, shall not be acceptable.

3. The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.

4. The Web browser client shall support at a minimum, the following functions:

   a. User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.

5. Graphical screens developed for the GUI shall be the same screens used for the Web browser client. Any animated graphical objects supported by the GUI shall be supported by the Web browser interface.

6. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.

7. Storage of the graphical screens shall be in the Server, without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.

8. Real-time values displayed on a Web page shall update automatically without requiring a manual “refresh” of the Web page.

9. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:

   a. Modify common application objects, such as schedules, calendars, and set points in a graphical manner.

10. Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.

11. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.

12. The system shall provide the capability to specify a user’s (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just their defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.

13. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

H. SERVER FUNCTIONS AND HARDWARE

1. A central server, located by the owner shall be provided. The server shall support all Network Area Controllers connected to the customer’s network whether local or remote. Local connections shall be via an Ethernet LAN. Remote connections can be via ISDN, ADSL, T1 or dial-up connection.

2. The server shall provide scheduling for all Area Controllers and their underlying field control devices.

3. The server shall implement the BACnet Command Prioritization scheme (16 levels) for safe and effective contention resolution of all commands issued to Network Area Controllers. Systems not employing this prioritization shall not be accepted.

4. The server shall provide central management of alarm data for all Network Area controllers supported by the server inclusive of the following:

   a. View and acknowledge alarms

1. Server Hardware Requirements: The server hardware platform shall have the following requirements:

a. The computer shall be an Intel Pentium based computer of current new design with adequate minimal performance requirements to run the intended software and perform all necessary functions.

b. The server operating system shall be Microsoft Windows 7.

2.4 CONTROLLER SOFTWARE

A. Furnish the following applications software for building and energy management. All software applications shall reside and operate in the system controllers. Editing of applications shall occur at the operator workstation

B. System Security

1. User access shall be secured using individual security passwords and user names.

2. Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.

3. User Log On/Log Off attempts shall be recorded.

C. Scheduling. Provide the capability to schedule each object or group of objects in the system. Each schedule shall consist of the following:

1. Weekly Schedule. Provide separate schedules for each day of the week. Each of these schedules should include the capability for start, stop and optimal start. Each schedule may consist of up to 10 events. When a group of objects are scheduled together, provide the capability to adjust the start and stop times for each member.

2. Holiday Schedules. Provide the capability for the operator to define up to 99 special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.

D. Alarm Reporting. The operator shall be able to determine the action to be taken in the event of an alarm. Alarms shall be routed to the appropriate workstations based on time and other conditions.

E. Remote Communication. The system shall have the ability to dial out in the event of an alarm using BACnet Point-To-Point at a minimum of 56K baud. Receivers shall be BACnet workstations.

F. Maintenance Management. The system shall monitor equipment status and generate maintenance messages based upon user-designated run-time, starts, and/or calendar date limits.

G. Sequencing. Provide application software to properly sequence the start and stop of chillers, boilers, and pumps to minimize energy usage in the facility.

H. PID Control. A PID (proportional-integral-derivative) algorithm with direct or reverse action and anti-windup shall be supplied. The algorithm shall calculate a time-varying analog value that is used to position an output or stage a series of outputs. The controlled variable, setpoint, and PID gains shall be user-selectable.

I. Staggered Start. This application shall prevent all controlled equipment from simultaneously restarting after a power outage.

J. Energy Calculations. Provide software to allow instantaneous power (e.g., kW) or flow rates (e.g., L/s [GPM]) to be accumulated and converted to energy usage data. Provide an algorithm that calculates a sliding-window kW demand value.

K. Anti-Short Cycling. All binary output objects shall be protected from short cycling. This feature shall allow minimum on-time and off-time to be selected.

L. On/Off Control with Differential. Provide an algorithm that allows a binary output to be cycled based on a controlled variable and setpoint. The algorithm shall be direct-acting or reverse-acting, and incorporate an adjustable differential.

M. Run-time Totalization. Provide software to totalize run-times for all binary input objects. A high run-time alarm shall be assigned, if required, by the operator.

2.5 BUILDING CONTROLLERS

A. General. Provide an adequate number of Building Controllers to achieve the performance specified in the Part 1 Article on “System Performance.” Each of these panels shall meet the following requirements.

1. The Energy Management and Control System shall be comprised of one or more independent, standalone, microprocessor-based Building Controllers to manage the global strategies described in the System Software section.

2. The Building Controller shall have sufficient memory to support its operating system, database, and programming requirements.

3. Data shall be shared between networked Building Controllers.

4. The operating system of the Building Controller shall manage the input and output communication signals to allow distributed controllers to share real and virtual object information, and allow central monitoring and alarms.

5. Controllers that perform scheduling shall have a real-time clock.

6. The Building Controller shall communicate with other BACnet objects on the internetwork using the Read (Execute and Initiate) and Write (Execute and Initiate) Property services as defined in Clauses 15.5 and 15.8, respectively, of ASHRAE Standard 135-2001.

7. BACnet Functional Groups. The Building Controller shall support the following BACnet functional groups: Clock, Event Initiation, COV Event Response, Files, Device Communication and Time Master.

B. Communication

1. Each Building Controller shall support BACnet™ over Ethernet and BACnet™ over IP. The Building Controller shall be connected to the BACnet network using the ISO 8802-3 (Ethernet) Data L/ Physical layer protocol.

2. Each Building Controller with a communications card shall perform BACnet routing if connected to a network of Custom Application and Application Specific Controllers.

3. The controller shall provide a service communication port using BACnet Data Link/ Physical layer protocol P-T-P for connection to a hand-held workstation/ and/or modem.

4. The Building Controller secondary communication network shall support BACnet MS/TP.

C. Environment. Controller hardware shall be suitable for the anticipated ambient conditions.

1. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures, and shall be rated for operation at 0°C to 40°C [32°F to 100°F] and 10 to 90% RH.

2. Controllers used in conditioned space shall be mounted in dust-proof enclosures, and shall be rated for operation at 0°C to 50°C [32°F to 120°F].

D. Building Controllers shall be fully peer to peer.

E. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field- removable, modular terminal strips — or to a termination card connected by a ribbon cable.

F. Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. The Building Controller shall maintain all database information including BIOS and programming information in the event of a power loss for at least 72 hours. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m [3 ft].

G. Inputs/Outputs.

1. Inputs. Controller input/output board shall support dry contact, 0-5 VDC and 0-10 VDC-voltage, 4-20 mA- current and thermistor-resistive signal types on an individual basis for connecting any status or sensing device. Analog resolution shall be 10-bit A to D.

2. Outputs. Controller input/output board shall support built in HOA modules configured with manual-auto-off override switch. Output supported shall be 0-10 VDC. All HOA's shall be supervised.

3. Diagnostics. Controller input/output board shall have red LEDs providing input status indication.

4. Building Controller shall have the capability to create, delete and support the following BACnet Objects:

a. ANALOG INPUT, ANALOG OUTPUT AND ANALOG VALUE: These objects shall have the following writeable properties: Object Name; Object Value; Description; COV Increment; Out of Service and Units. In addition, these objects shall support the properties: Device type; Reliability; Min./Max. Values; Update Interval and Resolution.

b. BINARY INPUT, BINARY OUTPUT AND BINARY VALUE: These objects shall have the following writeable properties: Object Name; Object Value; Description; Polarity; Default Value; Min On/Off and Out of Service. In addition, these objects shall support the properties: Device Type; Reliability; Active/Inactive Texts; Update Interval; Resolution; Change-of-State Time; Count Times and Time Reset.

c. CALENDAR: This object shall have the following writeable properties: Object Name; Object Value; Description; and Date List.

d. DEVICE: This object shall have the following writeable properties: Object Name; Description; Location; and UTC Offset.

e. EVENT ENROLMENT: This object shall have the following writeable properties: Object Name; Object Value; Description; Out-of-Service; Event & Notify Types; Parameters; Property Ref; Enable; and Notification Class.

f. FILE: This object shall have the following writeable properties: Object Name; Description; File Type; and File Access.

g. LOOP (PID): This object shall have the following writeable properties: Object Name; Object Value; Description; Polarity; Output and Input Refs.; Input Value & Units; Setpoint Value; PID Values; Bias; Write Priority and COV Increment. In addition, this object shall support the properties: Reliability; Update Interval; Proportional Constant & Units; Derivative Constant & Units.

h. NOTIFICATION CLASS: This object shall have the following writeable properties: Object Name; Object Value; Description; Priority and Ack Required.

i. PROGRAM: This object shall have the following writeable properties: Object Name; Object Value and Description. In addition, this object shall support the property Reliability.

j. SCHEDULE: This object shall have the following writeable properties: Object Name; Object Value and Description; Effective period; Schedule; Exception; Controlled Properties and Write Properties.

k. TREND LOG: This object shall have the following writeable properties: Object Name; Description; Log Enable; Start/stop Times; Log Device Object Property; Log Interval; Stop When Full; Buffer Size; and Record Count.

2.6 ADVANCED APPLICATION CONTROLLERS

A. General. Provide an adequate number of Programmable Application Controllers to achieve the performance specified in the Part 1 Article on “System Performance.” Each of these panels shall meet the following requirements.

1. The Advanced Application Controller shall have sufficient memory to support its operating system, database, and programming requirements.

2. Advanced Application Controllers shall be fully peer to peer.

3. The operating system of the Controller shall manage the input and output communication signals to allow distributed controllers to share real and virtual object information, and allow central monitoring and alarms.

4. All equipment that requires scheduling shall be scheduled in that equipments controller.

5. Both firmware and controller database shall be loadable over the network.

6. Advanced Application Controllers shall support the following BACnet Interoperability Building Blocks (BIBBs):

Data Sharing	Alarm & Event	Scheduling	Trending	Device & Network Mgmt.
DS-RP-B	AE-N-B	SCHED-B		DM-DDB-B
DS-RPM-B	AE-ACK-B			DM-DOB-B
DS-WP-B	AE-ASUM-B			DM-DCC-B
DS-WPM-B				DM-TS-B
				DM-UTC-B
				DM-RD-B

B. Communication.

1. Each Advanced Application Controller shall reside on a BACnet network using the MS/TP or Ethernet Data Link/ Physical layer protocol.

2. The controller shall provide a service communication port using BACnet Data Link/ Physical layer protocol for connection to portable operators' workstation and allow access to the entire network.

C. Environment. Controller hardware shall be suitable for the anticipated ambient conditions.

1. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures, and shall be rated for operation at 0°C to 40°C [32°F to 100°F].

2. Controllers used in conditioned space shall be mounted in dust-proof enclosures, and shall be rated for operation at 0°C to 50°C [32°F to 120°F].

D. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips — or to a termination card connected by a ribbon cable.

E. Memory. The Advanced Application Controller shall be non-volatile FLASH memory.

F. Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to120 Hz and from keyed radios up to 5 W at 1 m [3 ft].

2.7 APPLICATION SPECIFIC CONTROLLERS

A. General. Application Specific Controllers (ASCs) are microprocessor-based DDC controllers which through hardware or firmware design are able to control a wide variety of equipment. They are fully user-programmable, and are not restricted to any one type of equipment.

1. Each ASC shall be capable of standalone operation and shall continue to provide control functions without being connected to the network

2. Each ASC will contain sufficient I/O capacity to control the target system.

3. Both firmware and controller database shall be loadable over the network

4. Application Specific Controllers shall be fully peer to peer

5. ASC's shall come with an integrated housing to allow for easy mounting and protection of the circuit board. Only wiring terminals shall be exposed.

6. Application Specific Controllers shall support the following BACnet Interoperability Building Blocks (BIBBs):

Data Sharing	Alarm & Event	Scheduling	Trending	Device & Network Mgmt.
DS-RP-B				DM-DDB-B
DS-WP-B				DM-DOB-B
				DM-DCC-B

B. Communication

1. The controller shall reside on a BACnet network using the MS/TP Data Link/ Physical layer protocol.

2. Each controller shall have a BACnet Data Link/ Physical layer compatible connection for a laptop computer or a portable operator's tool. This connection shall be extended to a space temperature sensor port where shown and allow access to the entire network.

3. Each controller shall have a secondary sub network for communicating sensors or I/O expansion modules

C. Environment. The hardware shall be suitable for the anticipated ambient conditions.

1. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures, and shall be rated for operation at -40°C to 65°C [-40°F to 150°F] and/or suitably installed in a heated or fan cooled enclosure

2. Controllers used in conditioned space shall be mounted in dust-proof enclosures, and shall be rated for operation at 0°C to 50°C [32°F to 120°F].

D. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips.

E. Memory. The Application Specific Controller shall use non-volatile memory and maintain all BIOS and programming information in the event of a power loss.

F. Immunity to power and noise. ASC shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80%. Operation shall be protected against electrical noise of 5-120 Hz and from keyed radios up to 5 W at 1 m [3 ft].

G. Transformer. Power supply for the ASC must be rated at minimum of 125% of ASC power consumption, and shall be fused or current limiting type.

H. Input/Output. ASC shall support as a minimum, directly connected, a combination of analog outputs and binary outputs and universal software selectable analog or digital inputs. ASC inputs shall support 0-5 VDC-voltage, 4-20mA-current, thermistor-resistance and dry contacts. ASC outputs shall support 0-10 VDC-voltage, digital triac rated at 0.5 amps at 24 VAC

I. System Object Capacity. The system size shall be expandable to at least twice the number of input/output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The Operator Workstations installed for this project shall not require any hardware additions or software revisions in order to expand the system.

2.8 AUXILIARY CONTROL DEVICES

A. Motorized control dampers, unless otherwise specified elsewhere, shall be furnished by the controls contractor.

B. Electric damper/valve actuators.

1. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator.

2. Where shown, for power-failure/safety applications, an internal mechanical, spring-return mechanism shall be built into the actuator housing.

3. All non-spring-return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring-return actuators with more than 7 N·m [60 in-lb] torque capacity shall have a manual crank for this purpose.

D. Control valves.

1. Control valves shall be two-way or three-way type for two-position or modulating service as shown.

2. Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:

a. Water Valves:

i. Two-way: 150% of total system (pump) head.

ii. Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.

b. Steam Valves: 150% of operating (inlet) pressure.

3. Water Valves:

a. Body and trim style and materials shall be per manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service.

4 Steam Valves:

a. Body and trim materials shall be per manufacturer's recommendations for design conditions and service. Linear ports for modulating service.

E. Binary Temperature Devices.

1 Low-limit thermostats. Low-limit thermostats shall be vapor pressure type with an element 6 m [20 ft] minimum length. Element shall respond to the lowest temperature sensed by any 30 cm [1 ft.] section. The low-limit thermostat shall be manual reset only and be supplied as DPST.

F. Temperature sensors.

1. Temperature sensors shall be thermistors.

2. Space sensors shall be equipped with the following:

a. programmable buttons for setpoint adjustment and override

b. 3-value, 96-segment LCD display

c. Communication port connected to entire network

d. Provide matched temperature sensors for differential temperature measurement.

G. Humidity sensors.

1. Duct and room sensors shall have a sensing range of 20% to 90%.

2. Duct sensors shall be provided with a sampling chamber.

3. Outdoor air humidity sensors shall have a sensing range of 20% to 95% RH. They shall be suitable for ambient conditions of -40°C to 75°C [-40°F to 170°F].

4. Humidity sensor's drift shall not exceed 3% of full scale per year.

H. Flow switches.

1 Flow-proving switches shall be either paddle or differential pressure type, as shown.

I. Pressure transducers.

1. Transducer shall have linear output signal. Zero and span shall be field-adjustable.

2. Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure 50% greater than calibrated span without damage

3. Water pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Transducer shall be complete with 1 - 5vdc or 4 to 20 mA output, required mounting brackets, and block and bleed valves.

4. Water differential pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Over-range limit (differential pressure) and maximum static pressure shall be 300 psi. Transducer shall be complete with 1 – 5vdc or 4 to 20 mA output, required mounting brackets, and five-valve manifold.

R. Differential pressure type switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application, or as shown.

S. Pressure-Electric (PE) Switches.

1. Shall be metal or neoprene diaphragm actuated, operating pressure rated 0–175 kPa [0–25 psig], with calibrated scale setpoint range of 14–125 kPa [2–18 psig] minimum, UL listed

2. Provide one- or two-stage switch action SPDT, DPST, or DPDT, as required by application.

3. Shall be open type (panel-mounted) or enclosed type for remote installation. Enclosed type shall be NEMA 1 unless otherwise specified

4. Shall have a permanent indicating gauge on each pneumatic signal line to PE switches.

T. Electro-pneumatic (E/P) transducers.

1. Electronic/pneumatic transducer shall provide a proportional 20 to 100 kPa [3 to 15 psig] output signal from a 0 to 10 VDC analog control input.

U. Local control panels.

1. All indoor control cabinets shall be fully enclosed NEMA 1 construction with [hinged door], key-lock latch, and removable sub-panels. A single key shall be common to all field panels and sub-panels

2. Interconnections between internal and face-mounted devices pre-wired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL Listed for 600 volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings

3. Provide 120v receptacle at each local panel location.

2.9 WIRING AND RACEWAYS

A. **General:** Provide copper wiring, plenum cable, and raceways as specified in the applicable sections of Division 26.

B. All insulated wire to be copper conductors, UL labeled for 90C minimum service.

PART 3 -- EXECUTION

3.0 SECTION INCLUDES

1. Examination
2. Protection
3. Coordination
4. General Workmanship
5. Field Quality Control
6. Wiring
7. Actuators
8. Identification of Hardware and Wiring
9. Controllers
10. Programming
11. Control System Checkout and Testing
12. Control System Demonstration and Acceptance
13. Cleaning
14. Training
15. Sequences of Operation

3.1 EXAMINATION

A. The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started

B. The Contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the Engineer for resolution before rough-in work is started

C. The Contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate — or if any discrepancies occur between the plans and the Contractor’s work, and the plans and the work of others — the Contractor shall report these discrepancies to the Engineer and shall obtain written instructions for any changes necessary to accommodate the Contractor’s work with the work of others. Any changes in the work covered by this specification made necessary by the failure or neglect of the Contractor to report such discrepancies shall be made by — and at the expense of — this Contractor.

3.2 PROTECTION

A. The Contractor shall protect all work and material from damage by its work or employees, and shall be liable for all damage thus caused

B. The Contractor shall be responsible for its work and equipment until finally inspected, tested, and accepted. The Contractor shall protect any material that is not immediately installed. The Contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects

3.3 COORDINATION

A. Site

1. Where the mechanical work will be installed in close proximity to, or will interfere with work of other trades, the Contractor shall assist in working out space conditions to make a satisfactory adjustment. If the Contractor installs its work before coordinating with other trades, so as to cause any interference with work of other trades, the Contractor shall make the necessary changes in its work to correct the condition without extra charge

2. Coordinate and schedule work with all other work in the same area, or with work which is dependent upon other work, to facilitate mutual progress.

B. Submittals. Refer to the “Submittals” Article in Part 1 of this specification for requirements

C. Test and Balance

1. The Contractor shall furnish all tools necessary to interface to the control system for test and balance purposes

2. The Contractor shall provide training in the use of these tools. This training will be planned for a minimum of 4 hours

3. In addition, the Contractor shall provide a qualified technician to assist in the test and balance process, until the first 20 terminal units are balanced.

4. The tools used during the test and balance process will be returned at the completion of the testing and balancing

D. Life Safety

1. Duct smoke detectors required for air handler shutdown are supplied and installed under Division 16. The Division 16 Contractor shall interlock smoke detectors to air handlers for shutdown as described in Part 3: “Sequences of Operation”.

2. Smoke dampers and actuators required for duct smoke isolation are provided under another Division 15 Section

3. Fire/smoke dampers and actuators required for fire rated walls are provided under another Division 15 Section. Control of these dampers shall be by Division 16.

E. Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the Contractor as follows:

1. All communication media and equipment shall be provided as specified in Part 2: “Communication” of this specification.

2. Each supplier of controls product is responsible for the configuration, programming, start-up, and testing of that product to meet the sequences of operation described in this section.

3. The Contractor shall coordinate and resolve any incompatibility issues that arise between the control products provided under this Section and those provided under other sections or divisions of this specification.

3.4 GENERAL WORKMANSHIP

A. Install equipment, piping, and wiring/raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.

B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment

C. Install all equipment in readily accessible locations as defined by Chapter 1, Article 100, Part A of the National Electrical Code (NEC).

D. All wiring shall be verified for its integrity to ensure continuity and freedom from shorts and grounds

E. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.5 FIELD QUALITY CONTROL

A. All work, materials, and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Part 1 of this specification

B. Contractor shall continually monitor the field installation for code compliance and quality of workmanship

C. Contractor shall have work inspected by local and/or state/provincial authorities having jurisdiction over the work

3.7 WIRING

A. All control and interlock wiring shall comply with national and local electrical codes and Division 16 of this specification. Where the requirements of this section differ with those in Division 16, the requirements of this section shall take precedence.

B. All NEC Class 1 (line voltage) wiring shall be UL Listed in approved raceway per NEC and Division 16 requirement.

C. All low-voltage wiring shall meet NEC Class 2 requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)

3.8 ACTUATORS

A. Mount and link control damper actuators per manufacturer's instructions.

1. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage

2. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.

3. Provide all mounting hardware and linkages for actuator installation.

B. Electric/Electronic

1. Dampers: Actuators shall be direct-mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° available for tightening the damper seals. Actuators shall be mounted following manufacturer's recommendations

2. Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

3.9 IDENTIFICATION OF HARDWARE AND WIRING

A. All wiring and cabling, including that within factory-fabricated panels, shall be labeled at each end within 5 cm [2"] of termination with the DDC address or termination number.

B. Permanently label or code each point/object of field terminal strips to show the instrument or item served.

C. Identify control panels with minimum 1 cm [½”] letters on laminated plastic nameplates.

D. Identify all other control components with permanent labels. All plug-in components shall be labeled such that removal of the component does not remove the label.

E. Identify room sensors relating to terminal box or valves with nameplates.

3.10 CONTROLLERS

F. Provide a separate controller for each AHU or other HVAC system.

A. Building Controllers and Advanced Application Controllers shall be selected to provide a minimum of 15% spare I/O point/object capacity for each point/object type found at each location. If input /objects are not universal, 15% of each type is required. If outputs are not universal, 15% of each type is required. A minimum of one spare is required for each type of point/object used.

1. Future use of spare capacity shall require providing the field device, field wiring, point/object database definition, and custom software. No additional controller boards or point/object modules shall be required to implement use of these spare points

3.11 PROGRAMMING

A. Provide sufficient internal memory for the specified sequences of operation and trend logging. There shall be a minimum of 25% of available memory free for future use.

B. Point/object Naming. System point/object names shall be modular in design, allowing easy operator interface without the use of a written point/object index. Use the following naming convention:

1. AAABBBCCCDDDEEE where:

2. AAA is used to designate the location of the point/object within the building such as mechanical room, wing, or level, or the building itself in a multi-building environment.

3. *BBB* is used to designate the mechanical system with which the point/object is associated (e.g., A01, HTG, CLG, LTG).

4. *CC*C represents the equipment or material referenced (e.g., SAF for supply air fan, EXF for exhaust fan, RAF for return air fan).

5. *D* or *DD* or *DDD* may be used for clarification or for identification if more than one of CCC exists (e.g., SAF10, EXF121).

6. *EE* represents the action or state of the equipment or medium (e.g., T for temperature, RH for humidity, CO for control, S for status, D for damper control, I for current).

C. Software Programming

1. Provide programming for the system and adhere to the sequences of operation provided. The Contractor also shall provide all other system programming necessary for the operation of the system, but not specified in this document. Imbed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation. Use the appropriate technique based on the following programming types:

a. Text-based:

i. must provide actions for all possible situations

ii. must be modular and structured

iii. must be commented

b. Graphic-based

i. must provide actions for all possible situations

ii. must be documented

c. Parameter-based

i. must provide actions for all possible situations

ii. must be documented

D. Operator Interface

1 Standard Graphics. Provide graphics for all mechanical systems and floor plans of the building. This includes each chilled water system, hot water system, chiller, boiler, air handler, and all terminal equipment. Point/object information on the graphic displays shall dynamically update. Show on each graphic all input and output points/objects for the system. Also show relevant calculated points/objects such as setpoints

2 Sow terminal equipment information on a “graphic” summary table. Provide dynamic information for each point/object show

3 The Contractor shall provide all the labor necessary to install, initialize, start up, and troubleshoot all Operator Workstation software and their functions as described in this section. This includes any operating system software, the Operator Workstation database, and any third-party software installation and integration required for successful operation of the operator interface

3.12 CONTROL SYSTEM CHECKOUT AND TESTING

A. Start-up Testing. All testing listed in this article shall be performed by the Contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the Owner’s Representative is notified of the system demonstration.

1. The Contractor shall furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification

2. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight

3. Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures per manufacturers’ recommendations

4. Verify that all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct

5. Verify that all analog output devices (I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. The Contractor shall check all control valves and automatic dampers to ensure proper action and closure. The Contractor shall make any necessary adjustments to valve stem and damper blade travel

6. Verify that the system operation adheres to the Sequences of Operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops and optimum Start/Stop routines.

7. Alarms and Interlocks

a. Check each alarm separately by including an appropriate signal at a value that will trip the alarm

b. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.

c. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action

3.13 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Demonstration

1. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed its own tests

2. The tests described in this section are to be performed in addition to the tests that the Contractor performs as a necessary part of the installation, startup, and debugging process and as specified in the “Control System Checkout and Testing” Article in Part 3 of this specification. The Engineer will be present to observe and review these tests. The Engineer shall be notified at least 10 days in advance of the start of the testing procedures.

3. The demonstration process shall follow that approved in Part 1: “Submittals.” The approved checklists and forms shall be completed for all systems as part of the demonstration

4. The Contractor shall provide at least two persons equipped with two-way communication, and shall demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the calibration, response, and action of every point/object and system. Any test equipment required to prove the proper operation shall be provided by and operated by the Contractor.

5. As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed.

6. Demonstrate compliance with Part 1: “System Performance

7. Demonstrate compliance with Sequences of Operation through all modes of operation

8. Demonstrate complete operation of Operator Workstation

9. Additionally, the following items shall be demonstrated:

   a. DDC Loop Response. The Contractor shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop's response to a change in setpoint, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the setpoint, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the Contractor.

b. Demand limiting. The Contractor shall supply a trend data output showing the action of the demand-limiting algorithm. The data shall document the action on a minute-by-minute basis over at least a 30-minute period. Included in the trend shall be building kW, demand limiting setpoint, and the status of shed-able equipment outputs.

c. Optimum Start/Stop. The Contractor shall supply a trend data output showing the capability of the algorithm. The hour-by-hour trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas

d. Interface to the building fire alarm system

e. Operational logs for each system that indicate all setpoints, operating points, valve positions, mode, and equipment status shall be submitted to the Architect/Engineer. These logs shall cover three 48-hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and disk formats.

f. Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. The Contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.

B. Acceptance

1. All tests described in this specification shall have been performed to the satisfaction of both the Engineer and Owner prior to the acceptance of the control system as meeting the requirements of Completion. Any tests that cannot be performed due to circumstances beyond the control of the Contractor may be exempt from the Completion requirements if stated as such in writing by the Engineer. Such tests shall then be performed as part of the warranty.

2. The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved as required in Part 1: “Submittals.”

3.14 CLEANING

A. The Contractor shall clean up all debris resulting from its activities daily. The Contractor shall remove all cartons, containers, crates, etc., under its control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.

B. At the completion of work in any area, the Contractor shall clean all of its work, equipment, etc., keeping it free from dust, dirt, and debris, etc.

C. At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.15 TRAINING

A. General

1. Provide a minimum of one onsite training class 8 hours in length during the construction period for personnel designated by the owner.

2. Provide two additional training sessions at 6 and 12 months following building's turnover. Each session shall be 8 hrs in length and must be coordinated with the building Owner.

B. **Train the designated staff of Owner's Representative and Owner to enable Day-to-day Operators to**:

1. Proficiently operate the system.

2. Understand control system architecture and configuration.

3. Understand DDC system components.

4. Understand system operation, including DDC system control and optimizing routines (algorithms).

5. Operate the workstation and peripherals.

6. Log on and off the system.

7. Access graphics, point/object reports, and logs.

8. Adjust and change system setpoints, time schedules, and holiday schedules.

9. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals.

10. Understand system drawings, and Operation and Maintenance manual.

11. Understand the job layout and location of control components.

12. Access data from DDC controllers and ASC.

13. Operate portable operator's terminals.

C. **Train the designated staff of Owner's Representative and Owner to enable Advanced Operators to**:

1. Make and change graphics on the workstation

2. Create, delete, and modify alarms, including annunciation and routing of these

3. Create, delete, and modify point/object trend logs, and graph or print these

4. Create, delete, and modify reports

5. Add, remove, and modify system's physical points/objects

6. Create, modify, and delete programming

7. Add panels when required

8. Add Operator Workstation stations

9. Create, delete, and modify system displays — both graphical and otherwise
10. Perform DDC system field checkout procedures
11. Perform DDC controller unit operation and maintenance procedures
12. Perform workstation and peripheral operation and maintenance procedures
13. Perform DDC system diagnostic procedures
14. Configure hardware including PC boards, switches, communication, and I/O points/objects
15. Maintain, calibrate, troubleshoot, diagnose, and repair hardware
16. Adjust, calibrate, and replace system components

D. **Train the designated staff of Owner's Representative and Owner to enable System Managers/Administrators to**:

1. Maintain software and prepare backups
2. Interface with job-specific, third-party operator software

Add new users and understand password security procedures

E. Provide course outline and materials as per "Submittals" Article in Part 1 of this specification. The instructor(s) shall provide one copy of training material per student.

F. The instructor(s) shall be factory-trained instructors experienced in presenting this material.

G. Classroom training shall be done using a network of working controllers' representative of the installed hardware.

3.16 SEQUENCES OF OPERATION

A. **Single Zone Unit (MAU-1)**

1. General Control Intent: The primary function of this unit is to provide air movement, and temperature and humidity control in the stock tank room. During cooler outside air temperatures, the unit will activate electric heat to maintain room setpoint. Since there is not active cooling section to this unit, cooling will be provided only if outside air temperatures are lower than the room setpoint.

   As moisture levels in the room rise to dewpoint setpoint, the controller will evaluate the outside air moisture levels. If outside air dewpoint is lower than setpoint, the unit will go to full outside air position, set the supply fan to 100% speed, introduce the dryer outdoor air into the space, and purge the moist indoor air. The energy recovery wheel will operate to provide sensible only heat transfer between the outside air and exhaust when the conditions are beneficial.

B. **Run Conditions - Scheduled:** The unit shall run according to a user definable time schedule in the following modes:

1. Production Mode: The unit shall maintain

    a. A 65°F (adj.) heating setpoint and a dewpoint less than 50°F (adj.)

    b. A 75°F (adj.) cooling setpoint and a dewpoint less than 50°F (adj.). Since the unit serving this space has no active cooling, this is a dry bulb temperature target point only.

2. Unoccupied Mode (no production): The unit shall maintain

    a. A 45°F (adj.) heating setpoint.

    b. An 85°F (adj.) cooling setpoint. Since the unit serving this space has no active cooling, this is a target point only

3. Alarms shall be provided as follows:

    a. High Zone Dewpoint: If the zone dewpoint is greater than the setpoint by a user definable amount (adj.).

    b. Low Zone Temp: If the zone temperature is less than the heating setpoint by a user definable amount (adj.).

C. **Zone Setpoint Adjust:** The occupant shall be able to adjust the zone temperature heating and cooling setpoints at the zone sensor.

D. **Return Air Smoke Detection:** The unit shall shut down and generate an alarm upon receiving a return air smoke detector status.

E. **Supply Fan:** The supply fan shall run anytime the unit is commanded to run, unless shutdown on safeties. To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime. Fan to be on always in Production Mode, and operate as required to meet zone temperature setpoints in Unoccupied Mode. Fan speed to be at 75% during normal operation, and increase to 100% when trying to meet dewpoint setpoint.

F. **Exhaust Fan:** The return fan shall run whenever the supply fan runs.

G. **Heat Recovery Wheel - Variable Speed:** The controller shall modulate the heat recovery wheel for energy recovery as follows:

H. **Heating Recovery Mode:** The controller shall measure the zone temperature and modulate the heat wheel speed to maintain a setpoint 2°F (adj.) greater than the zone heating setpoint. The heat wheel shall run for heat recovery whenever:

1. Return air temperature is 5°F (adj.) or more above the outside air temperature.

2. AND the zone temperature is below heating setpoint.

3. AND the economizer (if present) is off.

4. AND the supply fan is on.

I. **Periodic Self-Cleaning:** The heat wheel shall run at 5% speed (adj.) for 10sec (adj.) every 4hr (adj.) the unit runs.

J. **Frost Protection:** The heat wheel shall run at 5% speed (adj.) whenever:

1. Outside air temperature drops below 15°F (adj.)

2. OR the exhaust air temperature drops below 20°F (adj.).

K. **Alarms shall be provided as follows**:

1. Heat Wheel Rotation Failure: Commanded on, but the status is off.

2. Heat Wheel in Hand: Commanded off, but the status is on.

3. Heat Wheel Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

L. **Electric Heating with SCR:** The controller shall measure the zone temperature and modulate the heating to maintain its heating setpoint.

The heating shall be enabled whenever:

1. Outside air temperature is less than 55°F (adj.).

2. AND the zone temperature is below heating setpoint.

3. AND the supply fan status is on.

M. **Filter Differential Pressure Monitor:** The controller shall monitor the dirty filter switch and alarm when switch is activated.

N. **Return Air Dewpoint:** The controller shall monitor the return air dewpoint and use as required for humidity control.

O. **Return Air Temperature:** The controller shall monitor the return air temperature and use as required for economizer control (if present).

- END OF SECTION -

SECTION 23 23 00 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications.

1.2 PERFORMANCE REQUIREMENTS

A. **Line Test Pressure for Refrigerant R-410A**:

1. Suction Lines for Air-Conditioning Applications: 300 psig.

2. Suction Lines for Heat-Pump Applications: 535 psig.

3. Hot-Gas and Liquid Lines: 535 psig.

1.3 SUBMITTALS

A. **Product Data**: For each type of valve and refrigerant piping specialty indicated. Include pressure drop based on manufacturer's test data.

B. **Shop Drawings**: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.

1. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

C. Field quality-control test reports.

D. Operation and maintenance data.

1.4 QUALITY ASSURANCE

A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.5 PRODUCT STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. **Copper Tube**: ASTM B88, Type K or L.

B. **Wrought-Copper Fittings**: ASME B16.22.

C. **Wrought-Copper Unions**: ASME B16.22.

D. **Solder Filler Metals**: ASTM B32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

E. **Brazing Filler Metals**: AWS A5.8.

F. **Flexible Connectors**:

1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch- long assembly.
4. Pressure Rating: Factory test at minimum 500 psig.
5. Maximum Operating Temperature: 250 deg F.

2.2 VALVES AND SPECIALTIES

A. **Diaphragm Packless Valves**:

1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
3. Operator: Rising stem and hand wheel.
4. Seat: Nylon.
5. End Connections: Socket, union, or flanged.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

B. **Packed-Angle Valves**:

1. Body and Bonnet: Forged brass or cast bronze.

2. Packing: Molded stem, back seating, and replaceable under pressure.

3. Operator: Rising stem.

4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.

5. Seal Cap: Forged-brass or valox hex cap.

6. End Connections: Socket, union, threaded, or flanged.

7. Working Pressure Rating: 500 psig.

8. Maximum Operating Temperature: 275 deg F.

C. **Check Valves**:

1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.

2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.

3. Piston: Removable polytetrafluoroethylene seat.

4. Closing Spring: Stainless steel.

5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.

6. End Connections: Socket, union, threaded, or flanged.

7. Maximum Opening Pressure: 0.50 psig.

8. Working Pressure Rating: 500 psig.

9. Maximum Operating Temperature: 275 deg F.

D. **Service Valves**:

1. Body: Forged brass with brass cap including key end to remove core.

2. Core: Removable ball-type check valve with stainless-steel spring.

3. Seat: Polytetrafluoroethylene.

4. End Connections: Copper spring.

5. Working Pressure Rating: 500 psig.

E. **Solenoid Valves**: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.

1. Body and Bonnet: Plated steel.

2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.

3. Seat: Polytetrafluoroethylene.

4. End Connections: Threaded.

5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24-V ac coil.

6. Working Pressure Rating: 400 psig.

7. Maximum Operating Temperature: 240 deg F.

8. Manual operator.

F. **Safety Relief Valves**: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.

2. Piston, Closing Spring, and Seat Insert: Stainless steel.

3. Seat Disc: Polytetrafluoroethylene.

4. End Connections: Threaded.

5. Working Pressure Rating: 400 psig.

6. Maximum Operating Temperature: 240 deg F.

G. **Thermostatic Expansion Valves**: Comply with ARI 750.

1. Body, Bonnet, and Seal Cap: Forged brass or steel.

2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.

3. Packing and Gaskets: Non-asbestos.

4. Capillary and Bulb: Copper tubing filled with refrigerant charge.

5. Suction Temperature: 40 deg F.

6. Superheat: Adjustable.

7. Reverse-flow option (for heat-pump applications).

8. End Connections: Socket, flare, or threaded union.

9. Working Pressure Rating: 450 psig.

H. **Straight-Type Strainers**:

1. Body: Welded steel with corrosion-resistant coating.

2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 deg F.

I. **Angle-Type Strainers**:

1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg F.

J. **Moisture/Liquid Indicators**:

1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 240 deg F.

K. **Replaceable-Core Filter Dryers**: Comply with ARI 730.

1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.

6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.

7. Maximum Pressure Loss: 2 psig.

8. Rated Flow:

9. Working Pressure Rating: 500 psig.

10. Maximum Operating Temperature: 240 deg F.

L. **Permanent Filter Dryers**: Comply with ARI 730.

1. Body and Cover: Painted-steel shell.

2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.

3. Desiccant Media: Activated.

4. Designed for reverse flow (for heat-pump applications).

5. End Connections: Socket.

6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.

7. Maximum Pressure Loss: 2 psig.

8. Rated Flow:

9. Working Pressure Rating: 500 psig.

10. Maximum Operating Temperature: 240 deg F.

M. **Liquid Accumulators**: Comply with ARI 495.

1. Body: Welded steel with corrosion-resistant coating.

2. End Connections: Socket or threaded.

3. Working Pressure Rating: 500 psig.

4. Maximum Operating Temperature: 275 deg F.

2.3 REFRIGERANTS

A. **Manufacturers**: Subject to compliance with requirements, provide products by one of the following:

1. Atofina Chemicals, Inc.

2. DuPont Company; Fluorochemicals Div.

3. Honeywell, Inc.; Genetron Refrigerants.

4. INEOS Fluor Americas LLC.

B. ASHRAE 34, R-410A.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Suction Lines NPS 4 NPS 2 to NPS 4 for Conventional Air-Conditioning Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

B. **Hot-Gas and Liquid Lines**: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install service valves for gage taps at strainers if they are not an integral part of strainers.

B. Install a check valve at the compressor discharge.

C. Install solenoid valves upstream from each expansion valve. Install solenoid valves in horizontal lines with coil at top.

D. Install thermostatic expansion valves as close as possible to distributors on evaporators.

1. Install valve so diaphragm case is warmer than bulb.

2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.

3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

E. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

F. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

G. **Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected**:

1. Solenoid valves.

2. Thermostatic expansion valves.

3. Compressor.

H. Install filter dryers in liquid line between compressor and thermostatic expansion valve.

I. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Refer to Division 23 Sections "Instrumentation and Control for HVAC" and for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 08 Section "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. **Slope refrigerant piping as follows**:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.

2. Install horizontal suction lines with a uniform slope downward to compressor.

3. Install traps and double risers to entrain oil in vertical runs.

4. Liquid lines may be installed level.

P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Q. Install pipe sleeves at penetrations in exterior walls and floor assemblies.

R. Seal penetrations through fire and smoke barriers according to Division 07 Section "Penetration Firestopping."

S. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

T. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.

U. Seal pipe penetrations through exterior walls according to Division 07 Section "Joint Sealants" for materials and methods.

V. Identify refrigerant piping and valves according to Division 23

3.4 PIPE JOINT CONSTRUCTION

A. **Soldered Joints**: Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook."

B. **Brazed Joints**: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.

2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

3.5 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Division 23

B. **Install the following pipe attachments**:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.

2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.

3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.

4. Spring hangers to support vertical runs.

5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. **Install hangers for copper tubing with the following maximum spacing and minimum rod sizes**:

1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.

2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.

3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.

4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8 inch.

5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8 inch.

6. NPS 2: Maximum span, 96 inches; minimum rod size, 3/8 inch.

7. NPS 2-1/2: Maximum span, 108 inches; minimum rod size, 3/8 inch.

8. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.

9. NPS 4: Maximum span, 12 feet; minimum rod size, 1/2 inch.

D. Support multifloor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. **Tests and Inspections**:

1. Comply with ASME B31.5, Chapter VI.

2. Test refrigerant piping and specialties. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.

3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.

a. Fill system with nitrogen to the required test pressure.

b. System shall maintain test pressure at the manifold gage throughout duration of test.

c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.

d. Remake leaking joints using new materials and retest until satisfactory results are achieved.

3.7 SYSTEM CHARGING

A. **Charge system using the following procedures**:

1. Install core in filter dryers after leak test but before evacuation.

2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.

3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.

4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. **Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions**:

1. Open shutoff valves in condenser water circuit.

2. Verify that compressor oil level is correct.

3. Open compressor suction and discharge valves.

4. Open refrigerant valves except bypass valves that are used for other purposes.

5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

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SECTION 23 31 13 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. **Section Includes**:

1. Rectangular ducts and fittings
2. Round ducts and fittings
3. Sheet metal materials
4. Sealants and gaskets
5. Hangers and supports
6. Seismic-restraint devices

1.2 PERFORMANCE REQUIREMENTS

A. **Delegated Duct Design**: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated.

1. Static-Pressure Classes:
   a. Supply Ducts (Upstream from Air Terminal Units): 2.5-inch wg.
   b. Supply Ducts (Downstream from Air Terminal Units): 1-inch wg.
   c. Supply Ducts (in Mechanical Equipment Rooms): 2.5-inch wg.
   d. Return Ducts (Negative Pressure): 1-inch wg.
   e. Exhaust Ducts (Negative Pressure): 1-inch wg.
2. Leakage Class:
   a. Round Supply-Air Duct: 3 cfm/100 sq. ft. at 1-inch wg.
   b. Rectangular Supply-Air Duct: 6 cfm/100 sq. ft. at 1-inch wg.
   c. Flexible Supply-Air Duct: 6 cfm/100 sq. ft. at 1-inch wg.

B. **Structural Performance**: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
2. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
3. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

1.3 SUBMITTALS

A. **Product Data**: For each type of product indicated.

B. **Shop Drawings**:

1. Fittings.
2. Reinforcement and spacing.
3. Seam and joint construction.
4. Penetrations through fire-rated and other partitions.
5. Equipment installation based on equipment being used on Project.
6. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

C. **Delegated-Design Submittal**:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations for selecting hangers, supports, and seismic restraints.

D. Welding certificates.

1.4 QUALITY ASSURANCE

A. **Welding Qualifications**: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

PART 2 - PRODUCTS

2.1 RECTANGULAR DUCTS AND FITTINGS

A. **General Fabrication Requirements**: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. **Transverse Joints**: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. **Longitudinal Seams**: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. **Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction**: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 ROUND DUCTS AND FITTINGS

A. **General Fabrication Requirements**: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. **Lindab Inc.**

   b. **McGill AirFlow LLC.**

   c. **SEMCO Incorporated.**

   d. **Sheet Metal Connectors, Inc.**

   e. **Spiral Manufacturing Co., Inc.**

B. **Transverse Joints**: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

C. **Longitudinal Seams**: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger Than 90 inches in diameter with butt-welded longitudinal seams.

D. **Tees and Laterals**: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SHEET METAL MATERIALS

A. **General Material Requirements**: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. **Galvanized Sheet Steel**: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G90.

2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. **Carbon-Steel Sheets**: Comply with ASTM A1008/A1008M, with oiled, matte finish for exposed ducts.

D. **Stainless-Steel Sheets**: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

E. **Aluminum Sheets**: Comply with ASTM B209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

F. **Reinforcement Shapes and Plates**: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

G. **Tie Rods**: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.4 SEALANT AND GASKETS

A. **General Sealant and Gasket Requirements**: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. **Two-Part Tape Sealing System**:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 3 inches.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

C. **Water-Based Joint and Seam Sealant**:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.

8. Service: Indoor or outdoor.

9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. **Flanged Joint Sealant**: Comply with ASTM C920.

1. General: Single-component, acid-curing, silicone, elastomeric.

2. Type: S.

3. Grade: NS.

4. Class: 25.

5. Use: O.

E. **Flange Gaskets**: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. **Round Duct Joint O-Ring Seals**:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.

2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.

3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.5 HANGERS AND SUPPORTS

A. **Hanger Rods for Noncorrosive Environments**: Cadmium-plated steel rods and nuts.

B. **Hanger Rods for Corrosive Environments**: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. **Strap and Rod Sizes**: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."

D. **Steel Cables for Galvanized-Steel Ducts**: Galvanized steel complying with ASTM A 603.

E. **Steel Cables for Stainless-Steel Ducts**: Stainless steel complying with ASTM A492.

F. **Steel Cable End Connections**: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. **Duct Attachments**: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. **Trapeze and Riser Supports**:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.

3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.6 SEISMIC-RESTRAINT DEVICES

A. **Manufacturers**: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. **Cooper B-Line, Inc.; a division of Cooper Industries.**

2. **Ductmate Industries, Inc.**

3. **Hilti Corp.**

4. **Kinetics Noise Control.**

5. **Loos & Co.; Cableware Division.**

6. **Mason Industries.**

7. **TOLCO; a brand of NIBCO INC.**

8. **Unistrut Corporation; Tyco International, Ltd.**

B. **General Requirements for Restraint Components**: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. **Channel Support System**: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

D. **Restraint Cables**: ASTM A603, galvanized -steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

E. **Hanger Rod Stiffener**: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

F. **Mechanical Anchor Bolts**: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

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

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

3.2 SEAM AND JOINT SEALING

A. Seal duct seams and joints for duct static-pressure and leakage classes specified in "Performance Requirements" Article, according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 1-2, "Standard Duct Sealing Requirements," unless otherwise indicated.

B. **Seal Classes**: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 1-2, "Standard Duct Sealing Requirements."

3.3 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."

B. **Building Attachments**: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. **Hanger Spacing**: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. **Hangers Exposed to View**: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.4 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

1. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.

2. Brace a change of direction longer than 12 feet.

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.

F. **Attachment to Structure**: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. **Drilling for and Setting Anchors**:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.

3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.

4. Set anchors to manufacturer's recommended torque, using a torque wrench.

5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 DUCT SCHEDULE

A. **Fabricate ducts with galvanized sheet steel except as follows**:

1. Moist Environment Ducts: Aluminum.

B. **Intermediate Reinforcement**:

1. Galvanized-Steel Ducts: Galvanized steel.

2. Stainless-Steel Ducts: Galvanized steel.

3. Aluminum Ducts: Aluminum or galvanized sheet steel coated with zinc chromate.

C. **Elbow Configuration**:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."

a. Velocity 1,000 fpm or Lower:

1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.

2) Mitered Type RE 4 without vanes.

b. Velocity 1,000 to 1,500 fpm:

1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.

2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.

3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

c. Velocity 1,500 fpm or Higher:

1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.

2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.

3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."

a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

1) Velocity 1,000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.

2) Velocity 1,000 to 1,500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.

3) Velocity 1,500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.

b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.

c. Round Elbows, 14 Inches and Larger in Diameter: Welded.

D. **Branch Configuration**:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."

a. Rectangular Main to Rectangular Branch: 45-degree entry.

b. Rectangular Main to Round Branch: Spin in.

2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees." Saddle taps are permitted in existing duct.

a. Velocity 1,000 fpm or Lower: 90-degree tap.

b. Velocity 1,000 to 1,500 fpm: Conical tap.

c. Velocity 1,500 fpm or Higher: 45-degree lateral.

- END OF SECTION -

SECTION 23 31 16 - NONMETAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. **Section Includes**:

1. Fabric ducts and fittings.

1.3 QUALITY ASSURANCE:

A. Building Codes and Standards

1. Product must be Classified by Underwriter’s Laboratories in accordance with the 25/50 flame spread/smoke developed requirements of NFPA 90-A and are also classified in accordance with ICC Evaluation Service AC167.

2. All product sections must be labeled with the logo and classification marking of Underwriter’s Laboratories.

B. Design & Quality Control

1. Manufacturer must have documented design support information including duct sizing, vent and orifice location, vent and orifice sizing, length, and suspension. Parameters for design, including maximum air temperature, velocity, pressure and fabric permeability, shall be considered and documented.

1.4 SUBMITTALS:

A. **Product Data**: Submit manufacturer’s specifications on materials and manufactured products used for work of this section.

B. **Building Code Data**: Submit UL file number under which product is Classified by Underwriter’s Laboratories for both NFPA 90-A and ICC AC167.

C. **Shop drawings**:

1. Fittings.

2. Seam and joint construction.

3. Hangers and supports, including methods for duct and building attachment.

1.5 WARRANTY

A. Manufacturer must provide a 10 Year Non Pro-rated Product Warranty for products supplied for the fabric portion of this system as well as a Design and Performance Warranty.

1.6 DELIVERY, STORAGE AND HANDLING:

A. Protect fabric system and components from damage during shipping, storage and handling.

B. Where possible, store products inside and protect from weather. Where necessary to store outside, store above grade and enclose with a vented waterproof wrapping.

PART 2 - PRODUCTS

2.1 MANUFACTURER:

A. **Subject to compliance with requirements, provide products manufactured in the United States, choose one of the following**:

1. DuctSox® Corporation

   9866 Kapp Ct

   Peosta, IA 52068

   Phone: (866) 563-7729 or (563) 588-5300

   FAX: (563) 588-5330

   www.DuctSox.com

2. KE Fibertec

   2107 Emmorton Park Rd

   Suite 102

   Edgewood, MD 21040

   Phone: (443) 299-6435

   FAX: (443) 299-6439

   www.ke-fibertec.com

3. FabricAir, Inc.

   312-A Swanson Drive

   Lawrenceville, GA 30043

   Phone: (502) 493-2210

FAX: (502) 493-4002

www.fabricair.com

2.2 AIR DISTRIBUTION SYSTEM; FABRIC:

A. **Duct Fabric**: Air diffusers shall be constructed of a coated woven fire retardant fabric complying with the following physical characteristics:

1. Fabric Construction: 100% Polyester

2. Coating: Permeable per Schedule

3. Weight: 8.5 oz./yd^2 per ASTM D3776

4. Color: To be selected by Architect/Owner from Manufacturer's Standard Color Selection.

5. Air Permeability: 2 cfm/ft^2 (+/- 5%) per ASTM D737, Frazier

6. Temperature Range: -40 degrees F to 284 degrees F

7. Fire Retardancy: Classified by Underwriters Laboratories in accordance with the flame spread/smoke developed requirements of NFPA 90-A.

2.3 SYSTEMS FABRICATION REQUIREMENTS:

A. Dispersing orifice sizing up to 5 inch diameter (design dependant).

B. Size, quantity, and location of orifices to be specified and approved by manufacturer and engineer.

C. Inlet connection to metal duct via fabric draw band with anchor patches as supplied by manufacturer. Anchor patches to be secured to metal duct via. zip screw fastener – supplied by contractor.

D. Inlet connection includes zipper for easy removal / maintenance.

E. Lengths to include required zippers as specified by manufacturer.

F. System to include Adjustable Flow Devices to balance turbulence, airflow and distribution as needed. Flow restriction device shall include ability to adjust the airflow resistance from 0.06 – 0.60 in w.g. static pressure.

G. End cap includes zipper for easy maintenance.

H. Fabric system shall include connectors to accommodate suspension system listed below.

I. Any deviation from a straight run shall be made using a gored elbow or an efficiency tee. Normal 90 degree elbows are 5 gores and the radius of the elbow is 1.5 times the diameter of the Fabric Duct.

2.4 DESIGN PARAMETERS:

A. Fabric Duct systems shall be designed from 0.25” water gage minimum to 3.1” maximum, with 0.5” as the standard.

B. Fabric system shall be limited to design temperatures between 0 degrees F and 180 degrees F (-17.8 degrees C and 82 degrees C).

C. Design CFM, static pressure and diffuser length shall be designed or approved by the manufacturer.

D. Do not use fabric diffusers in concealed locations.

E. Use fabric diffusers only for positive pressure air distribution components of the mechanical ventilation system.

F. Each fabric section shall have a unique tag with manufacturer information, order number, and duct section number. Each section shall be optimized for installation and maintenance by utilizing zipper style connections.

2.5 SUSPENSION HARDWARE: (one of following)

A. **Tension Cable**: System shall be installed using a tension cable system including a single (1 Row) or double strands (2 Row) of cable located 3” above top-dead-center (1 Row) or 3” above the 10 and 2 o’clock locations of the fabric ductwork system. 2 Row supports are required for systems of 32” diameter and larger. Hardware to include cable, eye bolts, cable clamps and turnbuckle(s) as required. System attachment shall be made using nylon snap clips spaced 24 inches. Component options include (must specify per area if multiple on same project):

1. Galvanized Steel Cable

2. Stainless Steel Cable

3. Plastic Coated Stainless Steel Cable

B. **3x1 Suspension**: (*Available on duct diameters from 16” to 48”)* System shall include a 3 Row connection to fabric system at 10, 12, and 2 o’clock locations. Attachment spacing is not to exceed 3 feet. The powder-coated aluminum hangers are secured and integrated to a single (1 Row) tension cable every 3’ and connect to the fabric system at the 10 and 2 o’clock locations with detachable D-Clasps. The fabric system will also have clips located at 12 o’clock to attach directly to the single tension cable system located 3” above top-dead-center location of the fabric system. Tension cable hardware to include cable, eye bolts, cable clamps, and turnbuckles as required. Component options include:

1. Galvanized Steel Cable

2. Stainless Steel Cable

C. All-In-One style of suspension system shall have center support row, rigid or cable system with connections and fabric duct attachments. This system shall be designed to hold open the duct in a near round configuration in the absence of airflow. This system shall be All-In-One suspension system as manufactured by FabricAir or equal. See Schedule for support method. See fabric duct schedule on drawings for exact support details.

PART 3 - EXECUTION

3.1 INSTALLATION OF AIR DISTRIBUTION SYSTEM; FABRIC:

A. Install chosen suspension system in accordance with the requirements of the manufacturer. Instructions for installation shall be provided by the manufacturer with product.

B. Suspension system is to be installed as level as possible.

3.2 CLEANING AND PROTECTION:

A. Clean air handling unit and ductwork prior to the Fabric Duct system unit-by-unit as it is installed. Clean external surfaces of foreign substance which may cause corrosive deterioration of facing.

B. Temporary Closure: At ends of ducts which are not connected to equipment or distribution devices at time of ductwork installation, cover with polyethylene film or other covering which will keep the system clean until installation is completed.

C. If Fabric Duct systems become soiled during installation, they should be removed and cleaned following the manufacturers standard terms of laundry.

- END OF SECTION -

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SECTION 23 33 00 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. **Section Includes**:

1. Backdraft and pressure relief dampers
2. Manual volume dampers
3. Control dampers
4. Fire dampers
5. Smoke dampers
6. Fire / Smoke dampers
7. Flange connectors
8. Turning vanes
9. Duct-mounted access doors
10. Flexible connectors
11. Flexible ducts
12. Duct accessory hardware
13. Louvers and penthouses

1.2 SUBMITTALS

A. Submittals shall be in accordance with specification Section 01 33 00 – Contractor Submittals.

B. **Product Data**: For each type of product indicated.

C. **Shop Drawings**: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

a. Special fittings.

b. Manual volume damper installations.

c. Control damper installations.

d. Fire-damper and smoke-damper installations, including sleeves; and duct-mounted access doors.

e. Wiring Diagrams: For power, signal, and control wiring.

D. Operation and maintenance data.

1.3 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with AMCA 500-D testing for damper rating.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. **Galvanized Sheet Steel**: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G90.

2. Exposed-Surface Finish: Mill phosphatized.

C. **Stainless-Steel Sheets**: Comply with ASTM A480/A480M, Type 304, and having a No. 2 finish for concealed ducts and finish for exposed ducts.

D. **Aluminum Sheets**: Comply with ASTM B209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

E. **Extruded Aluminum**: Comply with ASTM B221, Alloy 6063, Temper T6.

F. **Reinforcement Shapes and Plates**: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

G. **Tie Rods**: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. **Manufacturers**: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. **American Warming and Ventilating**
2. **Greenheck Fan Corporation**
3. **Lloyd Industries, Inc.**
4. **Nailor Industries Inc.**
5. **NCA Manufacturing, Inc.**
6. **Pottorff; a division of PCI Industries, Inc.**
7. **Ruskin Company**
8. **SEMCO Incorporated**
9. **Vent Products Company, Inc.**

B. **Description**: Gravity balanced.

C. **Frame**: galvanized sheet steel, with welded corners and mounting flange.

D. **Blades**: Multiple single-piece blades, maximum 6-inch width, with sealed edges.

E. **Blade Action**: Parallel.

F. **Return Spring**: Adjustable tension.

G. **Accessories**:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Electric actuators.
4. Chain pulls.
5. Front of rear screens.
6. 90-degree stops.

H. **Sleeve**: Minimum 20-gage thickness.

2.3 MANUAL VOLUME DAMPERS

A. **Standard, Steel, Manual Volume Dampers**:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. **American Warming and Ventilating; a division of Mestek, Inc.**

b. **Flexmaster U.S.A., Inc.**

c. **McGill AirFlow LLC.**

d. **METALAIRE, Inc.**

e. **Nailor Industries Inc.**

f. **Penn**

g. **Ruskin Company**

h. **Vent Products Company, Inc.**

i. **NCA Manufacturing, Inc.**

2. Standard leakage rating

3. Suitable for horizontal or vertical applications.

4. Basis of Design:

a. Rectangular dampers may be single blade up to 24”x12” size and multiple, opposed blade design for larger sizes. Control shaft shall be solid 3/8” square or hex steel with synthetic or bronze bearings. Provide with 2” stand-off bracket and manual quadrant operator. Provide Ruskin model MD-15 or approved equal, rated for 1,500 FPM velocity and 2-1/2” static pressure differential.

b. Round dampers shall have solid 3/8” or ½” square or hex steel shaft with synthetic or bronze bearings. Provide with 2” operator stand-off bracket and manual quadrant operator. Provide Ruskin model MDRS25 or approved equal, rated for 1,500 FPM velocity.

c. All damper blades shall be secured to damper axles by mechanical (threaded) fasteners or by welding. Shop fabricated dampers are not acceptable.

d. Combination spin-ins with dampers are acceptable only if damper requirements listed herein are met. If damper requirements cannot be met by combination units, provide separate spin-in and volume damper.

2.4 CONTROL DAMPERS

A. **Manufacturers**: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. **American Warming and Ventilating; a division of Mestek, Inc.**

2. **Duro Dyne Inc.**

3. **Flexmaster U.S.A., Inc.**

4. **Greenheck Fan Corporation**

5. **Lloyd Industries, Inc.**

6. **McGill AirFlow LLC.**

7. **METALAIRE, Inc.**

8. **Metal Form Manufacturing, Inc.**

9. **Nailor Industries Inc.**

10. **Ruskin Company**

11. **Vent Products Company, Inc.**

12. **Young Regulator Company**

13. **NCA Manufacturing, Inc.**

B. **Basis of Design**:

1. Motorized dampers shall be Ruskin CD-50 or CD-40 low leakage damper with airfoil blades and vinyl double edge seals or Johnson Controls D1300 with edge seals. Dampers shall be opposed blade unless otherwise noted. Substitute units shall be AMCA certified as a low leakage damper and shall be equal to the models specified above in construction, features and quality. Damper actuators shall be provided under temperature control unless otherwise scheduled or noted on plans.

2.5 FIRE DAMPERS

A. **Manufacturers**: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. **Air Balance Inc.; a division of Mestek, Inc.**

2. **Greenheck Fan Corporation.**

3. **McGill AirFlow LLC.**

4. **METALAIRE, Inc.**

5. **Nailor Industries Inc.**

6. **Penn**

7. **Pottorff; a division of PCI Industries, Inc.**

8. **Prefco; Perfect Air Control, Inc.**

9. **Ruskin Company.**

10. **Vent Products Company, Inc.**

B. **Type**: Dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 4,000-fpm velocity.

D. **Fire Rating**: 1-1/2 and 3 hours.

E. Basis of Design:

1. Fire dampers shall be Ruskin dynamic curtain type DIBD2 Style B with 1-1/2 hour UL label, or approved equal. Where space does not permit installation of Style B, then Style A shall be used.

2. Fire dampers shall be furnished with factory sleeve; wall angles and 212 degree F fusible links to conform to U.L. tested and approved mounting means. Provide complete mounting details to the Contractor.

3. Fire dampers installed in flanged duct systems (Duct Mate) shall be furnished with Duct Mate break-away connections.

2.6 SMOKE DAMPERS

A. **Manufacturers**: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. **Air Balance Inc.; a division of Mestek, Inc.**

2. **Greenheck Fan Corporation.**

3. **Nailor Industries Inc.**

4. **Penn**

5. **Ruskin Company Manufacturers**

B. **General Requirements**: Label according to UL 555S by an NRTL

C. **Basis of Design**: Ruskin SD50 or SDS25

1. Damper to be power open / fail close with 120 V actuator.

2. Smoke dampers shall be furnished with factory sleeves and wall angles to conform to U.L. tested and approved mounting means. Provide complete mounting details to the Contractor.

3. Smoke dampers installed in flanged duct systems (Duct Mate systems) shall be furnished with Duct Mate break-away connections.

D. **Smoke Detector**: Integral, factory wired for single-point connection.

E. **Frame**: fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.

F. **Blades**: Roll-formed, horizontal, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.

G. **Leakage**: Class I.

H. Rated pressure and velocity to exceed design airflow conditions.

I. **Mounting Sleeve**: Factory-installed, 0.052-inch- thick, galvanized sheet steel; length to suit wall or floor application.

J. **Damper Motors**: two-position action.

K. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.

4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.

5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.

6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.

7. Electrical Connection: 115 V, single phase, 60 Hz.

L. **Accessories**:

1. Auxiliary switches for signaling or position indication.

2. Test and reset switches, damper, or remote mounted as required.

2.7 COMBINATION FIRE AND SMOKE DAMPERS

A. **Manufacturers**: Subject to compliance with requirements, provide products by one of the following:

1. **Air Balance Inc.; a division of Mestek, Inc.**
2. **Cesco Products; a division of Mestek, Inc.**
3. **Greenheck Fan Corporation**
4. **Nailor Industries Inc.**
5. **Ruskin Company**

B. **Type**: Static and dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 4,000-fpm velocity.

D. **Fire Rating**: 1-1/2 and 3 hours.

E. **Frame**: Multiple-blade type; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.

F. **Heat-Responsive Device**: Electric resettable link and switch package, factory installed, rated.

G. **Smoke Detector**: Integral, factory wired for single-point connection.

H. **Blades**: Airfoil-shaped, double-skin, single piece construction with 14 gage equivalent thickness, maximum 6” wide.

I. Rated pressure and velocity to exceed design airflow conditions.

J. **Mounting Sleeve**: Factory-installed, 0.052-inch- thick, galvanized sheet steel; length to suit wall or floor application.

K. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.

3. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.

4. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.

5. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.

6. Electrical Connection: 115 V, single phase, 60 Hz.

L. **Accessories**:

1. Auxiliary switches for signaling.

2. Test and reset switches, remote mounted.

2.8 FLANGE CONNECTORS

A. **Manufacturers**: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Ductmate Industries, Inc.

2. Nexus PDQ; Division of Shilco Holdings Inc.

3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. **Description**: roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. **Material**: Galvanized steel.

D. **Gage and Shape**: Match connecting ductwork.

2.9 TURNING VANES

A. **Manufacturers**: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Ductmate Industries, Inc.

2. Duro Dyne Inc.

3. METALAIRE, Inc.

4. SEMCO Incorporated.

5. **Ward Industries, Inc.; a division of Hart & Cooley, Inc.**

B. **Turning Vanes for Metal Ducts**: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. **Manufactured Turning Vanes for Nonmetal Ducts**: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. **General Requirements**: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."

E. **Vane Construction**: Single wall for ducts up to 36 inches wide and double wall for larger dimensions.

2.10 DUCT-MOUNTED ACCESS DOORS

A. **Manufacturers**: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. **American Warming and Ventilating; a division of Mestek, Inc.**
2. **Cesco Products; a division of Mestek, Inc.**
3. **Ductmate Industries, Inc.**
4. **Flexmaster U.S.A., Inc.**
5. **Greenheck Fan Corporation**
6. **McGill AirFlow LLC**
7. **Nailor Industries Inc.**
8. **Pottorff; a division of PCI Industries, Inc.**
9. **Ventfabrics, Inc.**
10. **Ward Industries, Inc.; a division of Hart & Cooley, Inc.**

B. **Duct-Mounted Access Doors**: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."

1. Basis of Design: Ruskin #ADC3 with cam type closers. Use largest standard square size acceptable by duct.

2. Door:

    a. Double wall, rectangular.

    b. Latches: cam latches.

    c. Fabricate doors airtight and suitable for duct pressure class.

3. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

2.11 FLEXIBLE CONNECTORS

A. **Manufacturers**: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    1. **Ductmate Industries, Inc.**

    2. **Duro Dyne Inc.**

    3. **Ventglass, Inc.**

    4. **Ward Industries, Inc.; a division of Hart & Cooley, Inc.**

B. **Materials**: Flame-retardant or noncombustible fabrics.

C. **Coatings and Adhesives**: Comply with UL 181, Class 1.

D. **Metal-Edged Connectors**: Factory fabricated with a fabric strip attached to 2 strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets to provide 4” metal-to-metal separation. Provide metal compatible with connected ducts.

2.12 FLEXIBLE DUCTS

A. **Manufacturers**: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    1. **Flexmaster U.S.A., Inc.**

    2. **McGill AirFlow LLC.**

    3. **Ward Industries, Inc.; a division of Hart & Cooley, Inc.**

B. **Insulated, Flexible Duct**: Shall be Thermalflex Type M-KE, Hart & Cooley, Flex Master or as approved. Duct shall be in accord with NFPA 90A requirements and shall be UL approved and rated for flame spread less than 25 smoke development not more than 50. Pressure rated for 6 inches WG. Flexible duct shall be insulated with an R value of not less than 5 and shall be manufactured with a fiberglass reinforced vapor barrier jacket.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.

2. Maximum Air Velocity: 4,000 fpm.

3. Temperature Range: Minus 10 to plus 160 deg F.

C. **Flexible Duct Connectors**:

1. Bands for securing flexible duct core liner to sheet metal connectors shall be stainless steel draw bands with screw operators. Bands for securing outer insulation jacket shall be stainless steel draw bands or may be nylon “zip-ties” not less than ¼” in width made specifically for the purpose.

2. Sealant tape for sealing the core liner to sheet metal connectors shall be “FoilGirp” as manufactured by Hardcast or approved equivalent product. Tape shall have a 2 mil aluminum foil facing with a modified BUTYL adhesive and shall be rated for SMACNA seal classes A, B, and C for duct static pressures up to 6” w.g. for a temperature range of -20°F to 220°F. tape shall be 2” in width and shall have a flamespread rating of less than 25 and a smoke development rating of less than 50. Submit complete product literature for sealing tapes.

2.13 DUCT ACCESSORY HARDWARE

A. **Instrument Test Holes**: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. **Adhesives**: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

2.14 LOUVERS AND PENTHOUSES

A. **Manufacturers**: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Airolite

2. Airstream

3. American Warming & Ventilating

4. Carnes

5. Perfco

6. Ruskin

7. United Sheet Metal

B. Sizes, materials, types and finishes shall be as noted in the schedules or elsewhere on the drawings. Substitute louvers shall not have less free area than the specified units.

C. All louvers furnished for mounting in masonry wall construction shall be furnished with an extended or separate sill.

D. Unless indicated otherwise, all louvers fro masonry walls will be box frame without face flange.

E. Penthouse units shall be provided with factory or field fabricated curbs as required or shown on the plans. Curbs shall take into account the pitch of the roof to provide a level surface/frame for mounting of the penthouse.

F. Penthouses shall be furnished with special materials, finishes, bird screens, snow screens, backdraft dampers, insulated top or other accessories as listed on the schedule.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.

2. Install aluminum volume dampers in aluminum ducts.

E. All dampers shall operate smoothly through their entire range. Provide locking mechanisms to secure volume dampers in position. Mark all damper axles permanently to indicated damper blade position using a file, scratch awl or similar tool.

F. Set dampers to fully open position before testing, adjusting, and balancing.

G. Install test holes at fan inlets and outlets and elsewhere as indicated.

H. Install fire and smoke dampers according to UL listing.

I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.

2. Downstream from manual volume dampers, control dampers, turning vanes, and equipment.

3. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors; and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.

4. At each change in direction and at maximum 50-foot spacing.

5. Upstream of turning vanes.

6. Elsewhere as indicated.

J. Install access doors with swing against duct static pressure.

K. **Access Door Sizes**:

1. One-Hand or Inspection Access: 8 by 5 inches.

2. Two-Hand Access: 12 by 6 inches.

3. Head and Hand Access: 18 by 10 inches.

4. Head and Shoulders Access: 21 by 14 inches.

5. Body Access: 25 by 14 inches.

6. Body plus Ladder Access: 25 by 17 inches.

7. At splitter dampers (use 8" X 8" door).

8. At volume dampers (use 8" X 8" door).

9. At fire dampers (use largest standard square size duct will accept).

10. At motorized dampers (use largest standard square size duct will accept or multiple 12" X 12" size to provide service access to the entire damper).

11. At duct coils (use largest standard square size duct will accept or multiple 12" X 12" size to provide service access to the entire coil. Access shall be provided at both sides of the coil to facilitate cleaning of coil). Immediately downstream of all duct-mounted humidifiers (Use largest standard square size duct will accept or multiple 12" X 12" size to provide service access to the entire coil. Access shall be provided at both sides of the coil to facilitate cleaning of coil) to provide access to entire humidifier grid.

L. Label access doors according to Division 23 Section "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

M. Install flexible connectors to connect ducts to equipment with at least 4” metal-to-metal. Flexible connections shall be airtight.

N. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

O. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

P. Connect diffusers or light troffer boots to low-pressure ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.

Q. Connect flexible ducts to metal ducts with adhesive draw bands.

R. Install duct test holes where required for testing and balancing purposes.

S. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

T. Provide air volume extractors or extended, tapered inlet connection where branch ducts are set into the side of trunk ducts as indicated on the plans.

U. Spin-in connector for round duct connection shall be conical in design unless otherwise noted on plans. Connectors for branch ducts which attach to main duct runs shall be fitted with volume damper.

V. Flexible Ducts

   1. Support all flexible ducts with strap hangers in accordance with SMACNA recommendations and mechanical code requirements. Support ducts at an interval not exceeding 4 feet on center and limit sag to less than ½” per foot. Support duct to prevent contract with structural members, ceilings and all sources of heat such as lights and piping.

   2. Install sheet metal elbows for all bends with a turning radius of less than four feet. All sheet metal elbows, connectors, etc., shall be insulated as specified for sheet metal ductwork.

   3. Secure the inner duct liner to sheet metal connectors and fittings with two wraps of sealant tape. Install a stainless steel draw band over the sealant tape and liner. The liner shall overlap the sheet metal connector by not less than 2”.

   4. After securing the inner liner, secure the outer insulation jacket with stainless steel or nylon draw bands. Fold the insulation jacket under the draw band so that no fiberglass insulation is exposed.

W. Wall and Floor Penetrations

1. Provide sheet metal sleeves in all concrete or masonry walls and floors. Frame or sleeve openings through stud walls.

2. Sleeves and openings sized to accept the duct with insulation. Pack insulation in after duct is installed.

3. Grout sleeves in place in existing masonry walls or floors.

4. Provide finishing collars on each side of wall or floors at all penetrations.

5. Seal the space between ductwork and sleeves with mildew resistant silicone caulk.

3.2 FIELD QUALITY CONTROL

A. **Tests and Inspections**:

1. Operate dampers to verify full range of movement.

2. Inspect locations of access doors and verify that purpose of access door can be performed.

3. Operate fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.

4. Inspect turning vanes for proper and secure installation.

- END OF SECTION -

SECTION 23 34 23 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. **This Section includes the following**:

1. Centrifugal roof ventilators
2. Centrifugal wall ventilators
3. Ceiling-mounting ventilators
4. In-line centrifugal fans

1.2 SUBMITTALS

A. **Product Data**: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

B. **Shop Drawings**: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

C. Field quality-control test reports.

D. Operation and maintenance data.

1.3 QUALITY ASSURANCE

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

B. **NEMA Compliance**: Motors and electrical accessories shall comply with NEMA standards.

C. **UL Standard**: Power ventilators shall comply with UL 705.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. **Basis-of-Design Product**: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. **Greenheck**
2. **Loren Cook Company**
3. **Soler and Palau, USA**

2.2 CENTRIFUGAL ROOF VENTILATORS

A. **Description**: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

B. **Housing**: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.

1. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

C. **Fan Wheels**: Aluminum hub and wheel with backward-inclined blades.

D. **Belt-Driven Drive Assembly**: Resiliently mounted to housing, with the following features:

1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.

2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

3. Pulleys: Cast-iron, adjustable-pitch motor pulley.

E. **Accessories**:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.

3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.

F. **Roof Curbs**: Galvanized steel; mitered and welded corners; 1-1/2-inch thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

2.3 CENTRIFUGAL WALL VENTILATORS

A. **Description**: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.

B. **Housing**: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; venturi inlet cone.

C. **Fan Wheel**: Aluminum hub and wheel with backward-inclined blades.

D. **Belt-Driven Drive Assembly**: Resiliently mounted to housing, with the following features:

1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.

2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

3. Pulleys: Cast-iron, adjustable-pitch motor pulley.

E. **Accessories**:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through internal aluminum conduit.

2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.

3. Wall Grille: Ring type for flush mounting.

4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in wall sleeve; factory set to close when fan stops.

2.4 CEILING-MOUNTING VENTILATORS

A. **Description**: Centrifugal fans designed for installing in ceiling or wall or for concealed in-line applications.

B. **Housing**: Steel, lined with acoustical insulation.

C. **Fan Wheel**: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

D. **Grille**: Plastic, louvered grille with flange on intake and thumbscrew attachment to fan housing.

E. **Electrical Requirements**: Junction box for electrical connection on housing and receptacle for motor plug-in.

F. **Accessories**:

1. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.

2. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.

3. Filter: Washable aluminum to fit between fan and grille.

4. Isolation: Rubber-in-shear vibration isolators.

5. Manufacturer's standard roof jack or wall cap and transition fittings.

2.5 IN-LINE CENTRIFUGAL FANS

A. **Description**: In-line, direct -driven centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.

B. **Housing**: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

C. **Direct-Driven Units**: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.

D. **Belt-Driven Units**: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

E. **Fan Wheels**: Aluminum, airfoil blades welded to aluminum hub.

F. **Accessories**:

1. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.

2. Companion Flanges: For inlet and outlet duct connections.

3. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.

4. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

2.6 MOTORS

A. Comply with requirements in Specification Section 23 05 13 – Common Motor Requirements for HVAC Equipment.

B. **Enclosure Type**: Totally enclosed, fan cooled.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Support units using spring isolators having a static deflection of 1 inch.

1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.

C. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

D. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Division 07 Section "Roof Accessories" for installation of roof curbs.

E. **Ceiling Units**: Suspend units from structure; use steel wire or metal straps.

F. Support suspended units from structure using threaded steel rods and spring hangers having a static deflection of 1 inch.

G. Install units with clearances for service and maintenance.

H. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in specification Section 23 33 00 – Air Duct Accessories.

I. Install ducts adjacent to power ventilators to allow service and maintenance.

J. Ground equipment according to Division 26 Section.

K. Connect wiring according to Division 26 Section.

3.2 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Verify that shipping, blocking, and bracing are removed.

2. Verify that unit is secure on mountings and supporting devices and that the connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.

3. Verify that cleaning and adjusting are complete.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.

5. Adjust belt tension.

6. Adjust damper linkages for proper damper operation.

7. Verify lubrication for bearings and other moving parts.

8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.

10. Shut unit down and reconnect automatic temperature-control operators.

11. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

- END OF SECTION -

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SECTION 23 37 13 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

A. **Section Includes**:

1. Round ceiling diffusers
2. Rectangular and square ceiling diffusers
3. Perforated diffusers
4. Louver face diffusers
5. Linear bar diffusers
6. Linear slot diffusers
7. Adjustable bar registers, grilles, registers and grilles
8. Fixed face registers, grilles, registers and grilles
9. Linear bar grilles

1.2 SUBMITTALS

A. **Product Data**: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. **Samples**: For each exposed product and for each color and texture specified.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. **Subject to compliance with requirements, provide products by one of the following**:

a. **Carnes**
b. **Titus**
c. **Tuttle & Bailey**
d. **Krueger**

2.2 CEILING DIFFUSERS

A. **Round Ceiling Diffuser**:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the manufacturers listed in section 2.1.

B. **Rectangular and Square Ceiling Diffusers**:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the manufacturers listed in section 2.1.

C. **Perforated Diffuser**:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the manufacturers listed in section 2.1.

D. **Louver Face Diffuser**:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the manufacturers listed in section 2.1.

2.3 CEILING LINEAR SLOT OUTLETS

A. **Linear Bar Diffuser**:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the manufacturers listed in section 2.1.

B. **Linear Slot Diffuser**:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the manufacturers listed in section 2.1.

2.4 REGISTERS AND GRILLES

A. **Adjustable Bar Register**:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the manufacturers listed in section 2.1.

B. **Adjustable Bar Grille**:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the manufacturers listed in section 2.1.

C. **Fixed Face Register**:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the manufacturers listed in section 2.1.

D. **Fixed Face Grille**:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the manufacturers listed in section 2.1.

E. **Linear Bar Grille**:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the manufacturers listed in section 2.1.

2.5 SOURCE QUALITY CONTROL

A. **Verification of Performance**: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. **Ceiling-Mounted Outlets and Inlets**: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.2 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

- END OF SECTION -

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SECTION 23 57 05 – WATER SOURCE HEAT PUMPS

PART 1 - GENERAL

1.1 GENERAL DESCRIPTION

A. This section includes the design, controls and installation requirements for packaged water source heat pumps.

1.2 QUALITY ASSURANCE

A. Packaged air-cooled condenser units shall be certified in accordance with ANSI/AHRI Standard 340/360 performance rating of commercial and industrial unitary air-conditioning and heat pump equipment.

B. Unit and refrigeration system shall comply with ASHRAE 15, Safety Standard for Mechanical Refrigeration.

C. Unit shall be certified in accordance with UL Standard 1995/CSA C22.2 No. 236, Safety Standard for Heating and Cooling Equipment.

D. Unit Energy Efficiency Ratio (EER) shall be equal to or greater than prescribed by ASHRAE 90.1, Energy Efficient Design of New Buildings except Low-Rise Residential Buildings.

E. Unit shall comply with Idaho and Bingham County code requirements for a Heat Pump unit.

F. Unit shall be safety certified by ETL and be ETL US and ETL Canada listed.

1.3 SUBMITTALS

A. **Product Data**: Literature shall be provided that indicates dimensions, operating and shipping weights, capacities, ratings, fan performance, filter information, factory supplied accessories, electrical characteristics and connection requirements. Installation, Operation and Maintenance manual with startup requirements shall be provided.

B. **Shop Drawings**: Unit drawings shall be provided that indicates assembly, unit dimensions, construction details, clearances, and connection details. Computer generated fan curves for each fan shall be submitted with specific design operation point noted. Wiring diagram shall be provided with details for both power and control systems and differentiate between factory installed and field installed wiring.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Unit shall be shipped with doors bolted shut to prevent damage during transport and thereafter while in storage awaiting installation.

B. Follow Installation, Operation and Maintenance manual instructions for rigging, moving, and unloading the unit at its final location.

C. Unit shall be stored in a clean, dry place protected from construction traffic in accordance with the Installation, Operation and Maintenance manual.

1.5 WARRANTY

A. Manufacturer shall provide a limited “parts only” warranty for a period of 12 months from the date of equipment startup or 18 months from the date of original equipment shipment from the factory, whichever is less, and unless indicated otherwise within this specification. Warranty shall cover material and workmanship that prove defective, within the specified warranty period, provided manufacturer’s written instructions for installation, operation and maintenance have been followed. Warranty excludes parts associated with routine maintenance, such as belts and air filters.

PART 2 - PRODUCTS

2.1 WATER SOURCE HEAT PUMPS (WSHP-02)

A. General Description

1. Indoor air handling unit shall include filters, supply fans, dampers, exhaust fans, and unit controls.

2. All units must be factory run tested of the completed unit with full water flow.

3. All equipment must be safety agency listed with ETL and shall be certified for capacity and efficiency in accordance with AHRI standard 13256-1.

4. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.

5. Unit components shall be labeled, including pipe stub outs, refrigeration system components and electrical and controls components.

6. Estimated sound power levels (dB) shall be shown on the unit ratings sheet.

7. Installation, Operation and Maintenance manual shall be supplied within the unit.

8. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment’s access door.

9. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment’s access door.

B. Unit Construction

1. The cabinet walls, access doors, roof and floor shall be constructed of 18 gauge interior panels with ¾-inch 1-1/2 lb density fiberglass as the interior core. All openings through the casing shall be grommeted.

2. Unit shall include dual sloped stainless steel drain pains and be externally trapped.

3. Filters shall be side loaded from the same side as the electrical access door. A 2-inch MERV 7 pleated media filter shall suite the unit.

C. Fan Section

1. The fan section shall consist of the fan, motor, and discharge outlet. Airside components shall be separated from the compressor section to limit noise transmission from the compressor.

2. Unit shall include direct drive, dynamically balance, airfoil-shaped blade plug fans. Motors shall be premium efficiency totally enclosed with sealed and locked bearings and TEAO rated frame design for quiet operation.

3. Motors shall be designed for use with VFD's and include bearing protection rings to reduce bearing frosting, pitting, and failure caused by VFD induced voltages on the motor shaft.

4. Vertical unit shall be provided with supply air discharge from the top of the unit.

D. Refrigeration System

1. Unit shall have two separate circuits complete with scroll compressor, coaxial water refrigerant coil, airside direct expansion coil, reversing valve, thermal expansion valve with external equalizer line and shall be serviceable and adjustable while the unit is in operation.

2. Units shall be designed for use with R-410A refrigerant.

3. The reversing valve shall be energized in the cooling mode and is fail-safe to the heating mode.

4. Each circuit shall be equipped with low and high pressure refrigerant manual reset safety controls. The circuit shall also have Schrader valves on both the high and low pressure sides and liquid line filter drier.

5. Each refrigeration circuit shall ship fully charged and ready for operation, requiring only connection of water and electrical services.

E. Compressors

1. Compressors shall be scroll type with thermal overload protection and be isolated from the unit with neoprene isolators as recommended by the compressor manufacturer.

2. Compressors shall be mounted in an isolated service compartment that can be accessed without affecting unit operation.

F. Unit Piping and Coils

1. The refrigeration side piping shall be rated to 650 psi and the waterside piping shall be rated to 300 psi.

2. Field piping connections shall be MPT connections and incorporate isolation valve and manual drain valves as standard equipment.

3. Direct expansion airside coils shall be constructed of half-inch rifled copper tubes with lanced aluminum fins mechanically bonded to the tubes and galvanized steel end casings.

4. Coils shall have interlaced circuitry.

5. Coils shall be factory tested with air at 450 psi under water and shall be rated for 250 psi working pressure.

6. Economizer coil shall have a minimum of four, ½-inch diameter tubing, and 8 FPI. The coil shall be located upstream from the direct expansion airside coil and shall be factory mounted. The coil shall have factory-installed drain and vent connections extended to permit draining into a watertight condensate pan. The coil shall be factory tested with air at 450 psi under water and shall be rated for 250 psi working pressure. The coil shall have a single or double actuator valve dependant on the size of the unit. The coil fluid side shall be factory piped to the water-cooled condenser inlet such that the only field piping required shall be from the water supply main to the three-way diverting valve inlet, and from the water-cooled condenser discharge to the water return main.

G. Temperature Control System

1. The unit shall have a DDC controller that shall be I/O Flex 6126 and be fully capable of operating in a 100% stand-alone control mode or be fully capable of connecting to a BAS BACnet.

2. The controller shall have the minimum open protocol points: Operation mode, supply air temperature, entering air temperature, supply air temperature set point, duct static, and duct static set point.

3. The system shall be prewired in such a manner that remote start-stop can be accomplished through the BMS system via contact closure.

H. Electrical

1. The unit shall be complete with an ETL listed electrical control panel, which includes contactors, motor protectors, relays, and transformers.

2. A non-fused disconnect shall be located on the control panel for connecting building power to the unit.

3. All branch circuits shall be individually protected and shall include a low-voltage control circuit transformer.

4. Motors and compressors shall be protected on all phases.

5. Units shall be provided with phase and brown out protection that shuts down all motors in the unit if the electrical phases are more than 10% out of balance voltage, the voltage is more than 10% under design voltage or on phase reversal.

PART 3 - EXECUTION

3.1 GENERAL

A. Installation, Operation and Maintenance manual shall be supplied with the unit.

B. Installing contractor shall install unit, including field installed components, in accordance with Installation, Operation and Maintenance manual instructions.

C. Start up and maintenance requirements shall be complied with to ensure safe and correct operation of the unit.

- END OF SECTION -

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SECTION 23 57 10 – WATER SOURCE HEAT PUMPS WITH ENERGY RECOVERY

PART 1 - GENERAL

1.1 GENERAL DESCRIPTION

A. This section includes the design, controls and installation requirements for packaged water source heat pumps with energy recovery.

1.2 QUALITY ASSURANCE

A. Packaged water-cooled condenser units shall be certified in accordance with ANSI/AHRI Standard 340/360 performance rating of commercial and industrial unitary air-conditioning and heat pump equipment.

B. Unit and refrigeration system shall comply with ASHRAE 15, Safety Standard for Mechanical Refrigeration.

C. Unit shall be certified in accordance with UL Standard 1995/CSA C22.2 No. 236, Safety Standard for Heating and Cooling Equipment.

D. Unit Energy Efficiency Ratio (EER) shall be equal to or greater than prescribed by ASHRAE 90.1, Energy Efficient Design of New Buildings except Low-Rise Residential Buildings.

E. Unit shall comply with Idaho and Bingham County code requirements for an air handling and heat pump unit.

F. Unit shall be safety certified by ETL and be ETL US and ETL Canada listed.

G. **Options**:

1. Unit cabinet construction shall be designed and manufactured to meet IBC 2009/2012 seismic standards.

2. Unit shall be IBC 2009/2012 seismically certified. Unit shall be certified through seismic analysis and shake testing in accordance with ASCE-7-05/7-10 and ICC-ES AC-156.

1.3 SUBMITTALS

A. **Product Data**: Literature shall be provided that indicates dimensions, operating and shipping weights, capacities, ratings, fan performance, filter information, factory supplied accessories, electrical characteristics and connection requirements. Installation, Operation and Maintenance manual with startup requirements shall be provided.

B. **Shop Drawings**: Unit drawings shall be provided that indicates assembly, unit dimensions, construction details, clearances, and connection details. Computer generated fan curves for each fan shall be submitted with specific design operation point noted. Wiring diagram shall be provided with details for both power and control systems and differentiate between factory installed and field installed wiring.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Unit shall be shipped with doors bolted shut and outside air hood closed to prevent damage during transport and thereafter while in storage awaiting installation.

B. Follow Installation, Operation and Maintenance manual instructions for rigging, moving, and unloading the unit at its final location.

C. Unit shall be stored in a clean, dry place protected from construction traffic in accordance with the Installation, Operation and Maintenance manual.

1.5 WARRANTY

A. Manufacturer shall provide a limited "parts only" warranty for a period of 12 months from the date of equipment startup or 18 months from the date of original equipment shipment from the factory, whichever is less. Warranty shall cover material and workmanship that prove defective, within the specified warranty period, provided manufacturer's written instructions for installation, operation and maintenance have been followed. Warranty excludes parts associated with routine maintenance, such as belts and air filters.

PART 2 - PRODUCTS

2.1 WATER SOURCE HEAT PUMPS WITH ENERGY RECOVERY (HPR-01)

A. General Description

1. Indoor air handling unit shall include filters, supply fans, dampers, refrigeration circuits, exhaust fans, energy recovery wheels, and unit controls.

2. Unit shall be factory assembled and tested including leak testing of the coils, pressure testing of the refrigeration circuit, and run testing of the completed unit. Run test report shall be supplied with the unit in the controls compartment's literature pocket.

3. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.

4. Unit components shall be labeled, including pipe stub outs, refrigeration system components and electrical and controls components.

5. Estimated sound power levels (dB) shall be shown on the unit ratings sheet.

6. Installation, Operation and Maintenance manual shall be supplied within the unit.

7. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's access door.

8. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment’s access door.

B. **Unit Features**:

1. Direct drive supply fans

2. WSHP with necessary heating and cooling coils.

3. Energy Recovery Wheel

4. Double wall cabinet construction

5. Standby Electrical Heating Coil

6. Stainless steel drain pans

7. All other provisions of the specifications must be satisfactorily addressed

C. Construction

1. All cabinet walls, access doors, and roof shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels.

2. Unit construction shall be double wall with heavy gauge galvanized steel on both sides and a thermal break. Double wall construction with a thermal break prevents moisture accumulation on the insulation, provides a cleanable interior, prevents heat transfer through the panel, and prevents exterior condensation on the panel.

3. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Cabinet leakage shall not exceed 1% of total airflow when tested at 3 times the minimum external static pressure provided in AHRI Standard 340/360. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, at a maximum 8 inches of positive or negative static pressure, to reduce air leakage. Deflection shall be measured at the midpoint of the panel height and width. Continuous sealing shall be included between panels and between access doors and openings to reduce air leakage. Refrigerant piping and electrical conduit through cabinet panels shall include sealing to reduce air leakage.

4. Access to filters, dampers, heaters, exhaust fans, energy recovery wheels, and electrical and controls components shall be through hinged access doors with quarter turn, zinc cast, lockable handles. Full length stainless steel piano hinges shall be included on the doors.

5. Units with cooling coils shall include double sloped 304 stainless steel drain pans. Dain connection shall be field supplied and installed.

6. Unit shall have lifting and forklift holes in the unit base for rigging or lifting to mounting location.

D. Electrical

1. Unit shall be provided with standard power block for connecting power to the unit.

2. Options:

   a. Unit shall be provided with factory installed and factory wired, non-fused disconnect switch.

   b. Unit shall be provided with factory installed and field wired 115V, 20 amp GFI outlet in the unit control panel.

   c. Unit shall be provided with phase and brown out protection which shuts down all motors in the unit if the electrical phases are more that 10% out of balance on voltage, the voltage is more that 10% under design voltage, or on phase reversal.

   d. Unit shall be provided with manual reset low temperature limit controls which shut off the unit when the discharge temperature reaches a field adjustable setpoint.

   e. Unit shall be provided with blower auxiliary contacts on the low voltage terminal block which close when the supply fans are energized.

   f. Unit shall be provided with remote stop/start terminals which require contact closure for unit operation. When these contacts are open the low voltage circuit is broken and the unit will not operate.

E. Supply Fans

1. Unit shall include direct drive, unhoused, backward curved plenum supply fans.

2. Blowers and motors shall be dynamically balanced and mounted on rubber isolators.

3. Motors shall be premium efficiency ODP with ball bearings rated for 200,000 hours service with external lubrication points.

F. Exhaust Fans

1. Exhaust dampers shall be sized for 100% relief.

2. Fans and motors shall be dynamically balanced.

3. Motors shall be premium efficiency ODP with ball bearings rated for 200,000 hours service with external lubrication points.

4. Access to exhaust fans shall be through double wall, hinged access doors with quarter turn handles.

G. Filters

1. Options:

a. Unit shall include 2-inch-thick, pleated panel filters with an ASHRAE efficiency of 30% and MERV rating of 7, upstream of the heating coil.

b. Unit shall include 5/16-inch lint screen pre-filters upstream of the standard filters.

c. Unit shall include 1 inch aluminum mesh pre-filters upstream of the outside air opening.

d. Unit shall include a clogged filter switch.

H. Enthalpy Wheel

1. Enthalpy wheel substrate should be of pure aluminum foil as to allow quick and efficient uptake of thermal energy, provide sufficient mass for optimum heat transfer and give maximum sensible heat recovery at low rotational speeds.

2. Energy recovery performance for the wheel shall be certified by AHRI to AHRI Standard 1060. Wheels tested in independent labs and rated in accordance to AHRI Standard 1060 without AHRI certification are not acceptable.

3. Non-AHRI Certified™ wheels must be tested at a third party independent laboratory. Previously tested wheel data is not acceptable. Wheel manufacturer to include all expenses associated with the wheel testing in this proposal. Notify the Engineer and Owner four weeks in advance of wheel testing to all for witnessing and travel arrangements. All travel expenses for Owner and Engineer shall be included in the wheel manufacturer's price.

4. Enthalpy wheel shall conform to the requirements of NFPA-90A and have documented proof of smoke development of no more than 50 and flame spread of no more than 25.

5. Enthalpy drive system shall not have any take-up pulley and shall require no field adjustments by employing minimal stretch, non-adjustable drive belts.

6. Enthalpy wheel cassette shall be complete with face seal and perimeter seal to minimize EATR (Exhaust Air Transfer Ratio) when tested in accordance to AHRI Standard 1060. EATR values must be certified to AHRI.

7. Enthalpy wheel shall be self-cleaned by two counter flow airstreams and come equipped in a slide out cassette for easy removal for maintenance.

8. Enthalpy wheel shall be cleanable with low pressure air or vacuum without degrading the latent performance and shall allow dry particles up to 800 microns to pass freely to prevent clogging of the media.

9. Enthalpy wheel comes equipped with permanently sealed ball bearings with 200,000-hour L-10 life.

10. Unit shall come equipped with an aluminum energy recovery wheel, 6" wheel depth, no purge.

I. Controls

1. Factory Installed and Factory Provided Controller

2. Unit controller shall be capable of controlling all features and options of the unit. Controller shall be factory installed in the unit controls compartment and factory tested.

3. Controller shall be capable of standalone operation with unit configuration, set point adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling available without dependence on a building management system.

4. Controller shall have an on-board clock and calendar functions that allow for occupancy scheduling.

5. Controller shall include non-volatile memory to retain all programmed values, without the use of an external battery, in the event of a power failure.

6. Constant Volume Controller

    a. Unit shall modulate heating with constant airflow to meet space temperature heating loads. With staged heating, capacity shall modulate based on space temperature. With modulating heating, capacity shall modulate based on supply air temperature.

J. Indirect Direct Expansion Cooling

1. Units shall be equipped with an integrated Water Source Heat Pump (WSHP) section which shall be suitable for geothermal ground/vertical loop or boiler applications with entering summer and winter temperature, glycol type and concentration per the schedule: Evaporator (Dx) coil shall include cooling and heating stages in quantities sufficient to meet the scheduled cooling and heating capacities. Reversible refrigerant circuits shall include externally equalized thermostatic expansion valve and reversing valve. Safety controls shall be auto reset on low and manually reset on high pressure sides. Condenser shall be coaxial tube-in-tube with copper inner tubes and steel outer tubes (shells) or brazed stainless steel plates; be selected with 5° F sub-cooling; have maximum working pressures of 400 psig on the water side and 660 psig on the refrigerant side; be UL and CSA approved. Water piping connections to the unit shall be NPT type. On indoor units, main water connections shall be external to the unit.

    a. Refrigeration system shall incorporate a single circuit with Variable Refrigerant Control compressor.

b. Water-to-refrigerant coaxial coil tubes shall be made from cupronickel for corrosion resistance

c. A low leaving water temperature (freeze stat) safety switch shall be supplied with the unit for freeze protection.

d. A waterside economizer with factory mounted multi-row water economizer coil, three-way diverting valve and an entering water temperature sensor shall be supplied with the unit. Coils shall be tested in accordance with AHRI 410. The three-way diverting valve shall be controlled based on a dry bulb discharge temperature sensor. The entering water sensor shall be supplied with the unit and field installed.

e. A waterside head pressure control 3-way valve modulated by the DDC controller via a refrigerant pressure reading shall be supplied with the unit for field installation for inlet water temperatures below 65° F (mechanical valves not controlled via DDC are not acceptable).

f. A motorized on/off 2-way water shut-off valve controlled by the DDC shall be supplied for energy conservation when the unit is off

g. A water strainer with 20-40 mesh shall be field supplied and installed on the water supply line.

h. An air vent shall be field supplied and installed on the water supply line on the high side to vent non-condensable air.

i. Manual shut off valves on the water lines shall be field supplied and installed for service.

K. Accessories

1. Options:

a. Unit shall be provided with a smoke detector(s) sensing the return and supply air of the unit, wired to shut off the unit’s control circuit.

b. Unit shall be provided with a terminal block for field installation of a smoke detector which shuts off the unit’s control circuit.

c. Unit shall be provided with a firestat sensing the return and supply air of the unit, wire to shut off the unit’s control circuit.

PART 3 - EXECUTION

3.1 GENERAL

A. Installation, Operation and Maintenance manual shall be supplied with the unit.

B. Installing contractor shall install unit, including field installed components, in accordance with Installation, Operation and Maintenance manual instructions.

C. Start up and maintenance requirements shall be complied with to ensure safe and correct operation of the unit.

- END OF SECTION -

SECTION 23 82 39 - UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. **Section Includes**:

1. Cabinet unit heaters with centrifugal fans and electric coils

2. Propeller unit heaters with hot-water and electric coils

3. Electric resistance wall heaters

1.2 SUBMITTALS

A. **Product Data**: Include rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated.

B. **Shop Drawings**: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Plans, elevations, sections, and details.

2. Location and size of each field connection.

3. Equipment schedules to include rated capacities, furnished specialties, and accessories.

C. Field quality-control test reports.

D. Operation and maintenance data.

1.3 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 CABINET UNIT HEATERS

A. **Basis-of-Design Product**: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. **Qmark**

2. **Trane**

3. **Indeeco**

B. **Description**: A factory-assembled and -tested unit complying with ARI 440.

1. Comply with UL 2021.

C. **Cabinet**: Steel with baked-enamel finish with manufacturer's standard paint, in color selected by Architect.

1. Vertical Unit, Exposed Front Panels: Minimum 0.0677-inch- thick, galvanized sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.

2. Horizontal Unit, Exposed Bottom Panels: Minimum 0.0677-inch- thick, galvanized, sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.

3. Recessing Flanges: Steel, finished to match cabinet.

4. Control Access Door: Key operated.

5. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, mounted in ceramic inserts in galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware

D. **Fan and Motor Board**: Removable.

1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.

2. Motor: Permanently lubricated multispeed; resiliently mounted on motor board. Comply with requirements in specification Section 23 05 13 – Common Motor Requirements for HVAC Equipment.

3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

E. Control devices and operational sequences are specified in Section 23 09 00 – Instrumentation and Control for HVAC.

F. **Basic Unit Controls**:

1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.

2. Unit Supply-Air Fan Operations:

a. Occupied Periods: Fan runs continuously.

b. Unoccupied Periods: Fan cycles to maintain setback room temperature.

G. **Electrical Connection**: Factory wire motors and controls for a single field connection.

H. **Capacities and Characteristics**:

1. Cabinet:

    a. Vertical, Semirecessed: Upflow.

        1) Air Inlet: Front, punched louver grille.

        2) Air Outlet: Front

2.2 WALL AND CEILING HEATERS

A. **Basis-of-Design Product**: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. **Berko Electric Heating**; a division of Marley Engineered Products

2. **Chromalox, Inc.**; a division of Emerson Electric Company

3. **Markel Products**; a division of TPI Corporation

4. **Marley Electric Heating**; a division of Marley Engineered Products

5. **QMark Electric Heating**; a division of Marley Engineered Products

6. **Trane**

B. **Description:** An assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.

C. **Cabinet**:

1. Front Panel: Stamped-steel louver, with removable panels fastened with tamperproof fasteners.

2. Finish: Baked enamel over baked-on primer with manufacturer's standard color, applied to factory-assembled and -tested wall and ceiling heaters before shipping.

D. **Surface-Mounting Cabinet Enclosure**: Steel with finish to match cabinet.

E. **Electric-Resistance Heating Coil**: Nickel-chromium heating wire, free from expansion noise and hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic sheath. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware, and limit controls for high temperature protection. Provide integral circuit breaker for overcurrent protection.

F. **Fan**: Aluminum propeller directly connected to motor.

1. Motor: Permanently lubricated, multispeed. Comply with requirements in specification Section 23 05 13 – Common Motors Requirements for HVAC Equipment.

G. **Controls**: Unit-mounted thermostat.

H. **Electrical Connection**: Factory wire motors and controls for a single field connection.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install unit heaters to comply with NFPA 90A.

B. Suspend cabinet unit heaters from structure with elastomeric hangers and seismic restraints. Vibration isolators and seismic restraints are specified in specification Section 22 - Vibration and Seismic Controls for Plumbing Piping and Equipment.

C. Suspend propeller unit heaters from structure with all-thread hanger rods and spring hangers. Hanger rods and attachments to structure are specified in specification Section 22 – Vibration and Seismic Controls for Plumbing Piping and Equipment. Vibration hangers are specified in specification Section 22 – Vibration and Seismic Controls for Plumbing Piping and Equipment.

D. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

E. Install new filters in each unit within two weeks of Substantial Completion.

F. Comply with safety requirements in UL 1995.

G. Ground equipment and connect wiring in accordance with Division 26 specifications.

3.2 FIELD QUALITY CONTROL

A. **Perform the following field tests and inspections and prepare test reports**:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

2. Operate electric heating elements through each stage to verify proper operation and electrical connections.

3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

- END OF SECTION -

SECTION 26 05 00 – ELECTRICAL WORK, GENERAL

PART 1 -- GENERAL

1.1 DESCRIPTION OF WORK

A. The work includes furnishing all materials, labor and equipment to install complete electrical and control systems as shown on the Drawings and specified herein.

B. Requirements specified in this section apply to all sections in Division 26. Work specified herein shall be performed as if specified in the individual Sections of these specifications.

1.2 EXISTING EQUIPMENT AND SYSTEMS

A. None of the existing electrical equipment will be reused for this project, unless specifically noted on the Drawings.

1.4 COMPLIANCE WITH ELECTRICAL AND SAFETY CODES

A. Electrical equipment and installation work shall conform to the requirements of the latest National Electric Code, National Electrical Safety Code and applicable State and local codes. Other standards specified in each Section of these specifications are additionally applicable to the work of this Contract.

B. Qualifications of Electrical Installer: Installation and termination of field electrical circuits shall be performed by electricians licensed by the State of Washington. Proof of journeyman licensure shall be submitted for review.

C. Manufacturers of electrical control panels and enclosures shall be UL 508 certified.

1.5 POWER SOURCES

A. Primary station power source shall be by a 12.47-kV service provided by Puget Sound Energy (PSE). Contractor shall provide all necessary material and labor to extend the primary circuit from the service connection point to the service transformer near the Hatchery building. Contractor is responsible for applying for and obtaining electrical service from PSE, as well as all electrical permits for the project.

B. Secondary service power shall consist of a 480VAC, 3-phase, 4-wire system as provided by the step-down transformer provided by PSE and installed by CONTRACTOR.

C. CONTRACTOR shall also provide standby diesel generator set for standby backup power.

D. Other voltages, including DC control power, if required, shall be provided by CONTRACTOR by use of suitable step-down transformers and voltage converters. No battery banks shall be used unless they are a part of enclosed inverter system.

1.6 CONTRACTOR SUBMITTALS

A. See Section 01 33 00 – Contractor Submittals requirements.

B. Submit proof of licensure in the State of Washington for all electricians.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Provide materials and equipment listed by UL wherever standards have been established by that agency.

B. Equipment Finish:

1. Provide manufacturers' standard finish and color, except where specific color is indicated. Manufacturer's standard colors are subject to OWNER's approval.
2. If manufacturer has no standard color, provide equipment with ANSI No. 61, light gray color.

PART 3 -- EXECUTION

3.1 GENERAL

A. Contract Drawings are designed to show general locations of equipment and conduit routing. Unless specifically noted on the drawing, CONTRACTOR is responsible for determining final equipment locations, conduit routing, and wiring requirements to avoid conflicts with structures and mechanical equipment and based on approved suppliers' shop drawings, which may have specific wiring requirements not available on the Drawings.

B. Install work in accordance with these specifications, NESC and NEC. NESC shall govern where there is conflict between NESC and NEC requirements.

C. Schedule with OWNER for work requiring power outages. Power outages will be subject to limitation in accordance with OWNER's plant operation requirements.

3.2 LOAD BALANCE

A. Balance electrical loads between phases as nearly as possible on panelboards, motor controlles, and other equipment where balancing is required.

B. When loads must be reconnected to different circuits to balance phase loads, maintain accurate record of changes made, and provide circuit directory that lists final circuit arrangement.

3.3 INSTALLATION

A. Cooperate with other entities engaged in or working near the project. Execute work in a manner not to interfere with other CONTRACTORs or other activities.

B. Coordinate work with other CONTRACTORs regarding location of equipment so there is no interference between installation or progress of any contractor.

C. At project completion, clean all equipment to the original finish. Remove all shipping labels.

- END OF SECTION –

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SECTION 26 05 02 - MICELLANEOUS ELECTRICAL DEVICES

PART 1 -- GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. National Electrical Manufacturers Association (NEMA):

   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).

   b. AB 1, Molded Case Circuit Breakers and Molded Case Switches.

   c. ICS 2, Industrial Control Devices and Systems: Controllers, Contactors, and Overload Relays Not More than 2000 volts ac or 750 Volts DC.

   d. PB 1, Panelboards.

   e. ST 20, Dry-Type Transformers for General Applications.

   f. WD 1, General Requirements for Wiring Devices.

2. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC)

3. Institute of Electrical and Electronics Engineers: C2, National Electrical Safety Code (NESC).

4. Underwriters Laboratories, Inc. (UL):

   a. 67, Standard for Safety Panelboards.

   b. 98, Standard for Safety Enclosed and Dead-Front Switches.

   c. 486E, Standard for Safety for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.

   d. 489, Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.

   e. 508, Standard for Safety for Industrial Control Equipment.

1.2 SUBMITTALS

The following shall be submitted in accordance with Section 01300:

A. Shop Drawings and Manufacturer's Data:

1. Outlet and device boxes.
2. Junction and pull boxes.
3. Wiring devices.
4. Circuit breakers.

1.3 QUALITY ASSURANCE

A. UL Compliance: Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

PART 2 -- PRODUCTS

2.1 OUTLET AND DEVICE BOXES

A. Sheet Steel: One-piece drawn type, zinc- or cadmium-plated.

B. Cast Metal:

1. Box: Cast ferrous metal.
2. Cover: Gasketed, weatherproof, cast ferrous metal, with stainless steel screws.
3. Hubs: Threaded.
4. Lugs: Cast Mounting.

C. Nonmetallic:

1. Box: PVC.
2. Cover: PVC, weatherproof, with stainless steel screws.
3. Manufacturer and Product: Carlon Type FS or FD, with Type E98 or E96 covers.

2.2 JUNCTION AND PULL BOXES

A. Outlet Boxes Used as Junction or Pull Box: As specified under Article OUTLET AND DEVICE BOXES.

B. Conduit Bodies Used as Junction Boxes: As specified under Article FITTINGS in Section 16110, RACEWAYS.

C. Steel Box:

1. NEMA 250, Types: 1, 3R and 12.

2. Box: 12-gauge steel, with white enamel painted interior and gray primed exterior, over phosphated surfaces. Provide gray finish as approved by: OWNER.

3. Cover: Hinged with clamps.

4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.

2.3 WIRING DEVICES

A. Switches:

1. NEMA WD 1 and FS W-S-896F/GEN.

2. Industrial grade, totally enclosed, ac type, with quiet tumbler switches and screw terminals.

3. Rivetless one-piece brass or copper alloy contact arm with silver alloy contacts.

4. Capable of controlling 100 percent tungsten filament and fluorescent lamp loads.

5. Rating: 20 amps, 120/277 volts.

6. Automatic grounding clip and integral grounding terminal on mounting strap.

B. Receptacle, Single and Duplex:

1. NEMA WD 1 and FS W-C-596.

2. Specification grade, two-pole, three-wire grounding type with screw type wire terminals suitable for No. 10 AWG.

3. Contact Arrangement: Contact to be made on two sides of each inserted blade without detent.

4. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps.

5. One-piece mounting strap with integral ground contact (rivetless construction).

C. Receptacle, Ground Fault Circuit Interrupter:

1. Duplex, listed Class A to UL Standard 943, tripping at 5 mA.

2. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps.

3. Size: For 2-inch by 4-inch outlet boxes.

4. Standard Model: NEMA WD 1, with screw terminals and provisions for testing.

5. Feed-Through Model: NEMA WD 1, with feed-through screw terminals and provisions for testing.

2.4 FUSED SWITCH, INDIVIDUAL, 0 TO 600 VOLTS

A. Quick-make, quick-break, motor rated, load-break, heavy-duty type with external markings clearly indicating ON/OFF positions.

B. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

C. Fuse mountings shall reject Class H fuses and accept only current-limiting fuses specified.

D. Enclosure: NEMA 250, Type as indicated in Part 3 of this Specification, unless otherwise shown.

E. Interlock: Enclosure and switch to prevent opening cover with switch in ON position.

2.5 NONFUSED SWITCH, INDIVIDUAL, 0 TO 600 VOLTS

A. NEMA KS 1.

B. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

C. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

D. Enclosure: NEMA 250, Type as indicated in Part 3 of this Specification unless otherwise shown.

E. Interlock: Enclosure and switch to prevent opening cover with switch in the ON position.

2.6 TERMINAL BLOCK (0 TO 600 VOLTS)

A. UL 486F/GEN and UL 1059.

B. Size components to allow insertion of necessary wire sizes.

C. Capable of termination of control circuits entering or leaving equipment, panels, or boxes.

D. Screw clamp compression, dead front barrier type, with current bar providing direct contact with wire between compression screw and yoke.

E. Yoke, current bar, and clamping screw of high strength and high conductivity metal.

F. Yoke shall guide all strands of wire into terminal.

G. Current bar shall ensure vibration-proof connection.

H. Terminals:

1. Capable of wire connections without special preparation other than stripping.
2. Capable of jumper installation with no loss of terminal or rail space.
3. Short-circuiting type for current transformer leads.

I. Marking system, allowing use of preprinted or field-marked tags.

2.7 DRY TYPE TRANSFORMER (0- TO 600-VOLT PRIMARY)

A. UL 1561, NEMA ST 20, unless otherwise indicated.

B. Self-cooled, two-winding.

C. Insulation Class and Temperature Rise: Manufacturer's standard.

D. Core and Coil:

1. Encapsulated for single-phase units 1/2 to 25 kVA and for three-phase units 3 to 15 kVA.

2. Thermosetting varnish impregnated for single-phase units 37.5 kVA and above, and for three-phase units 30 kVA and above.

E. Units larger than 5 kVA suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

F. Enclosure:

1. Single-Phase, 3 to 25 kVA: NEMA 250, Type 3R, non-ventilated.

2. Single-Phase, 37-1/2 kVA and Above: NEMA 250, Type 2, ventilated.

3. Three-Phase, 3 to 15 kVA: NEMA 250, Type 3R, non-ventilated.

4. Three-Phase, 30 kVA and Above: NEMA 250, Type 2, ventilated.

5. Outdoor Transformers: NEMA 250, Type 3R.

G. Wall Bracket: For single-phase units, 15 to 37-1/2 kVA, and for three-phase units, 15 to 30 kVA.

H. Voltage Taps:

1. Single-Phase, 3 to 10 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.

2. Single-Phase, 15 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.

3. Three-Phase, 3 to 15 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.

4. Three-Phase, 30 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.

I. Impedance: 4.5 percent minimum on units 75 kVA and larger.

J. Maximum Sound Level: NEMA ST 20:

1. 40 decibels for 0 to 9 kVA.

2. 45 decibels for 10 to 50 kVA.

3. 50 decibels for 51 to 150 kVA.

4. 55 decibels for 151 to 300 kVA.

5. 60 decibels for 301 to 500 kVA.

K. Vibration Isolators:

1. Rated for transformer's weight.

2. Isolation efficiency: 99 percent, at fundamental frequency of sound emitted by transformer.

3. Less Than 30 kVA: Isolate entire unit from structure with external vibration isolators.

4. 30 kVA and above: Isolate core and coil assembly from transformer enclosure with integral vibration isolator.

2.8 CONTROL DEVICES

A. PUSHBUTTONS:

Pushbuttons shall be flush head, heavy-duty, with NEMA rating to match enclosure type. The pushbutton operators shall be red for stop functions and black for all other functions. Unless otherwise specified, pushbuttons shall be momentary contact type. Contact blocks shall be NEMA 1CS-2 designation A600 except when switching circuits monitored by programmable controllers or other solid state circuits, contact blocks shall be hermetically sealed, logic-reed type as manufactured by Allen-Bradley, or equal.

B. SELECTOR SWITCHES (AS APPLICABLE):

Selector switches shall be heavy-duty, with NEMA rating to match enclosure type. Unless otherwise specified, selector switches shall have maintained position contacts. Switches shall be provided with contact blocks and number of positions as required to perform the specified operations.

C. INDICATING LIGHTS:

Indicating lights shall be the push-to-test transformer type with LEDs. They shall be heavy-duty, with NEMA rating to match enclosure type. The escutcheon and lens color shall be as specified.

D. CONTROL PANELS:

Unless otherwise specified, control stations indoors shall be NEMA 12. Control panels located outdoors and in wet or corrosive areas shall be stainless steel, NEMA 4X. The pushbuttons shall have protective Hypalon boots. The control panels shall be Allen-Bradley 800 H series, Crouse-Hinds NCS series, or approved equal.

2.9 CONTROL RELAYS

A. LOAD-SWITCHING CONTROL RELAYS:

Control relays used for switching loads (solenoids, actuators, contactors, motor starter coils, etc.) shall be heavy-duty machine tool type. Relays that have contacts used for remote interlocking or for which the switching load is not shown shall also be heavy-duty machine tool type.

Contacts shall, as a minimum, be 4-pole and be field interchangeable to either normally open or normally closed. Relay shall be capable of accepting a 4-pole adder.

AC relays shall have NEMA A600 contact ratings and electrical clearances for up to 600 volts. DC relays shall have NEMA P300 contact ratings and electrical clearances of up to 250 volts.

Relays shall be Allen Bradley, or approved equal.

B. LOGIC LEVEL SWITCHING CONTROL RELAYS:

Control relays used for switching solid-state logic and signal circuits shall be Potter Brumfield series KUP, Schrack Series RA, or equal. Relays shall have a minimum of three SPDT, gold-flashed, fine silver contacts rated 3 amps resistive at 120V AC or 28V DC. Relay shall be plug-in type with heavy-duty, barrier-protected screw terminal sockets and clear polycarbonate dust cover with clip fastener. AC models shall have neon lamp indicator wired in parallel with coil.

C. LATCHING RELAY:

The unit shall be an electrically actuated latching relay or an industrial relay with an electrically operated latching attachment. The latching mechanism shall contain one SET coil and one RESET coil rated for continuous duty on 120 VAC or as otherwise shown. The action of the relay shall be such that it will maintain the last state upon a power failure. The relay contacts rated B300 and hermetically sealed in a glass envelope. They shall be normally open and normally closed as shown. The unit shall be as manufactured by Allen-Bradley or equivalent.

D. TIMERS (AS APPLICABLE):

1. TIMING RELAYS

a. DPDT On Delay. The on-delay time delay relay shall have the following features: solid state timing circuitry; time delay setting via digital thumbwheel switches; digital elapsed-time display; timed-out indicator; 120 VAC 60 Hz operating voltage; two pole double throw (DPDT) delayed contacts; relay contact minimum full load rating 125 VAC 5 Amp; minimum electrical life at rated load 100,000 operations; din rail mounted 8-pin octal type socket mounting and hold-down springs. Manufacturer Idec series GT3D-3 with SR2P-06 socket and SFA-202 hold-down springs, or approved equal.

b. 4PDT On Delay. The 4PDT on-delay time delay relay shall have the following features; solid state timing circuitry; time delay setting via hand or screw driver dial knob; power on and timed out LED indicators; four pole double throw (4PDT) delayed contacts; relay contact minimum full load inductive rating 125 VAC 0.8 Amp; minimum electrical life at rated load 200,000 operations; din rail mounted blade screw terminal socket and hold-down strings. Manufacturer Idec series GT5Y with SY4S-05 socket and SFA-2.02 hold-down springs, or approved equal.

c. DPDT True Off Delay. The operation of the true off delay time delay relay shall be as follows: When voltage is applied to the coil, normally open contacts close and normally closed contacts open immediately; when voltage is removed from the coil, the timer begins timing; when preset time times out, contacts transfer to the OFF state; if power is reapplied before the preset time has timed out, the timing resets to the starting point of the timing period. The unit shall have the following features: solid state timing circuitry; time delay setting via hand dial knob; 120 VAC 60 Hz operating voltage and power indicator; two pole double through (DPDT) delayed contacts; relay contact minimum full load rating 125 VAC 3 Amp (resistive); minimum electrical life at rated load 100,000 operations; din rail mounted 8-pin octal type socket mounting and hold-down springs. Manufacturer Idec series GT3F with SR2P-06 socket and SFA-202 hold-down springs; or approved equal.

2. MOTOR DRIVEN TIMERS: Motor driven timers shall be driven by a synchronous motor which starts timing when initiated by an external signal. Time settings shall be made by turning a knob on the front of the dial. A neon pilot light visible from the front of the timer shall glow red when the timer motor is energized. Visual indication shall be provided by a cycle progress pointer which advances to zero from the setting back to zero as time progresses. There shall be two sets of "instantaneous" NEMA form-C contacts which actuate when the timing is initiated. There shall be one set of "delayed" NEMA form-C contacts which actuates when the unit has timed

out. When the timing cycle is completed, the timer shall automatically reset unless otherwise specified. The timer shall be mounted in a one-piece molded case that will be permanently mounted and wired. The timer shall be Eagle Cycle-flex reset timer, HP5 series; Automatic Timing Controls, Series 305D; or equal.

2.10 MAGNETIC CONTACTORS

A. MOTOR CONTACTORS:

Motor contactors shall be designed for continuous operation of induction motors at 600 V or less at 60 Hz and shall comply with NEMA ICS 2-210. Unless otherwise specified, minimum contactor size shall be NEMA size 1. The contactor shall be supplied with a normally open auxiliary contact for use as a hold-in contact as a minimum. Additional contacts shall be provided as specified. The coil voltage, frequency and number of poles shall be as specified.

2.11 INDIVIDUAL MOTOR STARTERS

1. Full voltage non-reversing contactors used for across the line starters and designed for operation at 600 V AC, 60 hertz. Contactors and starters shall be NEMA standard rated and not equivalent. IEC equipment will not be considered. Starters shall be compatible with solid-state overload relays.

2.12 SAFETY DISCONNECT SWITCHES

A. NONFUSIBLE:

Where shown on the drawings as nonfusible, safety disconnect switches shall be heavy-duty, nonfusible, safety type rated 600 V AC. Unless otherwise specified, indoor enclosures shall be NEMA 12; enclosures installed in outdoor, wet, or corrosive areas shall be NEMA 4X, nonmetallic; and enclosures installed in hazardous areas shall be NEMA 7. Switch enclosures located in classified areas shall be suitable for the specified classification. The operating handle shall be capable of being padlocked in the "off" position. The operator shall be a positive, quick-make, quick-break mechanism. Switch mechanisms shall be provided with one auxiliary contact that opens before the switchblades. This auxiliary contact shall be rated B150, per NEMA ICS 2-125.

B. FUSIBLE:

Where shown on the drawings as fusible, safety disconnect switches shall be heavy-duty, fusible, safety type rated 600 V AC. Fuse clips shall be UL Class R rejection type with Type RK-5 dual element fuses for a minimum 200,000-amp short circuit rating. Unless otherwise specified, indoor enclosures shall be NEMA 12; enclosures installed in outdoor , wet, or corrosive areas shall be NEMA 4X, stainless steel; and enclosures installed in hazardous areas shall be

NEMA 7. Switch enclosures located in classified areas shall be suitable for the specified classification. The operating handle shall be capable of being padlocked in the "off" position. The operator shall be a positive, quick-make, quick-break mechanism. Switch mechanisms shall be provided with one auxiliary contact that opens before the switchblades. This auxiliary contact shall be rated B150, per NEMA ICS 2-125.

Switches shall be horsepower rated for motors and shall comply with NEMA KS-1. Switches shall be provided with defeatable door interlocks that prevent the door from opening when the operating handle is in the "on" position. Switches shall have line terminal shields. Switches shall be Cutler Hammer Type DH; General Electric Mill Duty, Type TH; or equal. Fuses shall be provided per the equipment manufacturer's recommendations.

2.13 ELAPSED TIME INDICATORS (IF USED)

Elapsed time indicators shall be panel mounted, nonresettable, six digit, hour indicator, rated 120 V AC, 60 Hz.

2.14 SPEED ADJUSTMENT POTENTIOMETER (IF USED)

The speed adjustment potentiometer shall be a single-turn, heavy-duty potentiometer. The unit shall consist of a molded resistance track rated at 2 W, 500 V. The resistance value shall be as shown, or if not shown then the resistance value shall be suitable for the application and chosen by the Contractor. The unit shall be equipped with a positive positioning feature to prevent backlash and movement due to vibration. The unit shall be bushing mounted using a NEMA type 13 oiltight mounting and shall include a legend plate with graduated markings from 0 to 100 percent and the word “SPEED.” The unit shall be Allen-Bradley 800T or equal.

2.15 NAMEPLATES

Nameplates for all control panels, relays, timers, motor contactors and disconnect switches shall be provided.

PART 3 -- EXECUTION

3.1 GENERAL

A. Install equipment in accordance with manufacturer’s recommendations.

B. Use appropriate conduit and conductor entry fittings with enclosures to maintain the specified enclosure environmental capability after installation.

C. Equipment locations, if shown on Drawings, are approximate. Final locations shall be determined in accordance with field conditions and subject to OWNER's approval.

3.2 OUTLET AND DEVICE BOXES

A. Install suitable for conditions encountered at each outlet or device in wiring or raceway system, sized to meet NFPA 70 requirements.

B. Sizes:

1. Depth: Minimum 2 inches, unless otherwise required by structural conditions. Box extensions not permitted.

2. Hollow Masonry Construction: Install with sufficient depth such that conduit knockouts or hubs are in masonry void space.

3. Ceiling Outlet: Minimum 4-inch octagonal sheet steel device box, unless otherwise required for installed fixture.

4. Switch and Receptacle: Minimum 2-inch by 4-inch sheet steel device box.

C. Locations:

1. Drawing locations are approximate.

2. To avoid interference with mechanical equipment or structural features, relocate outlets as directed by OWNER.

3. Light Switch: Install on lock side of doors.

4. Light Fixture: Install in symmetrical pattern according to room layout, unless otherwise shown.

D. Mounting Height:

1. If shown on Drawings dimensions given are to centerline of box.

2. Where specified heights do not suit structural features or finish, mount as directed by OWNER.

3. Light Switch: 48 inches above floor.

4. Thermostat: 54 inches above floor.

5. Convenience Receptacles.

a. General Interior Areas: 15 inches above floor.

b. Outdoor, All Areas: 24 inches above finished grade, or as directed by OWNER.

6. Switch, Motor Starting: 48 inches above floor, unless otherwise indicated on Drawings.

E. Install plumb and level.

F. Flush Mounted:

1. Install with concealed conduit.

2. Install proper type extension rings or plaster covers to make edges of boxes flush with finished surface.

3. Holes in surrounding surface shall be no larger than required to receive box.

G. Support boxes independently of conduit by attachment to building structure or structural member.

H. Install bar hangers in frame construction or fasten boxes directly as follows:

1. Concrete or Brick: Bolts and expansion shields.

2. Hollow Masonry Units: Toggle bolts.

3. Steelwork: Machine screws.

I. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.

J. Provide plaster rings where necessary.

K. Boxes embedded in concrete or masonry need not be additionally supported.

L. Install galvanized mounting hardware in industrial areas.

M. Install separate junction boxes for flush or recessed lighting fixtures where required by fixture terminal temperature.

N. Boxes Supporting Fixtures: Provide means of attachment with adequate strength to support fixture.

O. Open no more knockouts in sheet steel device boxes than are required; seal unused openings.

P. Box Type (Steel Raceway System):

1. Exterior Locations:

    a. Exposed Raceways: Cast metal.

    b. Concealed Raceways: Cast metal.

    c. Concrete Encased Raceways: Cast metal.

2. Interior Locations:

    a. Exposed Rigid Conduit or IMC: Cast metal.

    b. Exposed EMT: Sheet steel.

    c. Concealed Raceways: Sheet steel.

    d. Concrete Encased Raceways: Cast metal.

    e. Lighting Circuits, Ceiling: Sheet steel.

3. Cast-In-Place Concrete Slabs: Sheet steel.

Q. Box Type, Corrosive Locations (PVC-Coated Rigid Galvanized Steel Raceway System): PVC-coated cast metal.

3.3 JUNCTION AND PULL BOXES

A. Install where shown and where necessary to terminate, tap-off, or redirect multiple conduit runs.

B. Install pull boxes where necessary in raceway system to facilitate conductor installation.

C. Install in conduit runs at least every 150 feet or after the equivalent of three right-angle bends.

D. Use conduit bodies as junction and pull boxes where no splices are required and their use is allowed by applicable codes.

E. Installed boxes shall be accessible.

F. Do not install on finished surfaces.

G. Install plumb and level.

H. Support boxes independently of conduit by attachment to building structure or structural member.

I. Install bar hangers in frame construction or fasten boxes directly as follows:

1. Wood: Wood screws.

2. Concrete or Brick: Bolts and expansion shields.

3. Hollow Masonry Units: Toggle bolts.

4. Steelwork: Machine screws.

J. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.

K. At or below grade:

1. Install boxes for below grade conduit flush with finished grade in locations outside of paved areas, roadways, or walkways

2. If adjacent structure is available, box may be mounted on structure surface just above finished grade in accessible but unobtrusive location

3. Obtain OWNER's written acceptance prior to installation in paved areas, roadways, or walkways

4. Use boxes and covers suitable to support anticipated weights

L. Flush Mounted:

1. Install with concealed conduit

2. Holes in surrounding surface shall be no larger than required to receive box

3. Make edges of boxes flush with final surface

M. Mounting Hardware:

1. Noncorrosive Dry Areas: Galvanized.

2. Noncorrosive Wet Areas: Stainless steel.

3. Corrosive Areas: Stainless steel.

N. Location/Type:

1. Finished, Indoor, Dry: NEMA 250, Type 1.

2. Unfinished, Indoor, Dry: NEMA 250, Type 12.

3. Unfinished, Indoor and Outdoor, Wet: NEMA 250, Type 4.

4. Steel Raceway System: Cast metal.

5. Unfinished, Indoor and Outdoor, Wet and Corrosive: NEMA 250, Type 4X.

6. Nonmetallic Raceway System: Nonmetallic.

7. Unfinished, Indoor and Outdoor, Wet, Dust, or Oil: NEMA 250, Type 13.

8. Underground Conduit: Concrete.

9. Outdoor Locations Where Indicated Weatherproof (WP): NEMA 250, Type 3R.

10. Areas Not Otherwise Classified: NEMA 250, Type 12.

3.4 WIRING DEVICES

A. Switches:

1. Mounting Height: See Article OUTLET AND DEVICE BOXES.

2. Install with switch operation in vertical position.

3. Install single-pole, two-way switches such that toggle is in up position when switch is on.

B. Receptacles:

1. Install with grounding slot down and house in NEMA 3R rated enclosure.

2. Weatherproof Receptacles:

a. Install in cast metal box.

b. Install such that hinge for protective cover is above receptacle opening.

C. Switch, Motor Rated:

1. Install with switch operation in vertical position such that toggle is in up position when ON.

2. Install within sight of motor when used as a disconnect switch.

3. Mounting Height: See Article OUTLET AND DEVICE BOXES.

4. Enclosure Type: See Article OUTLET AND DEVICE BOXES.

3.5 DEVICE PLATES

A. Securely fasten to wiring device; ensure a tight fit to box.

B. Flush Mounted: Install with all four edges in continuous contact with finished wall surfaces without use of mats or similar materials. Plaster fillings will not be acceptable.

C. Surface Mounted: Plate shall not extend beyond sides of box, unless plates have no sharp corners or edges.

D. Install with alignment tolerance to box of 1/16-inch.

E. Types (Unless Otherwise Shown):

1. Office: Plastic

2. Exterior: Weatherproof

3. Interior:

a. Flush Mounted Boxes: Plastic.

b. Surface Mounted, Metal Boxes:

1) General Purpose Areas: Sheet Steel.

2) Other Areas: Cast.

c. Surface Mounted, Aluminum Boxes:

1) General Purpose Areas: Stamped.

2) Other Areas: Cast.

d. Surface Mounted, Sheet Steel Boxes: Raised sheet steel.

e. Surface Mounted, Nonmetallic Boxes: Manufacturer’s standard.

- END OF SECTION -

SECTION 26 05 10 - ELECTRIC MOTORS

PART 1 -- GENERAL

1.1 SUMMARY

A. The work includes all labor, materials, and equipment required to furnish, install and test AC induction motors as shown on the Drawings and as specified herein.

1.2 QUALITY ASSURANCE

A. All motors shall be designed and constructed in accordance with the latest edition of NEMA Standard MG1 and applicable portions of the NEC. Motors for use in hazardous locations, as defined in NEC Article 500 shall be approved by a recognized testing laboratory. For this specification section, the term "recognized" shall mean having been listed as acceptable for at least 1 year by the authority having jurisdiction, as defined in the NEC.

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.

B. Submittal of motor data shall be in conjunction with the piece of mechanical equipment served. See individual sections for submittals required

C. Complete motor data shall be submitted with the driven machinery Shop Drawings. Motor data shall include:

1. Machine name and specification number of driven machine
2. Motor manufacturer
3. Motor type or model and dimension drawing. Include motor weight.
4. Nominal horsepower
5. NEMA design
6. Enclosure
7. Frame size
8. Winding insulation class and temperature rise class
9. Voltage, phase, and frequency ratings
10. Service factor
11. Full load current at rated horsepower for application voltage
12. Full load speed

13. Guaranteed minimum full load efficiency. Also nominal efficiencies at 1/2 and 3/4 load.

14. Type of thermal protection or over temperature protection, if included

15. Wiring diagram for devices such as motor leak detection, temperature, or zero speed switches, as applicable

16. Bearing data. Include recommendation for lubricants of relubricatable type bearings.

17. If utilized with a variable frequency drive, verify motor is inverter duty rated. Include minimum speed at which motor may be operated for the driven machinery.

18. Power factor at 1/2, 3/4 and full load.

19. Recommended size for power factor correction capacitors to improve power factor to 0.95 percent lagging when operated at full load.

1.4 WARRANTY

A. The motors shall be warranted for both labor, equipment and all components for a 2 year period after final acceptance and commissioned.

1.5 PRODUCT DELIVERY AND STORAGE

A. All motors shall be shipped to the jobsite with all openings plugged, taped or otherwise sealed to prevent entry of foreign materials, rodents, etc.

B. Motors stored at the jobsite shall be in a dry location protected from sun and rain, unless otherwise authorized by the OWNER.

PART 2 -- PRODUCTS

2.1 SERVICE CONDITIONS

A. All equipment shall be designed and built for industrial service and be capable of delivering rated horsepower under the following applicable conditions:

1. 40°C maximum ambient temperature.

2. System voltage variations to +10% of nameplate rating.

3. System frequency variations to +5% of nameplate rating.

4. Combined voltage and frequency variations to +10% total, as long as frequency does not exceed +5%.

2.2 VOLTAGE

A. Motors rated one-third horsepower and smaller shall be designed and connected for operation at either 120 volts single phase or 208 volts, three phase. Motors one-half horsepower and larger shall be rated for 208 or 460 volt, 3 phase; 120 volt or 208 volt single phase. In all cases where motor service connection voltage is depicted, CONTRACTOR shall provide the motor to operate on the voltage shown.

2.3 ENCLOSURE TYPES

A. Enclosures shall be identified as follows:

1. TEFC: totally enclosed, fan cooled.

B. Motors shall be TEFC with corrosion-resistant finish, or as other wised noted, or called out in other sections.

C. Drip-proof motors shall be designed such that particles of solid or liquid material falling at any angle from 0 to 15 degrees downward from the vertical shall not enter the ventilating openings or interfere with successful operation, as defined by NEMA standards.

D. TEFC motors shall conform to the appropriate NEMA standards and shall be provided with drilled and tapped holes to drain all cavities within the motor. Motors with frames 286T or smaller shall have corrosion-resistant plugs in the drain holes. Motors with frame 324T or larger shall be provided with automatic breather-drain devices.

2.4 ELECTRICAL REQUIREMENTS FOR MOTORS

A. Service factor for single-phase motors shall be 1.0 or greater unless indicated otherwise on the Drawings or component specifications.

B. Service factor for all 3 phase motors shall be 1.15 unless indicated otherwise on Drawings or in component specifications.

C. Time rating: All motors covered by this section shall have continuous time ratings.

D. Currents: Locked rotor currents shall not exceed the maximum values for NEMA Design B.

E. Protection: Current density and heating characteristics shall be such that the motors shall not burn out if subjected to a maximum of a 20-second stall at 6 times full-load current.

F. Rating: Motors shall not be required to operate at greater than their nameplate horsepower. Use of the service factor shall not be allowed under conditions of rated voltage and frequency.

G. Insulation: All motors shall have insulation systems conforming to the requirements for NEMA Class B or higher. Motors powered from VFD’s shall be insulated to meet the requirements of VFD-generated over-voltages in accordance with NEMA MG1, Part 31.

H. All motors powered by variable frequency drives (VFD’s) shall have winding embedded resistance temperature detectors (RTD), minimum two in each phase. The RTD’s shall be of the platinum type, 100 ohm at 0 degrees C. They shall be wired to a connection box with a terminal strip for external connections.

I. Motor efficiency shall be in accordance with the Washington State Energy Code.

2.5 NAMEPLATES

A. Motor nameplates shall be of a noncorrosive metal that is not discolored by hydrogen sulfide. Nameplates shall be engraved or stamped and shall be fastened to the motor frame with screws or drive pins of the same material.

B. Nameplates shall indicate clearly all the items of information enumerated in NEMA Standard MG1-0.37, MG1-10.38, or MG1-20.60, as applicable.

C. The CONTRACTOR shall coordinate the motor nameplate location so it is readily visible for inspection in the completed machine, and it shall not be painted.

2.6 MECHANICAL REQUIREMENTS FOR MOTORS

A. Frame sizes. Frames shall conform to latest NEMA Standard MG1-11.31 for "T" frames, and all dimensions shall meet NEMA Standards insofar as they apply.

B. Shafts shall be in accordance with NEMA "T" or "TS" dimensions. Long shafts shall be suitable for belt, chain or gear drive, within limits established by good industrial practice and documented by NEMA Standards MG1-14.42 and MG1-14.07. Short shafts shall be used for direct connection.

C. Connection diagrams shall be permanently attached to the motor, either inside the conduit box or on the motor frame, in a location readable from the conduit box side.

D. External finish: Shall be corrosion resistant for outdoor operation.

E. Hardware: All bolts, screws, and other external hardware shall be treated for resistance to corrosion by painting with a rust inhibitive primer immediately after installation and two final coats when final equipment painting is performed.

PART 3 -- EXECUTION

3.1 TESTS

A. Insulation check. The OWNER may test the insulation resistance of the motor at any time after delivery of the motor to the jobsite or at any time during the warranty period. Tests for acceptability shall be made using a 1,000-volt megohm meter (megger). Interpretations of test results for minimum acceptable values of insulation resistance shall be made in accordance with IEEE No. 43. All deficiencies identified by any testing shall be corrected by the CONTRACTOR.

B. Load testing. The OWNER may test a motor at any time after delivery of the motor to the jobsite or at any time during the warranty period to determine its ability to operate at nameplate current or less, under all normal operating conditions. In the event that a motor does not meet the load test requirements, the CONTRACTOR shall replace the motor at no additional cost to OWNER.

3.2 PREPARATION FOR SHIPMENT

A. Protective coating. Before shipment, the shaft extension and any other external bare exposed metal parts of each motor shall be coated with an easily removable rust preventive.

B. Packaging. All motors shall be packed in Styrofoam or securely fastened to a hardwood skid or pallet for fork-truck handling and shall be covered for protection against dirt and moisture during transit and for short-time outdoor storage.

- END OF SECTION -

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SECTION 26 05 19 - INSULATED WIRE AND CABLE

PART 1 -- GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this Section:

1. American Society for Testing and Materials (ASTM):

    a. A167, Standard Specification for Stainless and Heat Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
    b. B3, Standard Specification for Soft or Annealed Copper Wire
    c. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
    d. B263, Standard Test Method for Determination of Cross-Sectional Area of Stranded Conductors

2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

    a. 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminations

3. Insulated Cable Engineer's Association, Inc. (ICEA) and National Electrical Manufacturers' Association (NEMA):

    a. ICEA S-58-679, Standard for Control Cable Conductor Identification
    b. ICEA S-73-532 / NEMA WC57, Standard for Control, Thermocouple Extension, and Instrumentation Cables
    c. ICEA S-105-692, 600 Volt Single Layer Thermoset Insulated Utility Underground Distribution Cable
    d. ICEA S-81-570, Direct Burial, 600 Volt, Ruggedized Insulation
    e. ICEA T-29-520, Procedure for Conducting Vertical Cable Tray Flame Test With a Theoretical Heat Input of 210,000 Btu/hour
    f. NEMA CC1, Electric Power Connectors for Substations

4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC)
5. Underwriters Laboratories, Inc. (UL):

    a. 13, Standard for Safety Power-Limited Circuit Cables
    b. 44, Standard for Safety Thermoset-Insulated Wires and Cables
    c. 486A, Standard for Safety; Wire Connectors and Soldering Lugs for Use with Copper Conductors
    d. 510, Standard for Safety Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape
    e. 910, Standard for Safety Test Method for Flame Propagation and Smoke Density Values for Electrical and Optical-Fiber Cables Used in Spaces Transporting Environmental Air
    f. 1072, Standard for Safety Medium-Voltage Power Cables

g. 1277, Standard for Safety Electrical Power and Control Tray Cables with Optional Optical-Fiber Members
h. 1581, Standard for Safety Reference Standard for Electrical Wires, Cables, and Flexible Cords

1.2 CONTRACTOR SUBMITTALS

The following shall be submitted in accordance with Section 01 33 00 – Contractor Submittals:

A. Shop Drawings:

1. Wire and cable descriptive product information.
2. Wire and cable accessories descriptive product information.

1.3 UL COMPLIANCE

A. Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

PART 2 -- PRODUCTS

2.1 600-VOLT RATED CONTROL AND POWER CABLE

A. General:

1. Type TC, meeting requirements of UL 1277, including Vertical Tray Flame Test at 20,000 Btu/hr, and NFPA 70, Article 340, or UL 13 Listed Power Limited Circuit Cable meeting requirements of NFPA 70, Article 725
2. Conform to applicable requirements of NEMA WC 3, WC 5, and WC 7
3. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark
4. Suitable for installation in open air, in cable trays, or conduit
5. Minimum Temperature Rating: 90 degrees C dry locations, 75 degrees C wet locations

B. Multiconductor Control Cable:

1. Conductors:

a. Material: Copper
b. Size: No. 14 AWG
c. Stranding: Class B

2. Insulation:

a. Type: Cross-linked polyethylene (XLP)
b. Standards: UL 44 listed as Type XHHW-2 rated VW-1
c. Conductor group bound with spiral wrap of barrier tape
d. Color Code: In accordance with ICEA S-58-679, Method 1, Table 2

3. Jacket: Chlorinated polyethylene (cross-linked type) (CPE) per ICEA S-73-532 and UL 1277.
4. Cable: Passes the ICEA T-29-520 210,000 Btu/hr Vertical Tray Flame Test
5. Cable Sizes:

No. of Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
3	0.41	45
5	0.48	45
7	0.52	45
12	0.72	60
19	0.83	60
25	1.00	60
37	1.15	80

C. Multiconductor Power Cable:

1. Conductors:

   a. Material: Copper
   b. Stranding: Class B

2. Insulation:

   a. Type: Flame retardant, cross-linked polyethylene (FR-XLP)
   b. Standards: UL 44 listed as Type XHHW-2, rated VW-1
   c. Color Code: Conductors, size No. 8 AWG and smaller, colored conductors, ICEA S-58-679, Method 1, Table 1. Conductors size No. 6 AWG and larger, ICEA S-73-532, Method 4
   d. Jacket: Chlorinated polyethylene (cross-linked type) (CPE) per ICEA S-73-532 and UL 1277

3. Cable passes the ICEA T-29-520 210,000 Btu/hr Vertical Tray Flame Test
4. Cable Sizes:

Conductor Size	Minimum Ground Wire Size	No. of Conductors	Max. Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
12	12	2 3 4	0.42 0.45 0.49	45 45 45

Conductor Size	Minimum Ground Wire Size	No. of Conductors	Max. Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
10	10	2 3 4	0.54 0.58 0.63	60 60 60
8	10	3 4	0.66 0.72	60
6	8	3 4	0.74 0.81	60
4	6	3 4	0.88 0.97	60 80
2	6	3 4	1.01 1.11	80
1/0	6	3 4	1.22 1.35	80
2/0	4	3 4	1.32 1.46	80
4/0	4	3 4	1.56 1.78	80 110

D. Cable for Variable Frequency Drive Application

1. The variable frequency drive supplier shall confirm appropriate rating and configuration of the cable and adjust the below specified requirements accordingly.

2. Conductors: Copper, 3-conductor configuration with symmetric bare ground conductors.

3. Insulation: XLPE or EPR for conductors and PVC for jacket.

4. Voltage Rating: 1000V

5. Cable passes the ICEA T-29-520 210,000 Btu/hr Vertical Tray Flame Test

E. Single Conductor Power Cable

1. Conductors:

a. Material: Copper
b. Stranding:

1) Class B
2) Indoor lighting and receptacle circuits No. 10 AWG and smaller: Solid copper conductor if not terminated on terminal blocks.

c. Insulation:

1) Conductors No. 6 AWG and larger: Flame retardant, cross-linked polyethylene (FR-XLP)
2) Conductors smaller than No. 6 AWG: Polyvinyl chloride (PVC) sheathed with nylon

d. Standards: No. 6 AWG and larger: UL 44 listed as Type XHHW-2, rated VW-1
e. Jacket:

1) Conductors No. 6 AWG and larger: Chlorinated polyethylene (cross-linked type) (CPE) per ICEA S-73-532 and UL 1277.
2) Conductors smaller than No. 6 AWG: Nylon

2. Cable passes the ICEA T-29-520 210,000 Btu/hr Vertical Tray Flame Test

E. Direct Burial and Aerial Conductors and Cables:

1. Type USE/RHH/RHW insulation, UL 854 listed or Type RHW-2/USE-2
2. Conform to physical and minimum thickness requirements of NEMA WC 3

F. Flexible Cords and Cables:

1. Type SOW-A/50 with ethylene propylene rubber insulation in accordance with UL 62
2. Conform to physical and minimum thickness requirements of NEMA WC 8

2.3 600-VOLT RATED INSTRUMENTATION CABLE

A. General:

1. Type PLTC, meeting requirements of UL 13, UL Listed Power Limited Circuit Cable meeting requirements of NFPA 70, Article 725
2. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark
3. Suitable for installation in open air, in cable trays, or conduit
4. Minimum Temperature Rating: 105 degrees C
5. Passes vertical tray flame test
6. Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant

B. Twisted, Shielded Pair Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 55.

1. Size: No. 16 AWG
2. Outer Jacket: 60-mil nominal
3. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage

4. Conductors:

    a. Bare soft annealed copper, Class B, seven-strand concentric, ASTM B8
    b. Tinned copper drain wire
    c. Insulation: PVC
    d. Color Code: Pair conductors black and white

C. Twisted, Shielded Triad Instrumentation Cable: Single triad, designed for noise rejection for process control, computer, or data log applications meeting requirements of NEMA WC 55.

    1. Size: No. 16 AWG
    2. Outer Jacket: 60-mil nominal thickness
    3. Individual Pair Shield: double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage
    4. Conductors:

        a. Bare soft annealed copper, Class B, seven-strand concentric, ASTM B8
        b. Tinned copper drain wire
        c. Insulation: PVC
        d. Color Code: Triad conductors black, red, and white

D. Multi-Twisted, Shielded Pairs with a Common Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable meeting NEMA WC 55.

    1. Conductors:

        a. Size: No. 18 AWG
        b. Bare soft annealed copper, Class B, seven-strand concentric, ASTM B8
        c. Tinned copper drain wires
        d. Insulation: PVC
        e. Color Code: Pair conductors black and white, with white conductor numerically printed for group identification
        f. Individual Pair Shield: aluminum/mylar
        g. Cable Shield: double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage

    2. Cable Sizes:

Number of Pairs	**Maximum Outside Diameter (Inches)**	**Nominal Jacket Thickness (Mils)**
4	0.52	50
8	0.71	60
12	0.85	60
16	1.05	80

Number of Pairs	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
24	1.20	80
36	1.37	80
50	1.71	80

E. Multi-Twisted Pairs with a Common Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable meeting NEMA WC 55.

1. Conductors:

   a. Size: No. 18 AWG
   b. Bare soft annealed copper, Class B, seven-strand concentric, ASTM B8
   c. Tinned copper
   d. Group drain wire
   e. Insulation: PVC
   f. Color Code: Pair conductors black and white, with white conductor numerically printed for group identification
   g. Cable Shield: double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage

2. Cable Sizes:

Number of Pairs	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
4	0.49	50
8	0.65	60
12	0.76	60
16	0.89	80
24	1.03	80
36	1.18	80
50	1.45	80

F. Fire Alarm Cable: Power limited fire protective signaling circuit cable meeting requirements of NFPA 70, Article 760, Fire Alarm Systems:

1. Cable: Pass UL 70,000 Btu flame test and listed by California State Fire Marshall
2. Outer jacket: Red in color, identified along its entire length as fire protective signaling circuit cable
3. Conductors:

a. Solid, tinned, or bare copper
b. Insulation: 15 mil PVC

2.4 MEDIUM VOLTAGE POWER CABLE

A. Type: Three-conductor, armored, 15-kV, MV-105
B. Conductors: Bare annealed copper per ASTM B3
C. Grounding Conductor: Uncoated copper
D. Size: As shown on Drawings
E. Insulation: 133% EPR (220 mils) for conductors and PVC in accordance with ICEA for jacket
F. Insulation Shield: 5 mil copper tape with 25% overlap
G. Armor: Impervious, continuous welded corrugated aluminum
H. Vertical Cable Tray Flame Test: 210,000 BTU/hr per ICEA T-29-520
I. Service Conditions: The cable shall be suitable for aerial, direct burial and conduit installations in wet and dry locations.
J. Terminations: Cold shrink, outdoor type as manufactured by 3M, or equal.

2.5 GROUNDING CONDUCTORS

A. Equipment: Stranded copper with green, type USE/RHH/RHW-XLPE or THHN/THWN, insulation.

B. Direct Buried or Exposed: Bare stranded copper, No. 4/0 AWG.

2.6 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW

A. Tape:

1. General Purpose, Flame Retardant: 7-mil, vinyl plastic, Scotch Brand 33, rated for 90 degrees C minimum, meeting requirements of UL 510
2. Flame Retardant, Cold and Weather Resistant: 8.5-mil, vinyl plastic, Scotch Brand 88

B. Identification Devices:

1. Sleeve: Permanent, PVC, yellow or white, with legible machine-printed black markings
2. Heat Bond Marker:

a. Transparent thermoplastic heat bonding film with acrylic pressure sensitive adhesive
b. Self-laminating protective shield over text
c. Machine printed black text

3. Marker Plate: Nylon, with legible designations permanently hot stamped on plate
4. Tie-On Cable Marker Tags:

a. Chemical resistant white tag

5. Grounding Conductor: Permanent green heat-shrink sleeve, 2-inch minimum

C. Connectors and Terminations:

1. Nylon, Self-Insulated Crimp Connectors
2. Nylon, Self-Insulated, Crimp Locking-Fork, Torque-Type Terminator
3. Self-Insulated, Set Screw Wire Connector:

a. Two piece compression type with set screw in brass barrel
b. Insulated by insulator cap screwed over brass barrel

D. Cable Lugs:

1. In accordance with NEMA CC 1
2. Rated 600 volts of same material as conductor metal
3. Insulated, Locking-Fork, Compression Lugs:

a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity
b. Seamless

4. Uninsulated Crimp Connectors and Terminators:

a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity

2.7 PULLING COMPOUND

A. Nontoxic, noncorrosive, noncombustible, nonflammable, wax-based lubricant; UL listed.

B. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.

C. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.

PART 3 -- EXECUTION

3.1 GENERAL

A. Installation shall conform to NEC and NESC requirements.

B. Conductor storage, handling, and installation to be in accordance with manufacturer’s recommendations.

C. Conductor and cable sizing shown is based on copper conductors, unless noted otherwise.

D. Do not exceed cable manufacturer's recommendations for maximum pulling tensions and minimum bending radii.

E. Terminate all conductors and cables, unless otherwise indicated.

F. Tighten screws and terminal bolts in accordance with UL 486A for copper conductors.

G. Cable Lugs: Provide with correct number of holes, bolt size, and center-to-center spacing as required by equipment terminals.

H. Bundling: Where single conductors and cables in manholes, handholes, vaults, cable trays, and other indicated locations are not wrapped together by some other means, bundle conductors from each conduit throughout their exposed length with cable ties placed at intervals not exceeding 18 inches on center.

I. Ream, remove burrs, and clear interior of installed conduit before pulling wires or cables.

J. Concrete-Encased Raceway Installation: Prior to installation of conductors, pull through each raceway a mandrel approximately 1/4-inch smaller than raceway inside diameter.

K. Cable Tray Installation:

1. Install wire and cable parallel and straight in tray
2. Bundle, in groups, all wire and cable of same voltage having a common routing and destination; use cable ties, at maximum intervals of 8 feet
3. Clamp cable bundles prior to making end termination connections
4. Separate cables of different voltage rating in same cable tray with metallic barriers
5. Fasten wires, cables, and bundles to tray with nylon cable straps at the following maximum intervals:
   Horizontal Runs: 20 feet
   Vertical Runs: 5 feet

L. Medium voltage cable: Secure to walls and ceilings using clamps recommended by cable manufacturer. Maximum support spacing: 6-ft.

3.2 POWER CONDUCTOR COLOR CODING

A. Conductors 600 Volts and Below:

1. No. 6 AWG and Larger: Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering an area 1-1/2 to 2 inches wide
2. No. 8 AWG and Smaller: Provide colored conductors
3. Colors:

System	Conductor	Color
All Systems	Equipment Grounding	Green

System	Conductor	Color
240/120 Volts Single-Phase, Three-Wire	Grounded Neutral One Hot Leg Other Hot Leg	White Black Red
208Y/120 Volts Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Black Red Blue
240/120 Volts Three-Phase, Four-Wire Delta, Center Tap Ground on Single-Phase	Grounded Neutral Phase A High (wild) Leg Phase C	White Black Orange Blue
480Y/277 Volts Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Brown Orange Yellow
NOTE: Phase A, B, C implies direction of positive phase rotation.		

4. Tracer: Outer covering of white with an identifiable colored strip, other than green, in accordance with NFPA 70.

3.3 CIRCUIT IDENTIFICATION

A. Circuits Appearing in Circuit Schedules: Identify power, instrumentation, and control conductor circuits, using circuit schedule designations, at each termination and in accessible locations such as manholes, handholes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.

B. Circuits Not Appearing in Circuit Schedules:

1. Assign circuit name based on device or equipment at load end of circuit.
2. Where this would result in same name being assigned to more than one circuit, add number or letter to each otherwise identical circuit name to make it unique.

C. Method:

1. Conductors No. 3 AWG and Smaller: Identify with sleeves or heat bond markers
2. Cables, and Conductors No. 2 AWG and Larger:

   a. Identify with marker plates; or
   b. Tie-on cable marker tags
   c. Attach with nylon tie cord

3. Taped-on markers or tags relying on adhesives not permitted

3.4 CONDUCTORS 600 VOLTS AND BELOW

A. Install 10 AWG or 12 AWG conductors for branch circuit power wiring in lighting and receptacle circuits.

B. Do not splice incoming service conductors and branch power distribution conductors No. 6 AWG and larger, unless specifically indicated or approved by OWNER.

C. Connections and Terminations:

    1. Install wire nuts only on solid conductors
    2. Install nylon self-insulated crimp connectors and terminators for instrumentation and control, circuit conductors
    3. Install self-insulated, set screw wire connectors for two-way connection of power circuit conductors No. 12 AWG and smaller
    4. Install uninsulated crimp connectors and terminators for instrumentation, control, and power circuit conductors No. 4 AWG through No. 2/0 AWG.
    5. Install uninsulated, bolted, two-way connectors and terminators for power circuit conductors No. 3/0 AWG and larger
    6. Install uninsulated terminators bolted together on motor circuit conductors No. 10 AWG and larger
    7. Tape insulate all uninsulated connections
    8. Place no more than one conductor in any single-barrel pressure connection
    9. Install crimp connectors with tools approved by connector manufacturer
    10. Install terminals and connectors acceptable for type of material used
    11. Compression Lugs:

        a. Attach with a tool specifically designed for purpose
        b. Tool shall provide complete, controlled crimp and shall not release until crimp is complete
        c. Do not use plier type crimpers

D. Do not use soldered mechanical joints.

E. Splices and Terminations:

    1. Indoors: Use general purpose, flame retardant tape
    2. Outdoors: Use flame retardant, cold- and weather-resistant tape
    3. Cap spare conductors and conductors with UL listed end caps

F. Cabinets, Panels, and Motor Control Centers:

    1. Remove surplus wire, bridle and secure
    2. Where conductors pass through openings or over edges in sheet metal, remove burrs, chamfer edges, and install bushings and protective strips of insulating material to protect the conductors

G. Control and Instrumentation Wiring:

    1. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs

2. Terminate with methods consistent with terminals provided, and in accordance with terminal manufacturer's instructions
3. Locate splices in readily accessible cabinets or junction boxes using terminal strips
4. Cable Protection:

   a. Under Infinite Access Floors: May be installed without bundling
      All Other Areas: Install individual wires, pairs, or triads in flex conduit under the floor or grouped into bundles at least 1/2 inch in diameter
      Maintain integrity of shielding of instrumentation cables
      Ensure grounds do not occur because of damage to jacket over the shield

H. Extra Conductor Length: For conductors to be connected by others, install minimum 6 feet of extra conductor in freestanding panels and minimum 2 feet in other assemblies.

\-   - END OF SECTION -

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SECTION 26 05 26 – GROUNDING

PART 1 -- GENERAL

1.1 REQUIREMENTS

A. Provide a power grounding system for the hatchery facility as required by the National Electric Code (NFPA), National Electric Safety Code (NESC), and as shown on the engineering plans.

B. CONTRACTOR shall ensure that all grounding points are restored after any modifications and installation of new equipment.

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this Section:

1. American National Standards Institute (ANSI): C2, National Electrical Safety Code (NESC).
2. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).

1.3 CONTRACTOR SUBMITTALS

The following shall be submitted in accordance with Section 01 33 00 – Contractor Submittals:

A. Shop Drawings:

1. Product Data:

   a. Exothermic weld connectors.
   b. Mechanical connectors.
   c. Compression connectors.
   d. Grounding cables.

2. Shop Drawings

   a. Grounding system layout showing ground cable routing and interconnections to powerhouse and spillway walkway existing grounds.

1.4 UL COMPLIANCE

A. Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

PART 2 -- PRODUCTS

2.1 GROUND CONDUCTORS

A. As specified in Section 26 05 19 – Insulated Wire and Cable.

2.2 CONNECTORS

A. Exothermic Weld Type:

1. Outdoor Weld: Suitable for exposure to elements or direct burial.
2. Indoor Weld: Utilize low-smoke, low-emission process.
3. Manufacturers:

    a. Erico Products, Inc.
    b. Thermoweld

B. Compression Type:

1. Compress-deforming type; wrought copper extrusion material.
2. Single indentation for conductors 6 AWG and smaller.
3. Double indentation with extended barrel for conductors 4 AWG and larger.
4. Barrels prefilled with oxide-inhibiting and antiseizing compound and sealed.
5. Manufacturers:

    a. Burndy Corp.
    b. Thomas and Betts Co.
    c. Ilso Corp.

C. Mechanical Type: Split-bolt, saddle, cone screw type or embedded plate type; copper alloy material.

1. Manufacturers:

    a. Burndy Corp.
    b. Thomas and Betts Co.

PART 3 -- EXECUTION

3.1 GENERAL

A. Grounding shall be in compliance with NFPA 70 and ANSI C2.

B. Ground each system neutral to nearest effectively grounded building structural steel member or separate grounding electrodes.

C. Ground each section of metal railing, metal grating, stairs, building frames, motor frames, junction boxes, raceways, and equipment enclosures and tie to existing powerhouse ground connection points as shown on engineering plans. Remove paint and corrosion to ensure high conductivity connection when making connections to existing grounding systems.

D. Bond together system neutrals, service equipment enclosures, exposed noncurrent-carrying metal parts of electrical equipment, metal raceways, ground conductor in raceways and cables, receptacle ground connections, and metal piping systems.

E. Shielded Instrumentation Cables: Ground shields at each splice or termination in accordance with recommendations of splice or termination manufacturer.

F. Shielded Control Cables:

1. Ground analog signal cable shields at the source.
2. Expose shield minimum 1 inch at termination to field instrument and apply heat shrink tube.
3. Do not ground instrumentation cable shield at more than one point.

3.2 WIRE CONNECTIONS

A. Ground Conductors: Install in conduit containing power conductors and control circuits above 50 volts.

B. Connect ground conductors to raceway grounding bushings.

C. Extend and connect ground conductors to ground bus in all equipment containing a ground bus.

D. Connect enclosure of equipment containing ground bus to that bus.

E. Bolt connections to equipment ground bus.

F. Bond grounding conductors to metallic enclosures at each end, and to intermediate metallic enclosures.

G. Junction Boxes: Furnish materials and connect to equipment grounding system with grounding clips mounted directly on box, or with 3/8-inch machine screws.

3.3 MOTOR GROUNDING

A. Extend equipment ground bus via grounding conductor installed in motor feeder raceway; connect to motor frame.

B. Motors Less Than 10 hp: Furnish compression, spade-type terminal connected to conduit box mounting screw.

C. Motors 10 hp and Above: Tap motor frame or equipment housing; furnish compression, one-hole, lug type terminal connected with minimum 5/16-inch brass threaded stud with bolt and washer.

D. Circuits 20 Amps or Above: Tap motor frame or equipment housing; install solderless terminal with minimum 5/16-inch diameter bolt.

3.4 CONNECTIONS

A. General:

1. Abovegrade Connections: Install exothermic weld, mechanical, or compression-type connectors; or brazing.

2. Belowgrade Connections: Install exothermic weld or compression type connectors.
3. Remove paint, dirt, or other surface coverings at connection points to allow good metal-to-metal contact.
4. CONTRACTOR shall notify OWNER prior to backfilling ground connections.

B. Exothermic Weld Type:

1. Wire brush or file contact point to bare metal surface.
2. Use welding cartridges and molds in accordance with manufacturer's recommendations.
3. Avoid using badly worn molds.
4. Mold to be completely filled with metal when making welds.
5. After completed welds have cooled, brush slag from weld area and thoroughly clean joint.

C. Compression Type:

1. Install in accordance with connector manufacturer's recommendations.
2. Install connectors of proper size for grounding conductors and ground rods specified.
3. Install using connector manufacturer's compression tool having proper sized dies.

D. Mechanical Type:

1. Apply homogeneous blend of colloidal copper and rust and corrosion inhibitor before making connection.
2. Install in accordance with connector manufacturer's recommendations.
3. Do not conceal mechanical connections.

- END OF SECTION -

SECTION 26 05 30 - FIBER OPTIC CABLE

PART 1 -- GENERAL

1.1 SECTION INCLUDES

A. Requirements for fiber optic cable and accessories

1.2 REFERENCES

A. Institute of Electrical and Electronics Engineers, Inc.
1222 Standard for All-Dielectric Self-Supporting Fiber Optic Cable.

C2 National Electrical Safety Code.

B. Electronic Industries Alliance
EIA/TIA-455-170 (1989) FOTP-170 Cable Cutoff Wavelength of Single-Mode Fiber by Transmitted Power.

C. National Fire Protection Association.
70 National Electrical Code.

D. Telecommunications Industry Association
TIA-455-104-A (1993; R 2005) Standard for FOTP-104 Fiber Optic Cable Cyclic Flexing Test.

TIA-455-13-A (1996; R 2002) FOTP-13 Visual and Mechanical Inspection of Fiber Optic Components, Devices, and Assemblies.

TIA-455-46A (1990) FOTP-46 Spectral Attenuation Measurement for Long-Length, Graded-Index Optical Fibers.

TIA-455-78 (2002B) FOTP-78 Optical Fibers - Part 1-40: Measurement Methods and Test Procedures – Attenuation.

TIA/EIA-455-171-A (2001) FOTP-171 Attenuation by Substitution Measurement for Short-Length Multimode Graded-Index and Single-Mode Optical Fiber Cable Assemblies.

1.3 CONTRACTOR SUBMITTALS

A. Submit in accordance with Section 01 33 00 – Contractor Submittals.
B. Submit the following:

1. List of equipment and materials.
2. Manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts.
3. Installation instructions.
4. Splicing instructions.

5. Layout and anchorage of equipment and appurtenances, including clearance for maintenance and operations.

C. Calculations

1. Calculations of flux budget and gain margins to demonstrate installed fibers meet equipment operations requirements.

1.4 QUALIFICATIONS

A. Installation technicians shall have received formal specialty training and shall be regularly engaged in installation and testing of optical fibers and accessories. Proof of training and work experience shall be submitted to demonstrate relevant qualifications for work specified herein.

PART 2 -- PRODUCTS

2.1 OPTICAL FIBERS AND CABLE

A. Optical Fiber

1. Type: Multi-mode or Single-mode, depending on the application requirements, as indicated on the engineering plans.
2. Number of Fibers: 6, minimum.

B. Cable Construction

1. Type: All dielectric self-supporting.
2. UV-resistant and flame-retardant outer jacket.
3. Fully water-blocked for indoor and outdoor application.
4. Design and Test: In accordance with ICEA S-104-696.
5. Listing: NEC Type OFNR, FT-4.
6. Manufacturer: Corning, type Freedom One Riser Cable, or approved equal.

2.2 FIBER OPTIC CONNECTORS

A. Field installable, self-aligning and centering type to match field equipment.

B. Match the fiber core and cladding diameters.

C. Insertion Loss: 0.3 dB nominal and less than 0.5 dB max.

D. Type SC connectors are preferred if compatible with connected equipment.

2.3 PATCH PANEL AND PATCH CORDS

A. Wall-mounted for termination, splice storage, routing, radius limiting, cable fastening, storage, and cross-connection.

B. Patch cords: factory connector-terminated flexible optical fiber cable with connectors of the same type as used elsewhere in the system. Optical fiber shall be the same type as used elsewhere in the system.

PART 3 -- EXECUTION

3.1 GENERAL

A. Installation and splices shall be performed only by trained technician.

B. Minimize number of splices unless the maximum standard cable is not sufficient to cover the entire fiber route without splices.

C. Make splices using the method recommended by the cable manufacturer. House splices in a splice enclosure and encapsulate with an epoxy, ultraviolet light cured splice encapsulant or otherwise protected against infiltration of moisture or contaminants.

D. Fusion splices shall have nominal splice loss of 0.1dB or less for each single mode cable fusion splice.

E. Route fiber in orange inner duct through conduit and in cable tray.

3.2 FIELD TESTING

A. Optical Time Domain Reflectometer Tests

1. Perform optical time domain reflectometer (ODTR) tests using the FO test procedures per TIA-455-78.
2. If the OTDR test results show losses are greater than 0.1 dB per fusion splices, the splice is unacceptable to OWNER.
3. Replace the unsatisfactory splice with a new splice. The new segment of cable shall then be retested to demonstrate acceptability.

B. Power Attenuation Test

1. Perform power attenuation test of all fibers at 1310 nm and 1550 nm from each end.
2. The CONTRACTOR shall prepare and submit a report documenting the results of the tests.

C. Operations Tests

1. Perform operations tests using control signals between the powerhouse and the PLC 1 to ensure optical fiber systems work properly. Work with OWNER to ensure control system is properly interfaced with OWNER's SCADA system.
2. If the result is unsatisfactory, examine the circuit to determine the problem. Notify OWNER of the problem and of the procedures the CONTRACTOR proposes to eliminate the problem. The CONTRACTOR shall prepare and submit a report documenting the results of the test.

- END OF SECTION –

SECTION 26 05 43 - RACEWAYS

PART 1 -- GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this Section:

1. American National Standards Institute (ANSI):

   a. C80.1, Rigid Steel Conduit-Zinc Coated
   b. C80.3, Electrical Metallic Tubing-Zinc Coated
   c. C80.5, Aluminum Rigid Conduit
   d. C80.6, Intermediate Metal Conduit (IMC)-Zinc Coated

2. National Electrical Contractor's Association, Inc. (NECA): 5055, Standard of Installation
3. National Electrical Manufacturers Association (NEMA):

   a. RN 1, Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
   b. TC 2, Electrical Polyvinyl Chloride Plastic Tubing (PVC) and Conduit
   c. TC 3, PVC Fittings for Use with Rigid PVC Conduit and Tubing
   d. TC 6, PVC and ABS Plastic Utilities Duct for Underground Installation
   e. VE 1, Metallic Cable Tray Systems

4. National Fire Protection Association (NFPA): 70, National Electrical Code. (NEC)
5. Underwriters Laboratories, Inc. (UL):

   a. 1, Standard for Safety Flexible Metal Conduit
   b. 6, Standard for Safety Rigid Metal Conduit
   c. 360, Standard for Safety Liquid-Tight Flexible Steel Conduit
   d. 514B, Standard for Safety Fittings for Cable and Conduit
   e. 514C, Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
   f. 651, Standard for Safety Schedule 40 and 80 Rigid PVC Conduit
   g. 651A, Standard for Safety Type EB and A Rigid PVC Conduit and HDPE Conduit
   h. 797, Standard for Safety Electrical Metallic Tubing
   i. 870, Standard for Safety Wireways, Auxiliary Gutters, and Associated Fittings
   j. 1660, Standard for Safety Liquid-Tight Flexible Nonmetallic Conduit

1.2 CONTRACTOR SUBMITTALS

The following shall be submitted in accordance with Section 01 33 00 - Contractor Submittals:

A. Shop Drawings:

1. Manufacturer's Literature:

   a. Conduits of all types to be used

b. Other wireways
2. Cable Tray System:

a. Dimensional drawings, calculations, and descriptive information
b. NEMA load/span designation and how it was selected
c. Layout drawings and list of accessories being provided

3. Conduit and cable tray Layouts:

a. Plans and sections showing arrangement and location of conduit and duct bank to be used
b. Drawings shall be prepared using AutoCAD® files in 2014 or later version

1.3 UL COMPLIANCE

A. Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

PART 2 -- PRODUCTS

2.1 CONDUIT AND TUBING

A. Rigid Galvanized Steel Conduit (RGS):

1. Meet requirements of ANSI C80.1 and UL 6
2. Material: Hot-dip galvanized, with chromated protective layer

B. Intermediate Metal Conduit (IMC):

1. Meet requirements of ANSI C80.6 and UL 1242
2. Material: Hot-dip galvanized, with chromated and lacquered protective layer

C. Electric Metallic Tubing (EMT):

1. Meet requirements of ANSI C80.3 and UL 797
2. Material: Hot-dip galvanized, with chromated and lacquered protective layer

D. PVC Schedule 40 Conduit:

1. Meet requirements of NEMA TC 2 and UL 651
2. UL listed for concrete encasement, underground direct burial, concealed or direct sunlight exposure, and 90 degrees C insulated conductors

E. Flexible Metal, Liquid-Tight Conduit:

1. UL 360 listed for 105 degrees C insulated conductors
2. Material: Galvanized steel, with an extruded PVC jacket

F. Flexible Metal, Non-Liquid-Tight Conduit:

1. Meet requirements of UL 1
2. Material: Galvanized steel

G. Flexible, Nonmetallic, Liquid-Tight Conduit:

1. Material: PVC core with fused flexible PVC jacket
2. UL 1660 listed for:

   a. Dry Conditions: 80 degrees C insulated conductors
   b. Wet Conditions: 60 degrees C insulated conductors

2.2 FITTINGS

A. Rigid Galvanized Steel and Intermediate Metal Conduit:

1. General:

   a. Meet requirements of UL 514B
   b. Type: Threaded, galvanized -- Set screw and threadless compression fittings not permitted

2. Bushing:

   a. Material: Malleable iron with integral insulated throat, rated for 150 degrees C

3. Grounding Bushing:

   a. Material: Malleable iron with integral insulated throat rated for 150 degrees C, with solderless lugs

4. Conduit Hub:

   a. Material: Malleable iron with insulated throat with bonding screw
   b. UL listed for use in wet locations

5. Conduit Bodies:

   a. Sized as required by NFPA 70

6. Couplings: As supplied by conduit manufacturer
7. Unions:

   a. Concrete tight, hot-dip galvanized, malleable iron

8. Cable Sealing Fittings:

   a. To form watertight nonslip cord or cable connection to conduit
   b. For Conductors with OD of 1/2-inch or less: Neoprene bushing at connector entry

B. Electric Metallic Tubing:

1. Meet requirements of UL 514B
2. Type: Steel body and locknuts with steel or malleable iron compression nuts. Set screw and drive-on fittings not permitted
3. Electro zinc-plated inside and out
4. Raintight

C. PVC Conduit and Tubing:

1. Meet requirements of NEMA TC-3
2. Type: PVC, slip-on

D. Flexible Metal, Liquid-Tight Conduit:

1. Metal insulated throat connectors with integral nylon or plastic bushing rated for 105 degrees C
2. Insulated throat and sealing O-rings

E. Flexible Metal, Non-Liquid-Tight Conduit:

1. Meet requirements of UL 514B
2. Body: Galvanized: steel
3. Throat: Nylon insulated
4. 1-1/4-Inch Conduit and Smaller: One screw body
5. 1-1/2-Inch Conduit and Larger: Two screw body

F. Flexible, Nonmetallic, Liquid-Tight Conduit:

1. Meet requirements of UL 514B
2. Type: High strength plastic body, complete with lock nut, O-ring, threaded ferrule, sealing ring, and compression nut
3. Body/compression nut (gland) design to assure high mechanical pullout strength and watertight seal

G. Flexible Coupling, Hazardous Locations:

1. Approved for use in the atmosphere involved
2. Rating: Watertight and UL listed for use in Class I, Division 1 and 2 areas.
3. Outer bronze braid and an insulating liner
4. Conductivity equal to a similar length of rigid metal conduit

H. Watertight Entrance Seal Device:

1. New Construction:

   a. Material: Oversized sleeve, malleable iron body with sealing ring, pressure ring, grommet seal, and pressure clamp

2. Cored-Hole Application:

a. Material: Assembled dual pressure disks, neoprene sealing ring, and membrane clamp

2.3 CABLE TRAYS

A. Meet requirements of NEMA VE 1.

B. Type: Ladder, of welded construction.

C. Material: Copper-free aluminum alloy 6063-T6finish.

D. Dimensions: 6-inch NEMA nominal inside fill depth and fittings. Width shall be minimum 18”, 8” rung spacing, and bending radius to suit application. Cable tray shall be double or single layer as indicated on the engineering plans.

E. Fittings of same cross-sectional tray area, and hardware of same material as cable tray.

F. Tray Grounding: Conform to NFPA 70 and NEMA VE 1.

G. Provide next higher NEMA VE 1 class designation than required for support of designed span length.

H. Design Loads: Use working load adequate for actual cable installed plus 20 percent additional weight allowance for future cables with safety factor of 1.5 in accordance with NEMA VE 1, Table 3-1.

I. Expansion Joints: NEMA VE 1 for 50 degrees F maximum temperature variation.

J. Furnish Cable Tray with no sharp edges, burrs, or weld projections.

PART 3 -- EXECUTION

3.1 GENERAL

A. Conduit and tubing sizes shall be based on the use of copper conductors.

B. Crushed or deformed raceways not permitted.

C. Maintain raceway entirely free of obstructions and moisture.

D. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.

E. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.

F. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.

G. Group raceways installed in same area.

H. Proximity to Heated Piping: Install raceways minimum 12 inches from parallel runs.

I. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.

J. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes. Installation shall be plumb, square, and true.

K. Block Walls: Do not install raceways in same horizontal course with reinforcing steel.

L. Install watertight fittings in outdoor, underground, or wet locations.

M. Paint threads and cut ends, before assembly of fittings, galvanized conduit, PVC coated galvanized conduit, or IMC installed in exposed or damp locations with zinc-rich paint or liquid galvanizing compound.

N. Metal conduit to be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.

O. Do not install raceways in concrete equipment pads, foundations, or beams, unless they are required for bottom entry to control panels, motor control centers, switchgear, or similar equipment.

P. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.

Q. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.

R. Install conduits for fiber optic cables, telephone cables, and Category 5 data cables in strict conformance with the requirements of EIA/TIA 596-A.

S. Conduit larger than 1-inch shall not be embedded in concrete slabs, walls, foundations, columns or beams, unless approved by OWNER.

T. Embedded conduits emerging flush with concrete slab or wall shall be provided with bell ends.

U. Install pull boxes and junction boxes as required to meet NEC requirements or for ease of cable pulling, whether or not they are specifically shown on the Drawing in accordance with Section 26 05 01 Electrical Materials and Methods.

3.2 CONDUIT APPLICATION

A. Diameter: Minimum 3/4 inch.

B. Exterior, Exposed:

1. Rigid galvanized steel
2. Motors and transformers: See “Connections”

C. Interior, Exposed:

1. Rigid galvanized steel
2. Motors and transformers: See “Connections”

D. Interior, Concealed and Dry (Not Embedded in Concrete):

1. IMC or EMT

E. Aboveground, Embedded in Concrete Walls, Ceilings, or Floors:

1. Rigid galvanized steel

F. Direct Earth Burial:

1. Rigid galvanized steel

3.3 CONNECTIONS

A. For motors, wall- or ceiling-mounted fans and unit heaters, dry type transformers, electrically operated valves, instrumentation, and other equipment where flexible connection is required to minimize vibration:

1. Conduit Size 4 Inches or Less: Flexible, liquid-tight conduit
2. Conduit Size Over 4 Inches: Nonflexible
3. Wet or Corrosive Areas: Flexible, nonmetallic or flexible metal liquid-tight
4. Dry Areas: Flexible, metallic liquid-tight
5. Length: 18-inch minimum, 60-inch maximum, sufficient to allow movement or adjustment of equipment

B. Outdoor Areas, Process Areas Exposed to Moisture, and Areas Required to be Oil-Tight and Dust-Tight: Flexible metal, liquid-tight conduit.

C. Transition From Underground or Concrete Embedded to Exposed: Rigid galvanized steel conduit.

D. Under Equipment Mounting Pads: Rigid galvanized steel conduit.

3.4 PENETRATIONS

A. Make at right angles, unless otherwise shown.

B. Notching or penetration of structural members, including footings and beams, not permitted.

C. Fire-Rated Walls, Floors, or Ceilings: Firestop openings around penetrations to maintain fire-resistance rating using fire penetration seal as approved by OWNER.

D. Apply single layer of wraparound duct band to all metallic conduit protruding through concrete floor slabs to a point 2 inches above and 2 inches below concrete surface.

E. Concrete Walls, Floors, or Ceilings (Above ground): Provide non-shrink grout dry-pack, or use watertight seal device.

F. Entering Structures:

1. General: Seal raceway at the first box or outlet with oakum or expandable plastic compound to prevent the entrance of gases or liquids from one area to another
2. Concrete Roof or Membrane Waterproofed Wall or Floor:

    a. Provide a watertight seal
    b. Without Concrete Encasement: Install watertight entrance seal device on each side
    c. With Concrete Encasement: Install watertight entrance seal device on the accessible side
    d. Securely anchor malleable iron body of watertight entrance seal device into construction with one or more integral flanges
    e. Secure membrane waterproofing to watertight entrance seal device in a permanent, watertight manner

3. Heating, Ventilating, and Air Conditioning Equipment:

    a. Penetrate equipment in area established by manufacturer
    b. Terminate conduit with flexible metal conduit at junction box or condulet attached to exterior surface of equipment prior to penetrating equipment
    c. Seal penetration with approved sealant

4. Existing or Precast Wall (Underground): Core drill wall and install a watertight entrance seal device
5. Nonwaterproofed Wall or Floor (Underground, without Concrete Encasement):

    a. Provide Schedule 40 galvanized pipe sleeve, or watertight entrance seal device
    b. Fill space between raceway and sleeve with expandable plastic compound or oakum and lead joint, on each side

6. Manholes and Handholes:

    a. Metallic Raceways: Provide insulated grounding bushings
    b. Nonmetallic Raceways: Provide bell ends flush with wall
    c. Install such that raceways enter as near as possible to one end of wall, unless otherwise shown

3.5 SUPPORT

A. Support from structural members only, at intervals not exceeding NFPA 70 requirements, and in any case not exceeding 10 feet. Do not support from piping, pipe supports, or other raceways.

B. Multiple Adjacent Raceways: Provide ceiling trapeze.

C. Nails or wooden plugs inserted in concrete or masonry for attaching raceway not permitted. Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of straps or hangers.

3.6 BENDS

A. Install concealed raceways with a minimum of bends in the shortest practical distance.

B. Make bends and offsets of longest practical radius. Bending radius in conduits for fiber optic cables shall be not less than 20 times cable diameter or 15 inches, minimum, whichever is larger.

C. Install with symmetrical bends or cast metal fittings.

D. Avoid field-made bends and offsets, but where necessary, make with acceptable hickey or bending machine. Do not heat metal raceways to facilitate bending.

E. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.

F. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run, and raceways are same size.

G. PVC Conduit:

1. Bends 30-Degree and Larger: Provide factory-made elbows
2. 90-Degree Bends: Provide rigid steel elbows, PVC coated where direct buried
3. Use manufacturer's recommended method for forming smaller bends

H. Flexible Conduit: Do not make bends that exceed allowable conductor bending radius of cable to be installed or that significantly restricts conduit flexibility.

3.7 EXPANSION/DEFLECTION FITTINGS

A. Provide on all raceways at all structural expansion joints, and in long tangential runs.

B. Provide expansion/deflection joints for temperature variation between 20 degrees F and 100 degrees F.

C. Install in accordance with manufacturer's instructions.

3.8 PVC CONDUIT

A. Solvent Welding:

1. Provide manufacturer recommended solvent; apply to all joints
2. Install such that joint is watertight

B. Adapters:

1. PVC to Metallic Fittings: PVC terminal type
2. PVC to Rigid Metal Conduit or IMC: PVC female adapter

C. Belled-End Conduit: Bevel the unbelled end of the joint prior to joining.

3.9 CABLE TRAYS

A. Install in accordance with Application Information Section of NEMA VE 1.

B. Provide accessories as necessary for a complete system.

C. Install such that joints are not made at support brackets.

D. Install horizontal section support brackets between support point and quarter point of tray span.

E. Provide ceiling trapeze for all horizontal cable tray.

F. Install support within 2 feet on each side of expansion joints and within 2 feet of fitting extremity.

G. Provide expansion joints in accordance with NEMA VE 1 for 50 degrees F maximum temperature variation.

H. Install horizontal tray level, plumb, straight, and true to line or grade within a tolerance of 1/8 inch in 10 feet and within a cumulative maximum of 1/2 inch.

I. Install vertical tray plumb within a tolerance of 1/8 inch in 10 feet.

J. Install without exposed raw edges.

K. Maintain12-inch vertical separation between multi-tiered trays having a common support, and at all crossover locations.

L. Provide bonding jumper at each expansion joint and adjustable connection.

M. Ground Conductor: Provide properly sized clamps for each section, elbow, tee, cross, and reducer.

3.10 TERMINATION AT ENCLOSURES

A. Cast Metal Enclosure: Provide manufacturer's premolded insulating sleeve inside metallic conduit terminating in threaded hubs.

B. Nonmetallic Cabinets and Enclosures: Terminate conduit in threaded conduit hubs, maintaining enclosure integrity.

C. Sheet Metal Boxes, Cabinets, and Enclosures:

1. Rigid Galvanized Conduit:
   a. Provide one lock nut each on inside and outside of enclosure
   b. Install grounding bushing
   c. Provide bonding jumper from grounding bushing to equipment ground bus or ground pad; if neither ground bus nor pad exists, connect jumper to lag bolt attached to metal enclosure
   d. Install insulated bushing on ends of conduit where grounding is not required
   e. Provide insulated throat when conduit terminates in sheet metal boxes having threaded hubs
   f. Utilize sealing locknuts or threaded hubs on outside of NEMA 3R and NEMA 12 enclosures
   g. Terminate conduits at threaded conduit hubs at NEMA 4 and 4X boxes and enclosures

2. Electric Metallic Tubing: Provide gland compression, insulated connectors
3. Flexible Metal Conduit: Provide two screw type, insulated, malleable iron connectors
4. Flexible, Nonmetallic Conduit: Provide nonmetallic, liquid-tight strain relief connectors
5. PVC-Coated Rigid Galvanized Steel Conduit: Provide PVC-coated, liquid-tight, metallic connector
6. PVC Schedule 40 Conduit: Provide PVC terminal adapter with lock nut

D. Motor Control Center, Switchboard, Switchgear, and Free-Standing Enclosures:

1. Terminate metal conduit entering bottom with grounding bushing; provide a grounding jumper extending to equipment ground bus or grounding pad
2. Terminate PVC conduit entering bottom with bell end fittings

3.11 CONDUIT IDENTIFICATION TAGS

A. Conduit Identification Tags:

1. Identify all new or reused conduits with unique conduit designations. Conduit designations shall be as shown in Cable and Conduit Schedule or new designations approved by OWNER
2. Install at each terminus, near midpoint, and at minimum intervals of every 50 feet of exposed Raceway, whether in ceiling space or surface mounted.
3. Provide stainless steel tags with stamped lettering. Provide non-corrosive wire for attachment

3.12 PROTECTION OF INSTALLED WORK

A. Protect products from moisture, corrosion, and physical damage during construction.

B. Provide manufactured watertight and dust-tight seals over all conduit openings during construction.

C. Touch up painted conduit threads after assembly to cover nicks or scars.

- END OF SECTION -

SECTION 26 05 50 - HEAT TRACING

PART 1 -- GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this Section:

1. Factory Mutual.
2. Institute of Electrical and Electronics engineers, Inc (IEEE): 515, Testing, Design, Installation and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications.
3. National Electrical Manufacturers' Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
4. Underwriters Laboratories, Inc. (UL).
5. National Electrical Code (NEC).

1.2 CONTRACTOR SUBMITTALS

A. The following shall be submitted in accordance with Section 01 33 00 - Contractor Submittals:

1. Manufacturer's descriptive literature.
2. Plastic Pipe Installations: Output adjustment factors for heating tape for the services indicated.
3. Pipe heat loss calculations for each pipe size to be heat traced.

PART 2 -- PRODUCTS

2.1 ELECTRICAL HEATING TAPE

A. Cable: Self-limiting, parallel circuit construction consisting of continuous inner core of variable resistance conductive heating material between two parallel copper bus wires. Provide tinned copper braid for PVC, FRP, and stainless steel pipe applications.

B. UL Listing: Listed as self-limiting pipe tracing material for pipe freeze protection application in ordinary conditions.

C. Maximum Maintenance Temperature: 150 degrees F (65 degrees C).

D. Maximum Intermittent Temperature: 185 degrees F (85 degrees C).

E. Suitable for Class I, II, and III location

F. Service Voltage: 208 VAC or 480 VAC

G. Manufacturers and Products:

1. Chromalox, SRL
2. Raychem; Chemelex BTV or BRV-C.
3. Thermon; FLX-BC or FLX-OJ.

4. Nelson; CL1-J1 or L1-J1.

2.2 CONNECTION SYSTEM

A. Rating: NEMA 250, Type 4 and Factory Mutual approved.

B. Operating Monitor Light: Furnish with each circuit power connection kit to indicate when heat tracing is energized.

C. Connection system shall include the following accessories as required for application:

1. Power Connection Kit
2. Splice Kit
3. Tee Kit
4. End Seal Kit
5. Pilot Light
6. Pipe Adapter Kit

2.3 SECURING TAPE

A. Plastic Piping Systems:

1. Type: Aluminum foil coated adhesive tape.

B. Metallic Piping Systems:

1. Type: Glass or polyester cloth pressure sensitive tape.

2.4 PIPE MOUNTED THERMOSTAT

A. Type: Adjustable between 40 degrees F and 120 degrees F, set at 100 degrees F.

B. Sensor: Fluid-filled with 3-foot capillary.

C. Enclosure: Glass-filled nylon, NEMA 250, Type 4X weatherproof with gasketed lid.

D. Switch: SP-ST, UL listed, rated 30 amps, 208Vac.

E. Manufacturers and Products: Shall be same as heat tape manufacturer.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. General:

1. Install in accordance with the manufacturer's instructions and recommended practices.
2. Ground metallic structures or materials used for support of heating cable or on which it is installed in accordance with applicable codes.

3. Wiring between power connection points of heat tracing cable branch lines shall be provided by heat tracing system supplier.
4. Provide end of circuit pilot lights on heat tracing circuits for buried piping.
5. Wiring and grounding shall conform to NEC requirements.

B. Electrical Heating Tape:

1. Determine required length of electrical heating tape by considering length of circuit, number and type of fittings and fixtures, design heating load, and heating tape output.
2. Where design heating load exceeds heating tape capacity, install by spiraling.
3. Derate heating tape capacity when installed on plastic piping.
4. Install on services shown on Drawings and in accordance with manufacturer's instruction.

C. Heat Tracing Circuits: Limit individual lengths of heat tracing circuits such that maximum single circuit capacity is 30 amps when starting the circuit at 40 degrees F. Provide multiple 30-amp circuits as required at individual heat tracing locations.

D. Thermostats:

1. Install in accordance with manufacturer's instructions.

3.2 FIELD QUALITY CONTROL

A. Test each circuit with 500-volt insulation tester between circuit and ground with neutrals isolated from ground.

1. Insulation Resistance: Minimum 1,000 megohms per 1,000 feet.

- END OF SECTION -

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SECTION 26 08 00 - ELECTRICAL TESTING

PART 1 -- GENERAL

1.1 REQUIREMENTS

A. Provide the services of qualified testing personnel or firm for inspection, calibration, and testing of all installed equipment to establish equipment conforms to requirements specified in these specifications and is ready for commissioning tests. The testing firm shall be an independent business entity, or individuals not intimately involved with construction of the project, and shall be certified as a Nationally Recognized Testing Laboratory (NRTL) by OSHA, or otherwise qualified and approved by Owner.

B. Organize the tests such that all aspects of installed equipment are covered, including the interface to existing equipment.

C. Submit reports of all tests performed, including test procedures, measurements taken, settings entered, conclusions and recommendations.

1.2 REFERENCES

A. Testing shall be performed in accordance with the applicable test criteria and requirements included in the following list of standards:

1. American National Standards Institute (ANSI):

    a. C2, National Electrical Safety Code

2. Institute of Electrical and Electronics Engineers (IEEE)
3. National Electrical Manufacturers Association (NEMA)
4. International Electrical Testing Association (NETA): Acceptance Testing Specifications (ATS) for Electrical Power Distribution Equipment and Systems.
5. National Fire Protection Association (NFPA):

    a. 70, National Electrical Code (NEC).
    b. 70E, Standard for Electrical Safety in the Workplace.

1.3 CONTRACTOR SUBMITTALS

A. The following shall be submitted in accordance with Section 01 33 00 – Contractor Submittals:

B. Submit 20 days prior to performing inspections or tests:

1. Qualifications of testing firm or individuals.
2. Schedule for performing inspection and tests.
3. List of references to be used for each test.
4. Test procedures to be used for all equipment and subsystems
5. Equipment and materials inspection form(s) to be used.
6. Individual device test forms to be used.
7. Individual system test forms to be used.

C. Test Report: Submit within 7 days after completion of test. Report shall include:

1. Executive Summary
2. Test criteria or standards used
3. Test instruments used, including calibration records
4. Test sheets with tester’s and witness’ initials organized to cover the following subsystems:
   - Wiring and Conduit system
   - Control Panels
   - Field sensors
   - Motor Controls
   - Equipment Interconnections
   - Secondary unit substation
   - Interconnections with existing SCADA and control system
   - Others
5. Observation, summary, and recommendations

1.4 QUALIFICATIONS

A. Test personnel shall be engineers and/or technicians routinely engaged in testing and inspecting of electrical equipment, installations, and systems.

B. Test personnel certified by NETA or otherwise qualified and approved by Owner.

C. Test equipment shall have an operating accuracy equal to, or greater than, requirements established by NETA ATS.

D. Test instrument calibration shall be in accordance with NETA ATS.

1.5 SEQUENCING AND SCHEDULING

A. Perform inspection and electrical tests after equipment has been installed.

B. Perform tests with apparatus de-energized whenever feasible.

C. Inspection and electrical tests on energized equipment are to be:

1. Scheduled with OWNER prior to de-energization.
2. Minimized to avoid extended period of interruption to the operating plant equipment.

D. Notify OWNER at least 48 hours prior to performing tests on energized electrical equipment.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION

3.1 GENERAL

A. Tests and inspection shall establish that:

1. Electrical equipment is operational within industry and manufacturer's tolerances.
2. Wiring is correctly labeled and terminations are correct.
3. Equipment is suitable for energization.
4. Installation conforms to requirements of Contract Documents and referenced industry standards.
5. Manufacturers' settings have been correctly entered and equipment operation verified.
6. Equipment is ready for commissioning tests in accordance with Division 01 – General Requirements.

B. Perform inspection and testing in accordance with NETA Acceptance Testing Specifications, industry standards, and manufacturer's recommendations.

C. Verify, test, and calibrate protective relays, circuit breakers, fuses, VFDs, motor starters, and other applicable devices.

D. Adjust mechanisms and moving parts for free mechanical movement.

E. Adjust adjustable relays and sensors to correspond to operating conditions, or as recommended by manufacturer.

F. Verify nameplate data for conformance to Contract Documents.

G. Realign equipment not properly aligned and correct unlevelness.

H. Properly anchor electrical equipment found to be inadequately anchored.

I. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench to manufacturer's recommendations, or as otherwise specified.

J. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

K. Inspect raceways and busways for proper routing and support. Verify each raceway is properly identified with label.

L. Verify cables and wiring are properly identified with circuit labels and conductor identifications.

M. Investigate and repair or replace:

1. Electrical or control items that fail tests.
2. Active components not operating in accordance with manufacturer's instructions.
3. Damaged electrical equipment.

N. Electrical Enclosures and Panels:

1. Remove foreign material and moisture from enclosure interior.
2. Vacuum and wipe clean enclosure interior.
3. Remove corrosion found on metal surfaces.
4. Repair or replace door and panel sections having dented surfaces.
5. Repair or replace poor fitting doors and panel sections.

6. Repair or replace improperly operating latching, locking, or interlocking devices.
7. Replace missing or damaged hardware.
8. Finish:

    a. Provide matching paint and touch up scratches and mars.
    b. If required due to extensive damage, refinish the entire assembly.

3.2 WIRING AND CABLE TESTING

A. Visual and Mechanical Inspections:

1. Physical damage to jacket and insulation.
2. Cable bends not in conformance with manufacturer's minimum allowable bending radius where applicable.
3. Proper support.
4. Color coding conformance with specifications.
5. Proper shield grounding.
6. Proper circuit identification.
7. Correct phasing and polarities.
8. Correct point-to-point terminations.
9. Proper lug type for conductor material.
10. Proper lug installation.
11. Proper clearances.
12. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.

B. Insulation Resistance Tests:

1. Perform insulation resistance test using DC voltages per NETA ATS Table 100.1.
2. Test each conductor with respect to ground and to adjacent conductors per IEEE 118 procedures.
3. Investigate values less than shown in Table 100.1.
4. Continuity test by ohmmeter method to ensure proper cable connections.

C. Current and Voltage Application Tests:

1. Inject AC or DC test current, as applicable, to each current loop and confirm proper currents are measured at target devices.
2. Apply AC or DC test voltage, as applicable, and confirm proper voltage is received by target devices.

D. Operational Tests:

1. Initiate control devices.
2. Check proper operation of control system and VFDs.
3. Check alarms and shutdown circuits.

3.3 CONTROL PANELS AND DEVICES

A. Visual and Mechanical Inspection:

1. Verify that power supply and equipment grounding conductors are correctly provided in accordance with NEC.
2. Verify by point-to-point check that field wiring is correctly terminated with devices, sensors, switches, relays, interlocks, communication lines, PLCs, and other interfacing devices in accordance with the approved shop drawings.
3. Verify that low voltage signal wiring is correctly terminated and shields grounded.
4. Verify conductor labels and terminal identifications in accordance with shop drawings provided by manufacturers and suppliers.
5. Verify nameplate data.

B. Electrical Tests:

1. Verify and calibrate instrumentation input and output loops
2. Verify shutdown functions.
3. Verify proper inputs are received from field transducers and sensors.
4. Verify operation of control circuits by observing target field devices.
5. Verify HMI for data accuracy and correct control outputs.
6. Verify Hand-Off-Auto and Manual-Off-Auto functions.
7. Verify remote monitoring by existing SCADA system at the powerhouse.

3.4 SENSORS AND TRANSDUCERS

A. Visual and Mechanical Inspection:

1. Verify devices against nameplate data.
2. Verify correct locations, polarity and orientation.
3. Verify integrity of installation.

B. Electrical Tests:

1. Verify sensors are correctly connected to power source.
2. Calibrate for linearity and output range.
3. Verify signal isolation with adjacent circuits.
4. Verify proper grounding of conductor shields

3.5 GROUNDING SYSTEM

A. Visual and Mechanical Inspection:

1. Equipment and circuit grounds in motor controllers, panelboards, and switchgear assemblies for proper connection, continuity and tightness.
2. Ground bus connections in motor controllers, panelboards, and switchgear assemblies for proper termination and tightness.
3. Effective transformer core and equipment grounding.
4. Accessible connections to grounding electrodes for proper fit and tightness.
5. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.

B. Electrical Tests:

1. Verify interconnections to existing grounding grid system.

3.6 LOW VOLTAGE MOTOR CONTROL

A. Visual and Mechanical Inspection:

1. Proper barrier and shutter installation and operation.
2. Proper operation of indicating and monitoring devices.
3. Proper overload protection for each motor.
4. Improper blockage of air cooling passages.
5. Proper operation of drawout elements.
6. Integrity and contamination of bus insulation system.
7. Check nameplates for proper identification of devices installed.
8. Verify performance of each control device and feature furnished as part of the motor controller.
9. Control Wiring:

    a. Compare wiring to local and remote control, and protective devices with elementary diagrams.
    b. Check for proper conductor lacing and bundling.
    c. Check for proper conductor identification.
    d. Check for proper conductor lugs and connections.

B. Operational Tests:

1. Operate equipment by initiating controls from control station.
2. Check for correct rotation.
3. Verify HOA switch functions.

3.7 INTERFACE WITH EXISTING EQUIPMENT

A. Check that communication links are properly installed and operating between PLC1 controls and existing plant control SCADA system.

3.8 MISCELLANEOUS CIRCUITS AND DEVICES

A. CONTRACTOR shall ensure that all other equipment supplied and installed under this Contract are properly installed, interconnected, and ready for operation whether or not they are specifically identified in this Section.

- END OF SECTION -

SECTION 26 29 00 - MOTOR CONTROL CENTER

PART 1 -- GENERAL

1.1 DESCRIPTION

A. SCOPE:

This Section specifies freestanding, factory assembled 600 V motor control centers (MCC). The MCC will be dedicated to housing an assortment of VFDs operating ground well pumps, booster pumps, and energy recover pumps.

B. EQUIPMENT LIST:

MCCs specified herein shall be furnished by a single manufacturer. Configuration shall be as indicated on the engineering plans.

1.2 REFERENCES

This Section contains references to the following documents. They are a part of this Section as specified and modified. In case of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.

ANSI/NEMA ICS	General Standards for Industrial Controls and Systems
ANSI/NEMA ICS 2	Industrial Control Devices, Controllers and Assemblies
JIC EMP 1	Electrical Standards for Mass Production Equipment
UL 845	Motor Control Centers

1.3 CONTRACTOR SUBMITTALS

The following information shall be provided in accordance with Section 01 33 00 – Contractor Submittals:

1. Elementary connection and interconnection diagrams in accordance with JIC EMP 1 and/or NEMA ICS standards.

2. Time current curves for all protection devices.

3. List of starters, VFDS, and feeder tap compartments indicating the size and type of circuit protection.

4. Interrupting, Withstand and Continuous Current Rating of:

   a. Bus bars
   b. Feeder tap units
   c. Starter units
   d. Main incoming units

5. A copy of this specification Section with addenda updates, and all referenced Sections with addenda updates, with each paragraph check marked to show specification compliance or marked to show deviations.

6. Applicable operation and maintenance information.

7. Dimensions and weights.

8. Installation instructions.

9. Manufacturer's product data.

PART 2 -- PRODUCTS

2.1 ACCEPTABLE PRODUCTS

Motor control centers shall comply with ANSI/NEMA ICS 2-322, AC General-Purpose Motor Control Centers, and UL 845 and shall be Cutler Hammer, Allen Bradley, Square D, General Electric Spectra Series 8000, or equal.

2.2 SERVICE

Motor control centers shall be rated 600 V, 60 hertz, 3 phase, 4-wire as specified and shall be suitable for operation at the specified voltages and short circuit capacities.

2.3 STRUCTURE AND CONSTRUCTION

A. STRUCTURE:

Motor control centers shall be made of No. 14 gage steel minimum and each Section shall be 90 inches high by 20 inches wide by 20 inches deep. The individual unit compartments shall be a minimum of 12 inches high. There shall be 72 inches available for stacking starter units. Compartments shall have pan-type doors with a minimum of two quarter-turn hold-down latches; and neoprene gaskets.

A full height vertical wireway, 20 square inch minimum, shall be provided for each vertical motor control center Section. The wireway shall contain full height removable doors. Horizontal wireways shall be provided top and bottom, extending the length of motor control centers.

Bottom channel sills shall be mounted front and rear of the vertical sections extending the full length of the motor control center lineup. A removable lifting angle shall be mounted on top and shall extend the width of the motor control center lineup.

B. CONSTRUCTION:

Motor control centers located indoors shall have rated NEMA 1 enclosure.

Starter units, size 4 and smaller, and feeder tap units less than 225 A shall be drawout plug-in construction with hardened, plated copper free-floating stabs, steel spring backups. The door shall have interference tabs which prevent door closure if unit is improperly installed. Units shall be latched in the position to assure proper bus contact. The unit disconnect device shall be interlocked to prevent removal or reinsertion of a unit when the disconnect is in the "ON" or "TRIPPED" positions.

Fusible switch or circuit breaker disconnect operators shall be capable of accommodating three padlocks for locking in the "OPEN" position.

Hardware for mounting future starter and feeder tap units shall be provided at compartments specified as "FUTURE."

2.4 COLOR

The exterior color shall be ANSI 71 gray, internal compartments shall be painted white

2.5 BUS

A. GENERAL:

Bus shall be tin-plated copper with bolted connections between vertical and horizontal bus bars. Access for tightening these connections shall be from the front, without the need for tools on the rear of the connection. Insulated horizontal and vertical bus barriers shall be provided. Barriers shall be fabricated from high-strength, glass-filled polyester resin. Unless otherwise specified, the bus shall be braced to withstand a fault current of 32,000 A RMS, symmetrical.

B. HORIZONTAL BUS:

Unless otherwise specified or shown on the Drawings, the main horizontal bus shall be rated a minimum 600 A continuous.

C. VERTICAL BUS:

Unless otherwise specified or shown on the Drawings, the vertical bus shall be rated not less than that required by the load in that Section and no less than 300 A continuous.

D. NEUTRAL BUS:

Where specified, a neutral bus shall be provided. The neutral bus shall have the same rating as the main horizontal bus.

E. GROUND BUS:

A 1/4-inch by 2-inch ground bus shall be provided the full length of the motor control center. Ground bus shall be located at the bottom of the motor control center. Provide a lug to terminate a bare 4/0 AWG copper ground conductors at each end of the ground bus.

2.6 WIRING

A. GENERAL:

Motor control centers shall be provided with NEMA Class II, Type B wiring. All starter units shall have terminal blocks for control wiring. Terminal blocks shall be provided for power wiring for starters size 2 and smaller. Motor control centers shall be provided with all necessary interconnecting wiring and interlocking.

B. POWER WIRE:

Power wire shall be copper 90 degrees C, SIS type, sized to suit load; minimum power wire size shall be No. 12 AWG copper stranded.

C. CONTROL WIRE:

Control wire shall be No. 16 AWG stranded copper wire, rated 90 degrees C, SIS type and UL listed for panel wiring.

D. TERMINATIONS AND CABLE CONNECTIONS:

1. TERMINALS: Control wiring shall be lugged with ring-tongue or locking spade crimp type terminals made from electrolytic copper, tin-plated.

2. CABLE CONNECTORS: Cable connectors for use with stranded copper wire, sizes No. 8 AWG to 1000 MCM, shall be UL listed. Dished conical washers shall be used for each bolted connection. Connectors shall be reusable and shall be rated for use with copper conductors. Incoming line and outgoing feeder compartments shall be provided with crimp type lugs, 3M, Burndy, or equal.

2.7 MAIN AND FEEDER BRANCH CIRCUIT PROTECTION

A. GENERAL:

Main and feeder tap units shall consist of fused disconnect switches or circuit breakers, as specified.

B. CIRCUIT BREAKERS (THERMAL MAGNETIC):

Thermal-magnetic circuit breakers shall be molded case equipped with toggle type handle, quick-make, quick-break over center switching mechanism that is trip-free so that breaker cannot be held closed against short circuits and abnormal currents. The tripped position shall be clearly indicated by breaker handle maintaining a position between "ON" and "OFF." All poles shall open, close, and trip simultaneously. Minimum short circuit capacity shall be 65,000 A RMS symmetrical.

2.8 VFD OPERATION:

A. GENERAL:

VFDs starter units shall be combination type with fused disconnect switch or motor circuit protector as specified on the Drawings or the MCC schedule. The VFD units shall have a minimum combination UL listing of 32,000 A RMS, symmetrical or as specified in the engineering plans.

B. CONTROL TRANSFORMERS:

Each control transformer shall be rated 480/240-120V, single phase, 2 wire, 60 Hz. The transformer shall be sized for the load it feeds but shall not be less than the minimum ratings as follows:

NEMA starter size	Minimum transformer volt-ampere rating
1	100
2	150
3	200
4	300

Each control transformer shall be provided with time-delay, slow-blow secondary fuse rated to interrupt 10,000 amperes short circuit at 250 V AC. Two primary fuses rated to interrupt 200,000 amperes at 600 V shall be provided on all starters.

Fuse holder for secondary fuse shall be drawout indicating type and mounted on the door of the compartment. Fuse holders for primary fuses shall be fuse clips with full barriers between fuses.

C. VARIABLE FREQUENCY DRIVES (VFDs):

VFDs, per Section 26 29 23, shall be mounted in the MCC assembly as indicated on the engineering plans, designed for operation at 600 V AC, 60 Hz. Each VFD shall have a HMI type digital control panel mounted on the front of the MCC section in front of the VFD. Power cables leaving the VFD shall be bottom exit and control/instrumentation cables top exit.

D. LINE REACTORS:

A line reactor shall be provided for each VFD and located in the same MCC bucket compartment. Line reactors shall be rated for the application with a minimum 3% reactance.

E. AUXILIARY CONTACTS:

VFDs shall be equipped with auxiliary contacts, rated 10 A at 120 V AC. Unless otherwise specified on the drawings, each contactor shall be equipped with two normally open and two normally closed electrically isolated auxiliary contacts. Auxiliary contacts shall be wired out to terminal blocks. Refer to drawings for actual quantities required.

F. TERMINAL BLOCKS:

Terminal blocks shall be screw type rated 600 V; 20 A for control wiring and 30 A power wiring (starters size 3 and larger shall terminate the power leads directly to the VFD). The number of terminal blocks shall be specified on the drawings. Terminal blocks shall be provided with integral marking strips and shall be permanently marked with the conductor number as specified on the drawings. Internal wiring shall be connected on one side of the terminal block; outgoing conductors shall be connected to the other side.

2.9 MISCELLANEOUS

A. GENERAL:

Control devices such as pushbuttons, selector switches, indicating lights and overload reset pushbuttons shall be mounted on the unit compartment door. Where a VFD control panel is mounted on the compartment door.

B. NAMEPLATES:

Nameplates shall be provided for all cubicles and compartments. A Nameplate shall be provided identifying the motor control center.

2.10 SPARE PARTS

One set consisting of the following spare parts for each type shall be provided:

1--set each fuse size and type
10--indicating light bulbs

PART 3 -- EXECUTION

3.1 GENERAL

The motor control centers shall be erected in accordance with the recommendations of the manufacturer and with the details specified herein.

The overload relay heater elements shall be provided by the CONTRACTOR and sized based on the actual full load amperes of the motor connected to the starter.

The motor circuit protectors shall be adjusted by the CONTRACTOR to the lowest setting not causing false tripping.

3.2 FIELD TESTS

Follow the minimum requirements as stipulated in the NETA testing procedure for this type of motor control center assembly.

Generate a field report on tests performed, test values experienced, etc., and make available to OWNER upon request.

3.3 FACTORY TESTING

The motor control centers shall have been tested in a high power laboratory to prove adequate mechanical and electrical capabilities.

All factory tests required by the latest ANSI, NEMA and UL standards shall be performed.

Factory tests as outlined above shall be witnessed by individuals designated by the OWNER.

1. The manufacturer shall notify the OWNER two (2) weeks prior to the date the tests are to be performed.

2. The manufacturer shall include the cost of transportation and lodging for up to three (3) individuals designated by the OWNER. The cost of meals and incidental expenses shall be the responsibility of the OWNER.

The manufacturer shall provide three (3) certified copies of factory test reports.

The motor control centers shall be inspected by the OWNER before shipping.

- END OF SECTION -

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SECTION 26 29 23 - VARIABLE FREQUENCY DRIVES

PART 1 -- GENERAL

1.1 DESCRIPTION

A. SCOPE:

This Section specifies low voltage variable frequency drive (VFD) systems. The VFD systems shall include variable frequency drives, control circuitry, protective equipment, and accessories as necessary to provide the specified functions. All variable frequency drives provided on the project shall be the product of a single manufacturer.

B. VFD SYSTEM RESPONSIBILITY:

The VFD's specified in this Section shall be the product of a single vendor. Integrated VFDs in vendor supplied equipment may be of a different manufacturer, but shall adhere to these requirements.

The CONTRACTOR shall submit letters of certification with the shop drawings from the VFD manufacturer, the motor manufacturer, the power cable manufacturer and the driven equipment manufacturer stating that they have reviewed each application and that the combination will satisfy the application duties required, for the actual motor sizes required, regardless of deviations from the scheduled "nominal horsepower."

C. VFD FEATURES:

The VFD's shall be provided with the following features:

1. Line Reactors of at least 3% shall be provide with each VFD.
2. Input fused disconnect switch or circuit breaker as specified in this Section.
3. Fused control circuit transformer or transformers for all VFD control requirements including 120-V AC and 24-V DC requirements. Microprocessor based controller for system logic sequencing and local human machine interface for full local start and stop control, local manual speed control, drive programming interface, and diagnostics.
4. Speed reference signal input via 4-20 mA current signal.
5. Adjustable minimum/maximum frequency limits. Minimum frequency shall be adjustable from 6 to 40 hertz; maximum frequency shall be adjustable from 48 to 90 hertz.
6. Independent timed linear acceleration and deceleration functions, adjustable from 6 to 60 seconds.
7. Adjustable motor slip compensation based on motor current.

8. Terminal blocks for control and signal wires entering and leaving the controller and for associated controls.

9. All fuses shall be provided with blown fuse indicator lamps.

10. Current limit adjustable from 50 to 150 percent of motor rating.

11. Automatic restart with defeat selector.

12. Capability of picking up a spinning load.

13. 18 pulse input configuration with integral phase shifting autotransformer for drives 50 hp and larger.

D. FUNCTIONAL REQUIREMENTS:

1. GENERAL: The VFD shall convert 480 V, 4-wire, 60 hertz nominal input power to a suitable voltage and frequency to cause a standard inverter duty squirrel-cage induction motor to run at a speed proportional to the analog input signal speed reference from the instrumentation system. Each VFD shall be provided with a dedicated and independent digital control panel with HMI display. The VFD shall be capable of Modbus communications, either TCP Modbus or Serial Modbus.

2. SUPPLY POWER: The VFD shall operate continuously as specified with supply power from 440 V minimum to 504 V maximum, 60 hertz plus or minus 3 percent. The VFD shall remain on line and operate without damage to either the VFD or its connected load during a supply power variation of plus 50 percent lasting for a period of up to 0.01 seconds and minus 100 percent lasting for a period of up to 0.5 seconds.

3. AMBIENT CONDITIONS: The VFDs shall operate continuously at maximum load as specified with temperature of 10 to 110 degrees F and a humidity of 0 to 90 percent.

4. LOAD: The VFD system shall be capable of continuously driving the specified maximum motor load under the conditions specified herein. Variable-torque (VT) units shall be capable of delivering 110 percent of the full load rating of the driven equipment for up to 60 seconds in any one incident and up to 240 seconds per hour. Constant-torque (CT) units shall be capable of delivering 150 percent of the full load rating of the driven equipment for up to 60 seconds in any one incident and up to 240 seconds per hour.

5. POWER FACTOR: VFD systems shall have a displacement power factor of not less than 0.95 at any operating point.

6. EFFICIENCY: Efficiency of the variable frequency drives shall be not less than 98 percent at 60 hertz output driving the specified maximum load. Efficiency shall be defined as follows:

$$\text{Efficiency} = \frac{\text{POWER IN (watts) - LOSSES (watts)}}{\text{POWER IN (watts)}} \times 100\%$$

where losses include control power losses, rectifier, intermediate circuit, inverter, fan, and output filter. For 18 pulse drives, the above efficiency shall be not less than 96.5 percent including the drive transformer.

7. FREQUENCY AND VOLTAGE REGULATION: VFD inverter output frequency shall be regulated to within 0.6 hertz of the specified instrumentation signal/output frequency relationship. VFD inverter output voltage shall be regulated to within 1.0 percent of that value which will produce minimum motor heating at any operating frequency within the specified range.

8. FREQUENCY RANGE: VFD shall be capable of continuous operation with the specified load at any frequency between 6 and 90 hertz. Where operation at 90 hertz is required, it may be assumed that this corresponds to the maximum specified load.

9. AMBIENT NOISE: Free field noise generated by the VFD shall not exceed 85 dBA at 3 feet out from any point on the VFD cabinet under any normal operating condition, including enclosure ventilation fans where used.

10. dV/dt: The VFD Supplier shall be responsible for the coordination of the VFD's with the inverter duty motors supplied with the driven equipment. The peak voltage at the motor terminals shall be <1.6 kV, and the rise time shall be >0.1 μs. The VFD Supplier shall engineer each VFD with the necessary output filtering as required for each VFD/motor configuration to conform to these criteria. The VFD Supplier shall obtain cable and raceway characteristics from the project drawings. Filter losses shall be included in the efficiency calculation specified above.

11. RECTIFIER INPUT LINE HARMONICS: Rectifier input line current harmonics shall not exceed the following:

Order	Percent
5th	36
7th	16
11th	10
13th	6
17th	5

18 pulse drive's current distortion shall not exceed 5 percent at full load and speed.

12. CONVERTER OUTPUT HARMONICS: Total output voltage harmonics to motor shall not exceed 5 percent.

F. PROTECTION AND ANNUNCIATION:

1. OVERCURRENT PROTECTION: The VFD system shall provide adjustable electronic current limit. Current limit shall be accurate to within 1.0 percent and shall smoothly limit motor speed at whatever value is necessary to limit motor current to that value.

The VFD shall also provide motor running overcurrent protection in compliance with NFPA 70. This function may be included in the electronic overload circuitry if suitably UL labeled.

2. SHORT CIRCUIT PROTECTION: The VFD shall be fully protected against load and internal faults and shall be U.L.508C labeled as well as NEMA ICS 7.1 rated. Bolted, phase to phase, or phase to ground faults shall not damage the unit. In addition, these faults and/or internal faults shall not create a hazard to property or personnel. Fault protection shall be based on a power source short circuit capacity of 42,000 A RMS symmetrical at the VFD power input terminals. Any impedance or other current limiting necessary to meet this requirement shall be provided as part of the VFD system, and any losses caused by current limiting devices shall be included in efficiency calculation for the VFD system.

3. LINE VOLTAGE: The VFD shall be protected against high and low line voltage on one or more phases.

4. INTERNAL FAULTS: The VFD shall incorporate an internal fault monitoring system to detect malfunctions. This system shall be designed to protect the VFD from transient and sustained faults and to limit damage that may be caused by these faults.

5. EXTERNAL FAULTS: External fault requirements vary with the driven equipment. The VFD's shall be configured as required to shut down upon actuation of any of these external faults and to also provide an indication of the nature of the fault. The VFD Supplier shall note that certain driven equipment suppliers will include thermistors and thermistor relays rather than snap action type switches. In those cases, the VFD's shall include a 120 V AC power source for the thermistor relays and shall configure the VFD controls to accept a normally open rather than normally closed contact. In cases where the only external fault monitoring requirement is the motor thermal protection, the VFD shall include all components necessary to sense a contact opening or closing and disconnect the affected motor if the motor winding temperature exceeds maximum rated operating temperature. An indication of the fault shall be provided either via the unit mounted operator interface panel or by indicator lights. Where indicator lights are used, they shall include seal in provision with reset.

6. CONTROL PANEL ANNUNCIATION: The VFD shall be provided with a fault annunciation system, at both the control panel and through Modbus communications, which shall indicate the cause of any shutdown. Annunciator shall identify the first fault in those cases where multiple faults occur between manual or automatic resets and shall be visible without opening the motor control center door. As a minimum, the following faults shall be annunciated:

   a. External fault
   b. Input power loss
   c. DC bus undervoltage
   d. DC bus overvoltage
   e. Motor stalled
   f. Motor overload

g. Drive overtemperature
h. Drive overcurrent
i. Ground fault
j. Output short
k. Transistor short
l. Drive controller hardware fault
m. Drive controller software fault
n. Drive configuration error

G. EXTERNAL CONTROL AND MONITORING:

1. GENERAL: Control and monitoring interface shall conform to the requirements specified in this Section. Internal control and signal circuitry in the VFD that connects external to the VFD shall be designed to prevent the transmission of voltage and/or current harmonics inherent in power converter operation. VFD contacts for external status monitoring or control shall be isolated and shall be rated not less than 2 amps resistive or 2 amps inductive at 115 V AC/30V DC. AC coils in the VFD shall be suppressed to limit inductive switching surges to less than 200 volts peak. DC coils shall be provided with free-wheeling diodes to limit inductive surges to 28 V peak.

2. SPEED REFERENCE INPUT: The VFD shall accept a digital (for those with digital connections) reference signal for speed control in the REMOTE mode. Speed control in the LOCAL mode shall be via a manual potentiometer or via keypad input from the VFD operator interface panel. The speed reference shall be locally indicated via the VFD operator interface panel/HMI.

3. SPEED OUTPUT: The VFD speed signal output shall be available to the SCADA system via Modbus digital communications or by assignment of a 4-20mA output signal. The VFD output speed shall also be indicated locally by via the VFD operator interface panel.

4. RUNNING: The VFD shall include a running status indication either on its operator interface panel or via push to test indicating lights mounted on the enclosure door. Also provide running status via an isolated contact output for remote indication of running status. Where indicated on the drawings or specified in this contract, the VFD shall include control provisions to operate a 120 VAC solenoid valve. An additional run contact shall be included for this where indicated on the Drawings. Run contacts shall actuate when the controller is running at or above the minimum speed setting. Also include the 120-V AC source for the solenoid valves.

5. FAULT STATUS: The VFD shall provide a common fault status isolated contact output for remote fault annunciation. In addition, the VFD shall include local indication of the fault either via an indicator on the VFD operator interface panel or via a push to test indicator light mounted enclosure door. The fault status shall actuate on any internal or external monitored fault that shuts down the VFD.

6. LOCAL/REMOTE STATUS: The VFD shall allow the selection of exclusive command control including start, stop, and speed reference commands from either its unit mounted operator interface (LOCAL), or from externally wired inputs (REMOTE). The selection of this control shall be via a separate selector switch

mounted on the enclosure. In addition to this, provide a discrete isolated contact output that indicates that the controller is operating in the remote mode.

7. EXTERNAL RUN COMMAND: VFD shall accept an external digital command to run or stop in the REMOTE mode, following a speed set point command from the PLC. While in automatic mode, the VFD shall follow speed set points provided by the PLC.

8. EMERGENCY STOP COMMAND: The VFD shall be configured to accept a maintained emergency stop contact. When the contact is closed, the VFD shall operate normally. If the contact opens while the drive is running, the VFD shall instantly de-energize its output. The drive shall not re-start until the normal run command has opened and re-closed. This input shall be jumpered on the input terminals where this feature is not used. The status of this contact shall be included in the VFD READY status.

9. EXTERNAL WIRING INTERFACE: Terminal blocks shall be provided for all external wiring requirements.

10. HARDWIRED RUN PERMISSIVE: VFD's shall have provisions for accepting a wired contact input that functions as a run permissive in any mode. This input will be used for connection of the driven equipment disconnect switch auxiliary contact for de-energization of the VFD prior to power circuit interruption. This input shall be jumpered on the input terminals where this feature is not used. The status of this contact shall be included in the VFD READY status.

11. READY: The VFD shall include a ready status indication either on its operator interface panel or via push to test indicating lights mounted on the enclosure door. Also provide ready status via isolated contact output for remote indication of ready status. The ready status shall indicate the availability of control power, no overload fault, permissive contacts are okay, and no other internal or external active faults.

1.2 QUALITY ASSURANCE

A. REFERENCES:

This Section contains references to the following documents. They are a part of this Section as specified and modified. In case of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.

Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, whether or not the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
IEEE 519	Recommended Practices and Requirements for Harmonic Control in Electric Power Systems
NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1 through 10	Industrial Control and Systems
NFPA 70	National Electrical Code (NEC)
UL 508 C	Standard for Safety for Power Conversion Equipment

B. INDUSTRY STANDARDS:

The VFD shall comply with the applicable requirements of NEMA ICS 3 and 7 and additional standards referenced therein.

C. REGULATORY AGENCY APPROVALS:

The VFD shall comply with requirements of NEC and UL. All VFD's provided shall bear a UL 508 C label acceptable to the inspection authority having jurisdiction.

1.3 PRODUCT HANDLING

Where necessary to ensure against shipping damage, electronic assemblies or other fragile parts shall be removed from the VFD assembly and packed in suitable protective containers.

1.4 CONTRACTOR SUBMITTALS

A. Submittals shall be provided as specified in Section 01 33 00 – CONTRACTOR Submittals, and shall include the following:

1. A copy of this specification Section, with addendum updates included, and all referenced and applicable Sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.

2. Catalog and technical data indicating the equipment meets the specifications. Include information sufficient to verify that the VFD Supplier has met the specified functional requirements for the equipment specified in this Section and ascertained the equipment spatial requirements based on these requirements. This shall include panel layout drawings of the VFD's.

3. Include motor data sheets from the driven equipment suppliers with all information required to verify that the VFD's are coordinated with the specific requirements of each driven equipment application.

4. A copy of the contract document control diagrams and process and instrumentation diagrams, with addendum updates that apply to the equipment in this Section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required." Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

5. External connection diagram showing function and identification of all terminals requiring field connections.

6. Individual harmonic currents at input to VFD as a percentage of the fundamental for all through the 49th.

7. VFD cabinet layout drawings, showing the front, side and top views, and installation dimensions and anchor holes.

8. Product Data:

   a. Applicable operation and maintenance information including safety precautions, startup, operation, and shutdown procedures.

   b. Preventive maintenance instructions.

   c. Step by step troubleshooting and diagnostic techniques to promptly isolate the cause of typical malfunctions including descriptions of the procedure and conditions being sought.

   d. Bill of material listing all components including manufacturer's catalog numbers.

   e. Component fabrication drawings consisting of detailed circuit schematics, wiring diagrams, printed circuit board drawings, and chassis layouts for all electrical and electronic components.

   f. Manufacturer's certification that controller can withstand fault conditions specified in paragraph 1.01 F.2 of this Section.

   g. Manufacturer's certification that VFD can withstand environmental conditions specified in paragraph 1.01 E.3 of this Section.

   h. Installation and replacement instructions.

   i. List of recommended spare parts and supplies required for maintenance and repair.

   j. Manufacturer's certification that the equipment has been properly installed, aligned, and tested; and meets all requirements for satisfactory performance under the conditions specified.

   k. Manufacturer's instruction certification that instructions to operators have been completed.

I. Configuration parameters set up in the VFD.

1.5 SHIPPING AND STORAGE

The equipment shall be protected during shipping and storage as specified in Section 01 71 13 - Mobilization.

PART 2 -- PRODUCTS

2.1 ACCEPTABLE PRODUCTS

The VFD's shall be from one of the following manufacturers. The Owner prefers the manufacturer to be the same manufacturer of the motor control center specified in Section 26 29 00:

1. ABB;
2. Allen-Bradley;
3. ASI Robicon 454GT;
4. Siemens;
5. Clean Power.

2.2 ENCLOSURES

A. GENERAL:

Unless noted otherwise on the Drawings or these specifications, variable frequency drives shall be mounted in NEMA 12 MCC suitable for floor mounting as specified in Section 26 24 19.

2.3 VARIABLE FREQUENCY DRIVE

A. GENERAL:

Controller shall include the following assemblies:

1. Disconnect switch/circuit breaker
2. Line fuses or circuit breaker
3. Rectifier
4. DC bus filter
5. Inverter
6. Control processor
7. Thermal or electronic overload protection.
8. Output reactors as specified.

B. DISCONNECT SWITCH AND FUSES/CIRCUIT BREAKER:

A door interlocked fused disconnect switch or circuit breaker shall be provided in the enclosure to protect the converter against internal faults and as a backup for external load faults. Load faults shall normally be cleared by the inverter assembly. Disconnect assembly shall be rated for 42,000 A RMS symmetrical fault duty. The fuses or circuit breaker shall be selected as required to meet the UL 508 C listing requirement for the drive assembly in the proposed configuration. In addition, the overall assembly shall be designed to meet the requirements of NEMA ICS 7.1.

C. RECTIFIER:

The rectifier shall be uncontrolled full-wave silicon diode bridge.

D. DC BUS FILTER:

Filter shall include series inductive (dc link reactor) and shunt capacitive components to smooth the rectified wave form, and for reduction of the input line harmonics distortion.

E. INVERTER:

The inverter shall utilize volts/hertz control with programmable boost at low frequencies. Inverter shall be IGBT type with programmable carrier frequency initially set at not more than 4 kHz.

F. OVERLOAD PROTECTION:

Provide 3-phase motor overload protection in conformance with NEC requirements.

G. OUTPUT FILTERS:

Output filtering shall be provided as required to meet the maximum peak voltage and rate-of-rise limitations at the motor specified in this Section and shall be based on the characteristics of the VFD's supplied and the VFD to motor distances. Where output line reactors are required, but lead to an increase in the drive panel width beyond the space allocated on the Drawings, reflected wave reduction devices shall be provided as an alternative. These devices shall be furnished in NEMA 4X stainless steel enclosures with any required overcurrent protection included. CONTRACTOR shall be responsible for installation and connection and all associated costs shall be included under this Section.

2.4 PROGRAMMING PANEL:

Each VFD at 30kW and above shall have an interactive programming panel and HMI to permit set-up and adjustment of all VFD tuning parameters, indicate fault condition, permit manual monitoring and control of drive, and display the following operating parameters:

1. Motor speed in r.p.m.
2. Motor voltage
3. Motor current
4. Percent torque

The programming panel shall be mounted on the door of the VFD enclosure.

2.5 SPARE PARTS

The VFD manufacturer shall furnish one complete set of all components as spare parts for each size of controller supplied. The spare parts shall be labeled and packaged in a sturdy container suitable for storage. As a minimum, the spare parts shall include:

1. One set of 3 of each type power fuse
2. One set of 12 of each type control fuse
3. One main control board
4. One rectifier module of each size provided
5. One inverter module of each size provided
6. One inverter base controller module.
7. One spare option card of each type used
8. One reflected wave trap device if used

PART 3 -- EXECUTION

3.1 COORDINATION

Provide a fully coordinated drive system in accordance with the following:

1. It shall be the joint responsibility of the CONTRACTOR and the VFD Supplier under this Section to coordinate the VFD equipment requirements with the driven equipment in the bidding phase. The CONTRACTOR shall be responsible for ensuring that the driven equipment suppliers understand the importance of providing accurate equipment sizing information to VFD Supplier and the VFD Supplier shall ensure that the CONTRACTOR understands the information necessary for bidding their package.

2. The CONTRACTOR shall be responsible for coordinating the transfer of submittal information between the driven equipment suppliers and the VFD Supplier in a timely manner after notice to proceed. The CONTRACTOR shall assess the overall schedule impacts for the delivery of this equipment to the project site based on the project schedule analysis and shall establish the requirements and project timelines for submittals, manufacture, testing and delivery. It shall be the CONTRACTOR's responsibility to effect a contract for delivery of the equipment under this Section that can be coordinated with the overall contract construction sequence.

3. The VFD Supplier shall be responsible for ensuring the VFD's meet the performance requirements of the driven equipment based on the information provided. The VFD Supplier shall provide verification that this coordination has taken place by including the necessary driven equipment submittal information in their submittal package.

3.2 FACTORY TESTING AND DRIVE CONFIGURATION:

The VFD systems included under this Section shall be fully configured and debugged at the VFD Supplier's location prior to delivery to the project site. This shall include testing of all the input and output functions. Configuration parameters shall be based on recommendations from the driven equipment suppliers and the OWNER. Product information as specified in Section 1.4 of this specification shall be furnished to the OWNER prior to drive testing. The OWNER shall reserve the right to witness the factory testing. A minimum of three weeks advance notification shall be given in written form to the OWNER prior to testing.

3.3 START-UP AND FIELD TESTING

The VFD Supplier shall provide supervision during installation and startup service for all VFD's. The service shall include inspection, final adjustments of configuration settings, operational checks, functional checks of all spare parts and a final report for record purposes. Each variable frequency drive shall be inspected and tested by factory-trained service technicians in accordance with the manufacturer's specifications and approved test procedure. A minimum of one day per VFD supplied shall be included for field start up and testing services. Final O&M documentation shall reflect any modifications made during this period. Startup and field testing shall also include any necessary coordination with the driven equipment supplier for VFD configuration tuning and adjustments that may be required for optimization and protection of the equipment.

3.4 TRAINING

One four hour session of basic operation and maintenance training covering all sizes of controllers supplied shall be provided. Training shall be coordinated with the OWNER and shall be performed by a factory trained service technician at the plant site.

3.5 INSTALLATION

VFD systems furnished under this Section shall be installed per the manufacturer's requirements.

- END OF SECTION -

SECTION 26 31 00 – SOLAR POWER SYSTEMS, GRID-TIED

PART 1 -- GENERAL

1.1 SUMMARY

A. Requirements for complete solar power generation system, including solar panel array, power inverter, and necessary accessories required for a functional operating system.

B. Solar panels shall be mounted on top of the hatchery building.

C. Solar power system shall be tied to existing grid service. Solar power output shall shutdown upon loss of utility voltage.

D. Solar power system shall be provided and installed by a factory authorized and certified seller or installer.

1.2 DEFINITIONS

A. Electrical and electronic terms: unless otherwise specified or indicated, terms used in these specifications, and on drawings, are those defined by IEEE SP1122.

B. Definitions listed in the current National Electrical Code (NEC), Article 690.

1.3 REFERENCE STANDARDS

A. References:

IEC 60721-2-1 Classification of environmental conditions

IEC 61215 – Crystalline Silicon Photovoltaic (PV) Modules

IEC 61730 – Photovoltaic (PV) Module Safety Qualification

IEEE 1262 – Recommended Practice for Qualification of Photovoltaic Modules

NEC Article 690

UL 1703 - Standard for Flat-Plate Photovoltaic Modules and Panels

UL 1741 – Inverters, Converters, and Controllers for use in Independent Power Systems.

1.4 SUBMITTALS

A. Pursuant to the Review Procedure, the Contractor shall submit per the approved scheduled the following:

1. Shop Drawings:

   a. Drawings indicating the following:

1) Equipment and material list, with clearly indicated make and model.

2) Nameplate ratings for each component used in the solar installation.

3) Overall dimensions of solar array.

4) Terminal box location and size of terminals.

5) Arrangement and dimensions of accessories.

6) Factory supplied installation and maintenance instructions.

7) Front and plan view of all electrical panels and disconnects.

8) Site map showing solar array footprint.

b. Schematic Diagrams

c. System Wiring Diagrams

d. Site map showing solar array footprint.

e. Drawings shall be provided in AutoCAD format in a BPA and Yakima Tribe title block format.

2. Manufacturer's recommended list of spare parts.

3. Factory supplied installation and maintenance instructions.

B. Pursuant to the Review Procedure, the Contractor shall submit site tests results of installed electrical systems and instrumentation no later than 7 days after tests took place.

1.5 DESIGN AND PERFORMANCE REQUIREMENTS

A. Solar Panels

1. Certified to UL 1703 – “Flat Pate Photovoltaic Modules and Panels”.

2. Minimum of 25 year linear performance warranty with maximum performance degradation of 0.7% per year.

3. To have rated power output under Standard Test Conditions (STC) such that total system DC output is minimum 100 KW, maximum 110 KW.

4. Panel modules must be constructed of crystalline silicon.

B. AC Inverter

1. Certified to UL 1741, IEEE 1571, and IEEE 1571.1 standards.

2. Shall be transformer-less string inverters with three-phase 480 VAC output.

3. Rated for 1000 VDC input.

4. Compatible with Rapid Shutdown (RSD) equipment.

5. Minimum peak efficiency of 98.5% and minimum CEC efficiency 98%.

C. Rapid Shutdown Devices.

1. Minimum of one rapid shutdown device per MPPT input installed within 10 feet of the solar panel array(s).

2. Remote rapid shutdown controller (RSC) shall be installed within the hatchery building electrical room within reasonable proximity to electric service disconnect.

3. RSC shall have status output to report to hatchery control system.

1.6 QUALIFICATIONS

A. Manufactures of the equipment shall have designed and manufactured similar equipment for a minimum of 10 years. When requested, an acceptable list of installation with similar equipment shall be submitted.

B. ISO 9001 certified.

1.7 OPERATION AND MAINTENANCE MANUALS

A. Provide in accordance with section 01 33 00 – Contractor Submittals.

B. Operation and maintenance manuals shall include the following information:

1. Instruction books.

2. Recommended renewal parts list.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Equipment shall be factory assembled and tested, and delivered and stored in accordance with manufacturer's instructions.

B. If equipment is shipped in sections, all interconnecting wiring shall be pre-cut and labeled for field connection.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Equipment shall be certified by all referenced standards.

2.2 SOLAR PANELS

A. Arranged electrically in six 5x11 arrays for a total of 330 solar panels. Net output voltage to be 348 VDC and 48 ADC per array.

B. Solar panel surface area to be approximately 20.6 ft^2, with each array area approximately 1132.7 ft^2.

C. Individual solar panel ratings as follows:

1. Open Circuit Voltage: less than 40 V

2. Short Circuit Current: less than 10 A

3. Module efficiency at least 16.29%

D. Accessories: Features and accessories shall include:

4. Compatible with “Top-Down” and “Bottom” mounting methods.

5. 113 psf minimum rated snow load.

2.3 AC Inverters

A. Maximum AC power output limit of 100 Kw

B. Single inverter is preferred, however multiple inverters is acceptable provided they are paralleled and functionally operate as one inverter.

C. Inverter arrangement set up for 3-zone maximum power point tracking (MPPT)

D. Accessories: Features and accessories shall include:

1. Remote monitoring and control

2. RS485, ModBus, and/or Ethernet protocols.

3. 1 inch conduit knock outs

PART 3 -- EXECUTION

3.1 FACTORY TESTING

A. All equipment shall be tested in accordance with the latest version of IEC, ANSI, and NEMA standards.

3.2 FIELD QUALITY CONTROL

A. Provide services of a qualified electrical worker to assist in the field installation, testing, and termination.

B. Submit six hard copies of the manufacturer’s field startup report and in PDF format.

3.3 MANUFACTURER’S CERTIFICATION

A. A qualified electrical worker shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer’s recommendations.

B. Submit six hard copies of the manufacturer’s representative’s certification and in PDF format.

- END OF SECTION –

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SECTION 26 07 00 – STANDBY GENERATORS

PART 1 -- GENERAL

1.1 SCOPE

A. In accordance with the specifications contained in this section and as shown on the engineering plans, the Contractor shall design, furnish, install and commission one 800-kW diesel fueled, backup standby generator, to include the generator starting systems with batteries and charger, disconnect switch, electrically operated automatic transfer switch (ATS) in a single enclosure as depicted on the engineering plans. The generator, with day-tank, shall be installed outside as shown, with the ATS and associated control cabinet and accessories located in the Hatchery electrical room as indicated.

1.2 REFERENCE DOCUMENTS

A. Specifications

1. Specifications General Conditions

B. Drawings

C. CODES AND STANDARDS

1. Generally, the latest editions of the following codes and standards are used in the design, selection of equipment, materials and installation procedures:

a. ANSI American National Standards Institute

b. National Electric Code NFPA 70.

c. NFPA 30 Flammable and Combustible Liquids Code

d. NFPA 37 Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines

e. NFPA 54 National Fuel Gas Code

f. NFPA 110 Standard for Emergency and Standby Power Systems

g. IEEE 142 Grounding of Industrial and Commercial Power Systems

h. NEMA MG1-1998 part 32. Alternator shall comply with the requirements of this standard.

i. UL1236 - Battery Chargers

j. UL508. The entire control system of the generator set shall be UL508 listed and labelled

1.3 DESIGN REQUIREMENTS

A. Overview

The General Contractor shall supply and install:

(a) Single standby generator with 12 hour operating day-tank;
(b) Diesel fuel tank, with 4-20 mA fuel level output signal scaled to indicate remaining fuel within the tank;
(c) Generator controls and ATS controls;
(d) Generator disconnect switch, as indicated on the engineering plans;
(e) Necessary wire, cable, conduits and supports.

Each standby generator shall include:

(a) Diesel fuel operated engine-generator.

(b) Self-contained, weather-proof, fire rated, sound attenuated enclosure,

(c) Control panel, complete with local controls and Local/Remote selector switch

(d) Main circuit breaker,

(e) Starting battery and charger

(f) Exhaust system complete with silencer

(g) Generator ventilation and cooling system complete with radiator, fans, pumps and jacket water heaters

(h) All other equipment and facilities required for outdoor use.

(i) Above-ground diesel fuel storage vessel (sized for minimum 12 hour full loading operation), piping, valves, from the tank to the standby generator.

1.4 General Requirements

The contractor shall ensure that the diesel prime mover is sized to adequately power the alternator.

A. Standby Generators

Standby generator shall be capable of providing power to power the emergency loads within the hatchery building, surface water intake pumps, ground water pumps, and chiller system, for a continuous 12-hours of operation starting with a full fuel storage tank. The Generator package shall include.
(a) Generator and controls

(b) Generator circuit breaker

(c) Fueling system piping

(d) Engine starting battery and charger

(e) Vibration isolators

(f) Engine silencer

(g) Start input circuit allowing a dry contact relay to initiate operation

(h) Discrete and analog (4-20 mA) output circuits to provide operational status

1.5 Enclosure and Layout

A. Each standby generator shall be housed in a self-contained fire rated outdoor enclosure that shall be acoustically designed per NFPA 110 so that the measured peak sound level shall not exceed 85 dBA radially at one meter from the engine exhaust pipe and the enclosure at any time.

B. The standby generator shall be cooled by air flow or use of radiators mounted on the enclosure.

C. The generator, engine, and all auxiliaries shall be mounted on a common skid in accordance with the specified seismic anchoring and restraint requirements. Connections to the engine shall be with flexible couplings.

D. A containment area, for engine oil, around standby generator shall be provided.

1.6 Performance Requirements

The standby generator shall meet the following performance requirements:

(a) The standby generator shall have a Standby power rating for emergency power applications where:

(i) power is supplied for the duration of 24 hours,

(ii) where no utility parallel operation is permitted under the rating,

(b) The standby generators shall meet the requirements of both:

(i) NFPA 110-2005 (Chapter 4, Section 4.2 – 4.4), shall be a Class 24, Type 60,
Level 1 (Plant 1) and Level 2 (Plant 2), and

(ii) IBC clause 3008.16 Electrical Power, Type 60 / Class 2/ Level 1 Standby power

1.7 ELECTRICAL REQUIREMENTS

A. Standby alternator ratings:

(a) 460/277 VAC, three phase, 60 Hz, 8 0 0 kW at a minimum power factor of 0.8.

(b) Generator neutral shall be solidly grounded.

(c) All insulation system components shall meet NEMA MG1 temperature limits for Class H insulation system. Actual temperature rise measured by resistance method at full load shall not exceed 80 degrees Centigrade.

The control system shall maintain the voltage within ±1% under 0 to 110% steady state load conditions and the frequency within ±1% at steady state operation. The frequency regulation from no load to full load (step load) shall not exceed 10%.

1.8 Breaker and Controls

The standby generator circuit breaker and controls shall be housed inside the standby generator enclosure and shall be readily accessible from the exterior of the enclosure. A local engine control panel shall be mounted inside the enclosure which shall include status and alarm indication and an emergency stop pushbutton. Emergency stopping of the standby generator shall cause the engine to shutdown immediately and shall not allow for a cool down period.

The following I/O shall be associated with the standby generators.

#	Description	Type	Connected Device
1	Generator Start and Stop	Digital inputs	Automatic Transfer Switch
	Generator Emergency Stop	Digital inputs	Plant Controller
2	Alarms & Status		
	(a) Running	Digital output	Plant Controller
	(b) Trouble	Digital output	Plant Controller
	(c) Fail	Digital output	Plant Controller
	(d) Low fuel level	Digital output	Plant Controller
	(e) Low oil pressure	Digital output	Plant Controller
	(f) High oil temperature	Digital output	Plant Controller

#	Description	Type	Connected Device
	(g) Low oil level	Digital output	Plant Controller
	(h) High coolant temperature	Digital output	Plant Controller
	(i) Low coolant level	Digital output	Plant Controller
	(j) High bearing temperature	Digital output	Plant Controller
	(k) deleted	deleted	deleted

	(l) Over speed	Digital output	Plant Controller
	(m) Over cranking	Digital output	Plant Controller
	(n) Battery failure	Digital output	Plant Controller
	(o) Charger failure	Digital output	Plant Controller

Each generator shall be provided with a local control panel that shall include the following devices.

(a) manual/auto selector switch

(b) start/stop pushbuttons

(c) emergency stop pushbutton

(d) running indication

(e) trouble indication

(f) test indication

(g) fail to start

(h) fault reset

(i) panel lamp test

1.9 Construction

The engine-generator set shall be mounted on a steel base to maintain alignment between components. The base shall incorporate a battery tray with hold-down clamps within the rails

All switches, lamps, and meters in the control system shall be oil-tight and dust-tight, and the enclosure door shall be gasketed. There shall be no exposed points in the control (with the door open) that operate in excess of 50 volts.

1.10 Connections

The generator set load connections shall be composed of silver or tin plated copper bus bars, drilled to accept mechanical or compression terminations of the number and type as shown on the drawings. Sufficient lug space shall be provided for use with cables of the number and size as shown on the drawings.

Power connections to auxiliary devices shall be made at the devices, with required protection located at a wall-mounted common distribution panel, which is readily accessible.

Generator set control interfaces to other system components shall be made on a common, permanently labeled terminal block assembly

1.11 Testing

The standby generators shall need to be tested monthly in accordance with NFPA 110. Starting and stopping the standby generator for testing shall be initiated manually at the automatic transfer switch. For testing purposes the automatic transfer switch shall simulate a normal power failure, start the standby generator, and shall not transfer the essential loads unless a real power failure occurs during testing.

1.12 MECHANICAL REQUIREMENTS

A. Fuel Storage

The fuel storage vessel for the standby generator shall store diesel only. The location of the storage tank with respect to nearby buildings and equipment shall be in accordance with the local fire codes, NFPA 37 and NFPA 58, and as indicated on the engineering plans.

The fuel storage vessel shall store enough fuel for the following conditions:

(a) Supply fuel to the standby generator when the fuel consumption rate is at 100% of the electrical design load for a minimum of 12 hours.

The fuel storage vessels shall be equipped with fuel level gages and analog output signal (4-20 mA) indicating fuel level remaining within the tank. The analog fuel level signal shall feed the Hatchery SCADA system.

1.13 Fire Protection

A fire detection system shall detect a fire and shut down the standby generator, and close the fuel supply valve. Since the standby generator shall be enclosed in a fire rated enclosure, a fire suppression system shall not be provided.

PART 2 -- PRODUCTS

2.1 MANUFACTURERS

A. Materials and equipment specified in this section shall be products of:

1. Cummins.
2. Caterpillar
3. Onan Corporation
4. MTU/Detroit Diesel
5. OWNER approved alternative

2.2 SERVICE CONDITIONS

A. Ambient Temperature at Air Intake: 104 degrees F maximum.

B. Ambient Temperature at Engine Generator Set: 104 degrees F maximum.

2.3 GENERAL

A. Rating:

1. Manufacturer shall consider the application's high proportion of VFD controlled loads, as shown in the Oneline diagram, and determine the required standby generator rating called out herein will operate the loads indicated. If Contractor determines a larger generating unit is required, then Contractor shall inform Owner of the size required and supply the larger unit without additional cost to Owner.
2. Minimum Rating: 800 kW, 1000 kVA, 0.8PF, 1800 rpm, based on specified service conditions. Contractor to verify 800 kW is sufficient as stated in paragraph 1 above.
3. Voltage: 480Y volts, three-phase, three-wire, solidly grounded. 60-Hz.

B. Emissions: Engines shall meet emission requirements specified in 40 CFR Chapter I Part 89 for off-highway Internal Combustion (IC) engines.

C. Vibration Design:

1. Use vibration analytical techniques to determine shaft critical speeds, and to develop bearing design and shaft balancing to mitigate vibration.
2. Apply torsional analysis and design to mitigate torsional vibration.
3. Provide vibration dampers mounting engine to frame.

2.4 ENGINE

A. General:

1. Manufacturer's standard design, unless otherwise specified.
2. Engine parts designed with adequate strength for specified duty.
3. For standby rated generators, generator shall startup and transfer load within 30 seconds of start command.

B. Type: Diesel Cycle, 4-stroke type with unit mounted radiator and fan cooling.

C. Starting System:

1. Type: Automatic, using 12-volt or 24-volt battery-driven starter acting in response to control panel.
2. Starter shall be capable of three complete cranking cycles without overheating.
3. Batteries:
   a. Sized as recommended by engine manufacturer.
   b. Lead-acid type.
   c. Capable of providing 15 seconds minimum of cranking current at 0 degree C and three complete 15-second cranking cycles at 40 degrees C.
   d. Housed in acid-resistant frame isolated from engine generator main frame.
   e. Located such that maintenance and inspection of engine is not hindered.
   f. Complete with battery cables and connectors.
   g. Provide battery heater pad.
4. Battery Charger:
   a. UL 1236 listed and labeled.
   b. Charger shall be integral to generator enclosure, per manufacturer's standard.
   c. Charger shall be powered from a 120V, 20A power circuit, to be provided outside of this Section.
   d. Include:
      1) Ammeter and voltmeter.
      2) Fused ac input and dc output.
      3) Power ON pilot light.
      4) AC failure relay and light.
      5) Low and high dc voltage alarm relay and light.
   e. Alarm relay dry contacts rated 4 amps at 120V ac.

D. Fuel System:

1. Engine driven, mechanical, positive displacement fuel pump.
2. Capable of pumping fuel from the storage tank to the engine.
3. Provided with fuel filtration and moisture removal media.

E. Jacket Water Cooling System: Provide manufacturer's standard engine mounted cooling water pump.

F. Block Heating System:

1. Manufacturer shall supply a diesel block heater suitable for heating the engine to a desired temperature within 30 minutes. One 120 VAC, 30 A, circuit breaker shall provide for battery charger and block heater.
2. During cold weather the block heater shall maintain the block temperature at 70 degrees F.

G. Lubrication System: Manufacturer's standard.

H. Exhaust System:

1. Manufacturer shall supply recommended stainless steel, flexible connector to couple the engine exhaust manifold to the exhaust system. A hinged rain cap shall terminate the exhaust pipe after the silencer as shown on the Drawings. All components must be properly sized to assure operation without excessive back pressure when installed. See Drawings for minimum sizes.
2. Exhaust silencer shall be integral to engine generator package.
3. All exhaust piping from the exhaust manifold to the flexible connector fitting or to an elevation of 78 inches above the adjacent mounting pad, whichever is higher, shall be housed with a vented enclosure to guard operators from incidental contact with hot surfaces.
4. Silencer and exhaust piping to be insulated.

I. Air Intake System: Equip with dry type air cleaner with filter service (restriction) indicator.

2.5 GENERATOR

A. General:

1. Meet requirements of NEMA MG 1.
2. Synchronous type, revolving field, drip-proof construction, air cooled by a direct drive centrifugal blower fan.
3. The alternator shall meet temperature rise standards of UL 2200 (120 degrees C). The insulation system material shall be Class H, capable of withstanding 150 degrees C temperature rise.
4. The alternator shall be protected against overloads and short circuit conditions by advanced control panel protective functions. The control panel is to provide a time current algorithm that protects the alternator against short circuits and excessive over currents.
5. At minimum, remote status monitoring for the standby generator shall include "Trouble", "Running", "Fuel Leak", "Low Diesel", and "Ready-to-Start" shall be wired into the Automated Control System for remote monitoring and alarm indication.

B. Voltage Regulation:

1. Type: Manufacturer's standard.
2. Adjustable output voltage level to plus or minus 5 percent.
3. Upon synchronizing with electrical utility, voltage regulator shall operate in power factor or VAR, maintaining power factor of 95% or better or preset VARs.

C. Voltage and Frequency Regulation Performance:

1. Steady State Voltage Regulation: Less than plus or minus 1 percent from no load to continuous rating point.

2. NEMA MG 1 Defined Transient Voltage Dip:
   a. Less than 20 percent at rapid application of rated load.
   b. Recovery to rated voltage and frequency within 2 seconds following initial load application.
3. Steady State Frequency Regulation: Plus or minus 1.5-Hz overload range.
4. Upon paralleling with utility source, frequency regulation ceases and standby generator output is manually adjusted at the UPC Panel.

D. Short Circuit Capabilities: Sustain 300 percent of rated current for 10 seconds for external three-phase bolted fault without exceeding rated temperatures.

2.6 BASEPLATE

A. Mount engine generator set on a rigid common steel base frame, using vibration dampers.

B. Base frame shall be stiffened to minimize deflections.

2.7 INTEGRAL SUBBASE FUEL TANK

A. General:

1. Capacity: Sufficient for continuous minimum 12 hours operation at full load
2. UL 142 listed and labeled.
3. Installation shall be in compliance to NFPA 37.
4. Double-walled, steel construction and shall include the following features:
   a. Emergency tank and basin vents.
   b. Mechanical level gauge.
   c. Fuel supply and return lines, connected to generator set with flexible fuel lines as recommended by engine manufacturer and in compliance to UL 2200 and NFPA 37 requirements.
   d. Normal atmospheric vent shall not be less than 12 ft above adjacent grade, nor located for trapped vapors under eaves, and at least 5 feet from building openings or property lines per IFC 5704.2.7.3.3.
   e. Normal atmospheric or emergency vents shall not be manifolded per IFC 5704 2.7.3.5.
   f. The tank emergency vents shall not vent inside a building or weather housing per IFC 5704 2.7.4.2
   g. Leak detection provisions, wired to generator set control for local and remote alarm indication.
   h. High and low level float switches to indicate fuel level. Wire switches to generator control for local and remote indication of fuel level.
   i. Basin drain.
   j. Integral lifting provisions.

2.8 VIBRATION ISOLATORS

A. Provide vibration isolators, spring/pad type.

2.9 AUTOMATIC LOAD TRANSFER CONTROL

A. Engine generator set shall automatically start and run upon closure of a remote dry contact. Standby generator shall maintain proper voltage and frequency when running isolated from utility power. External switchgear standby generator breaker shall close, loading generator automatically, and shall provide primary protection for downstream faults.

2.10 CONTROL SYSTEM

A. Control System Configuration

1. The generator set shall be provided with a local control panel, mounted inside the set's weatherproof enclosure. These controls shall provide local manual, as well as automatic control functions, including alarm annunciation.

2. A free-standing, automatic transfer switch and control panel shall be provided to transfer emergency loads to standby generator.

B. Local Control Panel, Located at Generator Set:

1. Controls shall be solid-state, microprocessor based. Control panel shall be designed and built by generator manufacturer and shall provide all local operating, monitoring, and control functions for generator set.
2. Control system shall provide integrated digital control over all generator functions, including:
   a. Engine protection.
   b. Alternator protection.
   c. Speed governing.
   d. Voltage regulation.
   e. Air-fuel-ratio control (as required).
   f. All related generator operations.
3. The control system shall provide an environmentally sealed design including encapsulated circuit boards and sealed automotive style plugs for all sensors and circuit board connections. The use of non-encapsulated boards, edge cards, and pc ribbon cable connections are considered unacceptable.
4. Circuit boards shall utilize surface mount technology to provide vibration durability. Circuit boards that utilize large capacitors or heat sinks must utilize encapsulation methods to securely support these components.
5. Diagnostic capabilities shall include time-stamped event and alarm logs, ability to capture operational parameters during events, simultaneous monitoring of all input and output parameters, callout capabilities, support for multi-channel digital strip chart functionality and 0.2 msec data logging capabilities.
6. In addition to standard NFPA 110 alarms, the application loads shall also be protected through instantaneous and steady state protective settings on system voltage, frequency, and power levels.

7. The Control System shall provide pre-wired I/O for OWNER's use: Eight relay outputs (user definable functions), and Modbus communications support via RS232 and RS485.
    a. CONTRACTOR shall provide documentation, a copy of configuration software, administrative level access codes, and programming cable to the OWNER for operations and maintenance.
8. OWNER I/O shall be software configurable providing full access to all alarm, event, data logging, and shutdown functionality. In addition, custom ladder logic functionality inside the generator controller shall be supported to provide application support flexibility. The ladder logic function shall have access to all the controller inputs and OWNER assignable outputs. Other means for implementation of configurable I/O and digital communicatins may be substituted upon approval by OWNER.
9. The control panel shall display all user pertinent unit parameters. At a minimum display the following:
    a. Engine and alternator operating conditions.
    b. Oil pressure.
    c. Coolant temperature and level alarm.
    d. Engine speed.
    e. DC battery voltage.
    f. Run time hours.
    g. Generator voltages.
    h. Amps.
    i. Frequency.
    j. Kilowatts.
    k. Power factor.
    l. Alarm status.
2. Operator Controls (Minimum Required):
    a. LOCAL/REMOTE selector switch.
    b. STOP/AUTO/ENGINE TEST selector switch, or equivalent functionality.
    c. Generator voltage adjustment.
    d. Emergency Stop button (only hardwired E-stop is allowed).
10. External Interfaces:
    a. Furnish interfaces required for connection to remotely located paralleling control panel.
    b. Furnish a single, common DPDT relay output upon occurrence of alarm condition.

2.11 ENGINE-GENERATOR SET ENCLOSURE

A. Engine-generator set shall be furnished with a sound-attenuated, weatherproof enclosure.

1. Minimum 14-gauge steel construction with stainless steel hardware.

2. Wind rating: 150 mph.

3. Removable, or hinged panels shall be lockable and shall provide adequate access to all components requiring maintenance. Provide rain lips above all doors and panels.

4. Sound-attenuated (maximum 85 dBA at 1525 mm (5 feet) from any side, top and bottom to no more than 75 dBA when measured at 15 m (50 feet) horizontally from any part of the enclosure). Sound ratings shall be based on full load condition of engine generator in a single unit operation condition.

5. Airflow configuration shall be intake through rear of unit, and discharge air vertically up.

6. Enclosure shall provide ample airflow for engine generator continuous operation at rated load under maximum ambient air temperature condition.

7. Radiator exhaust outlet shall be ducted through the end of the enclosure.

8. All exterior surfaces shall be factory-painted with industrial enamel.

9. Unit shall have sufficient guards to prevent entrance by small animals.

10. Batteries shall fit inside enclosure and alongside the engine generator. Batteries under the generator are not acceptable.

11. The muffler shall be mounted and thermally-insulated inside the enclosure.

2.12 FACTORY FINISHING

A. Engine Generator Set and Instrument Panel: Factory-applied primer and two finish coats of manufacturer’s standard heat-resistant engine paint.

2.13 FACTORY TESTS

A. General: Conform to NFPA 110.

B. Steady Load Test: Test engine-generator set at steady load run of 60 minutes minimum duration at 100 percent full-rated load.

C. Transient Load Test: Conduct transient load test to demonstrate ability to meet load pickup and load release requirements specified.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Level and securely mount engine generator set in accordance with manufacturer’s recommendations.

B. Install in accordance with NECA 404.

C. Mount engine generator set on vibration isolators in accordance with isolator manufacturer's recommendations.

3.2 FIELD FINISHING

A. Touch up damaged coating with paint system compatible to existing.

3.3 FIELD TESTS

A. General: Conform to NFPA 110.

B. Performance Test:

1. Perform upon completion of installation.
2. Operate 4 hours minimum.
3. Manufacturer's representative shall make necessary adjustments.
4. Demonstrate ability of engine generator set to carry specified loads. If actual loads cannot be used for testing, provide a load bank to simulate at least 80 percent of rated genset capacity for a minimum of four hours.
5. Demonstrate engine generator set safety shutdowns.

C. Test Report: Record and report the following:

1. Electric load on generator.
2. Fuel consumption.
3. Safety shutdown performance results.
4. Output voltage.

D. Post-test Requirements:

1. Make final adjustments.
2. Replace fuel and oil filters.
3. Check belt drive tensions.
4. Demonstrate proper operation of equipment to OWNER or OWNER's Representative.

3.4 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by OWNER, for minimum person-days listed below, travel time excluded:

1. 1 person-day for installation assistance and inspection.
2. 1 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
3. 1/2 person-day for post-startup training of OWNER's personnel.
    a. Training shall include an overview of alarms, software, and instructions on how to modify and configure alarms.

- END OF SECTION -

SECTION 26 50 00 - LIGHTING

PART 1 -- GENERAL

1.1 SECTION INCLUDES

A. Interior and exterior luminaires.

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this Section:

1. Washington State Energy Code.
2. Certified Ballast Manufacturer (CBM).
3. Illuminating Engineering Society of North America (IESNA).
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. Underwriters Laboratories, Inc. (UL):

   a. 595, Standard for Safety Marine-Type Electric Lighting Fixtures.
   b. 924, Standard for Safety Emergency Lighting and Power Equipment.

1.3 CONTRACTOR SUBMITTALS

A. The following shall be submitted in accordance with Section 01 33 00 – Contractor Submittals:

B. Submit the following:

1. Luminaires:

   a. Catalog data sheets and pictures.
   b. Luminaire finish and metal gauge.
   c. Lens material, pattern, and thickness.
   d. Candle power chart 0 to 90 degrees.
   e. Lumen output chart.
   f. Mounting or suspension details.

2. Lamps:

   a. Voltages.
   b. Colors.
   c. Approximate life (in hours).
   d. Approximate initial lumens.
   e. Lumen maintenance curve.
   f. Lamp type and base.

3. Ballasts:

   a. Wiring diagram.
   b. Nominal watts and input watts.

c. Input voltage and power factor.
d. Starting current, line current, and restrike current values.
e. Sound rating.
f. Temperature rating.
g. Efficiency ratings.

1.4 QUALITY ASSURANCE

A. UL Compliance:

1. Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

PART 2 — PRODUCTS

2.1 LUMINAIRES, EMERGENCY LIGHTS, AND EXIT SIGNS

A. See Light Fixture Schedule on Drawing.

B. Include factory furnished installation accessories.

C. Emergency/Exit Lights: per IFC 1006 and 1011.

2.2 LAMPS

A. See Light Fixture Schedule.

2.3 BALLASTS

A. General

1. Meet requirements for fixture light output, reliable starting, radio interference, total harmonic distortion, electromagnetic interference, and dielectric rating.
2. Certified by electrical testing laboratory to conform to Certified Ballast Manufacturer's specifications.
3. Ballasts shall be able to produce reliable starting of lamps at 10 degrees F at 90 percent of nominal line voltage.

B. Compact Fluorescent

1. Type: High power factor, energy efficient, rapid-start type ballast, compatible with lamps specified.
2. Sound Rating: Minimum A, maximum allowable noise level of 30 decibels measured 2 feet from installed fixture.
3. Class: P.
4. Automatic resetting, thermo-protector to prevent case temperature from exceeding 110 degrees C in event of short circuit.

C. Metal Halide and High Pressure Sodium

1. High power factor, normal ambient, 180 degrees C insulation class.

2. Types:

   a. Autotransformer with capacitor and ignitor for lamps 150 watts and less.
   b. Constant wattage autotransformer with capacitor for lamps above 150 watts.

D. LED

   1. Except for flood lights, LED-based lights are not acceptable.

2.4 LIGHTING CONTROL

A. Manual Switch, ON/OFF.

   1. Provide where indicated on Drawings.

B. Manual Switch, AUTO/OFF/MANUAL

   1. Provide where indicated on Drawings.
   2. When the switch is in AUTO position the outdoor lights shall be controlled by photocell. When the switch is in MANUAL position the lights shall be controlled manually.

C. Three-Way Switch

   1. Provide where indicated on Drawings.

D. Occupancy Sensor

   1. Provide occupancy sensor switches in all spaces shown on the lighting plan. Occupancy sensors shall have an adjustable timer unit set at installation and shall shut off lighting power in the event no occupancy is detected.

E. Photocell

   1. Automatic ON/OFF switching,
   2. Shall not be affected by rain, vibration, or temperature changes.
   3. Field Adjustable Settings: ON at dusk and OFF at dawn.
   4. Time delay feature to prevent false switching.
   5. Provide for all exterior wall mounted lights.
   6. Mount in location not affected by lights

F. Lighting Control Panel

   1. Lighting Control Panel shall have low voltage (0-10V) control capability for at least six zones of lighting.

   2. Control panel, with required accessories, shall have at least six switching relays or modules capable of switching and dimming 120 or 277 volt power to the lighting fixtures.

3. Lighting control panel shall be mounted as in a weatherized NEMA 4 enclosure with a clear plastic or glass window or door to allow for visual access to the front panel. Easy access to the panel shall be provided to the control panel which does not require a hand tools.

4. Provide dimming interface modules as required which are compatible with control panel to meet dimming requirements. Modules must be designed for operation with LED lighting, employing a standard 0-10 VDC input dimming control function.

5. Lighting control panel shall be Lutron QSGRJ Control Unit, using dimming modules GRX-TVI Ten Volt interface modules, or approved substitution.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Install and adjust fixtures, lamps, ballasts, fuses, receptacles, and photoelectric units in accordance with manufacturer's recommendations.

B. Provide proper hangers, pendants, and canopies as necessary for complete installation at locations indicated on Drawings.

C. Install plumb and level. Mounting heights shall be as shown.

D. Install each luminaire outlet box with galvanized stud.

3.2 EMERGENCY LIGHTING UNIT AND EXIT SIGNS

A. Install in accordance with manufacturer's recommendations.

B. Provide permanent circuit connections with conduit and wire.

C. Connect to branch circuit feeding normal lighting in area ahead of all local switches.

3.3 CLEANING

A. Remove labels and markings, except UL listing mark.

B. Wipe luminaires inside and out to remove construction dust.

C. Touch up all painted surfaces of luminaires and poles with matching paint ordered from manufacturer.

- END OF SECTION -

SECTION 27 26 00 – SCADA AND AUTOMATION

PART 1 -- GENERAL

1.1 SCOPE OF WORK.

A. CONTRACTOR to provide a facility wide Supervisory Control and Data Acquisition (SCADA) system with a central Human-Machine-Interface (HMI), as specified herein. CONTRACTOR shall employ a qualified integrator/engineer experienced with HMI software programming, logic controls, VFD programming, Ethernet Control Networks, and configuring data historian applications.

B. CONTRACTOR shall design, fabricate and deliver standalone controllers for the Surface Intake Water Pumps, Surface Water Booster Pumps, Energy Recover Pumps, USBR Diversion Controller, and all others as shown on the engineering plans and/or specified herein, and integrate them into the SCADA system.

C. CONTRACTOR to integrate all third party vendor supplied control and monitoring systems, into the facility wide HMI scheme, networking on the Ethernet control network where possible, and alternatively using discrete I/O or Modbus serial interfaces.

D. CONTRACTOR shall coordinate its work with the OWNER and any other contractor hired by the OWNER performing work in or near the Project site.

1.2 QUALITY ASSURANCE

A. The SCADA/HMI system and standalone controllers shall be designed and fabricated in accordance with the following standards listed in sections B through E, below:

B. National Electrical Manufacturers Association (NEMA):

250, Enclosures for Electrical Equipment (1000 Volts Maximum)

AB 1, Molded Case Circuit Breakers and Molded Case Switches.

ICS 2, Industrial Control Devices and Systems: Controllers, Contactors, and Overload Relays Not More than 2000 volts ac or 750 volts.

WD 1, General Requirements for Wiring Devices.

C. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC)

D. Underwriters Laboratories, Inc. (UL):

486E, Standard for Safety for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors

489, Standard for Safety Molded-Case Circuit Breakers, Molded Case Switches, and Circuit Breaker Enclosures

508, Standard for Safety for Industrial Control Equipment

E. Instrumentation, Systems, and Automation (ISA) Standards and Guidelines

ISA-82.03-1988 Safety Standard for Electrical and Electronic Test, Measuring, Controlling, and Related Equipment.

ISA-84.00.01-2004 Parts 1-3 Functional Safety: Safety Instrumented Systems for the Process Industry Sector - Part 1: Framework, Definitions, System, Hardware and Software Requirements.

ANSI/ISA-61804-3 (104.00.01)-2007 - Function Blocks (FB) for Process Control - Part 3: Electronic Device Description Language (EDDL).

ANSI/ISA-TR61804-4 (104.00.02)-2007 - Function Blocks (FB) for Process Control - Part 4: EDD Interoperability Guideline

ANSI/ISA-62381-2011 - Automation Systems in the Process Industry - Factory Acceptance Test (FAT), Site Acceptance Test (SAT), and Site Integration Test.

ANSI/ISA-62382-2012 (IEC 62382 Modified) - Automation Systems in the Process Industry - Electrical and Instrumentation Loop Check.

1.3 Hatchery Equipment and Systems

A. Introduction

Hatchery facilities will include a hatchery building for incubation, early rearing and grow-out, hatchery water re-use modules, outdoor adult holding ponds, a shop building, three new residences, an effluent clarifier, nine groundwater wells and pumping systems, a surface water diversion, sump and pumping system, modification of the existing Cascade bypass, and additional work associated with achieving a functioning Coho smolt hatchery.

B. Cascade Intake and Fish Bypass

The USBR owns and operates the New Cascade diversion structure located upstream from the hatchery project. Surface water will be diverted to the side channel and then flow south to the hatchery. The project will require some control of the diversion gates to ensure proper water supply is provided. The project SCADA system will be extended to the Diversion facility and interfaced with the existing diversion gate controller. A local micro PLC and instrumentation, connected to the Hatchery SCADA system via a cellular wireless modem, will be installed by Contractor to allow remote operation of the gate.

Through SCADA, the Operator will be able to issue manual commands to local PLC to open or close the gate, and the PLC will manage actual gate movement. Instrumentation and gate position will be sent back to SCADA from the local PLC.

C. Surface Water Intake System (SP-201 & SP-202)

Diverted water from the New Cascade bypass flows south through the side channel to a new surface water diversion structure. This new diversion will supply up to 6 cfs of surface water to the facility from November through March when irrigation water flows are shut off. The remaining 4 cfs of surface water right will continue to flow through the side channel, providing instream flows for fish.

Diverted water is routed through a cone screen to an 8-foot-diameter concrete sump (or wet well). Water is pumped from the sump to a small well house located directly above the sump, housing two pumps (SP-201 & SP-202), instrumentation, and VFD based control panel. Water pumped from the sump is then routed to the hatchery building.

The two surface water pumps will operate automatically to maintain water pressure on the outlet side of the pumps. One pump will run at a time, with the second pump providing an automatic back if the primary pump fails. The local controller will be a single control panel with two VFDs to operate the pumps. The outlet pressure will be measured using independent pressure transducers, which the pumps will use to maintain a set pressure range. Each VFD will be networked to the Hatchery SCADA system, allowing the Operator to set the operating pressure range through the HMI.

For well and pump protection, a level sensor shall be provided in the sump and used to throttle back the surface water pump to prevent drying of the sump. The operating level range will be settable through the SCADA system.

SCADA will monitor all VFD system status and alarms, sump water level, and outlet pressure, through digital communications with the VFDs..

D. Booster Pumps (SP-203, SP-203, SP-205)

Pumped surface water is split and flows in two directions; one to the Adult Holding Pond (AHP) and the other to the surface water treatment area within the hatchery building. Flow meters FM-200 and FM-220 shall be monitored by SCADA, with FM-200 providing total surface water flow, FM-220 flow to the AHP, and the difference of the two flows indicating flow to the Hatchery Surface Water Supply Treatment (MS-200),

Flow to the Hatchery is throttled manually by the operator using V-210 and to the AHP using V-220. Flow from V-210 is filtered by the microscreen drum filter MS-200. Booster pumps SP-203, SP-204, and SP-205 pump water from MS-200 sump and is operated to maintain a set set pressure output, with an sump level sensor to supervise and prevent pumping the sump dry. A single three-VFD controller, as indicated by the engineering plans, provides booster pump control. One pump is designated as primary and another as secondary, with the third pump remaining as a manually operated standby.

The booster pump controller operates one pump at a time, and upon failure of the primary, the secondary pump will automatically start and shut down the primary. The sump will be instrumented with a sump level sensor and output pressor sensor feeding all pumps. The operating pump shall maintain a constant (settable) water pressure on the pump outlet. Each VFD shall be connected to the Hatchery SCADA system, allowing Operator to set the sump operating output pressure and minimum sump water level, as well as monitor the booster pump operation.

E. Adult Holding Pond (AHP)

Water flowing to the AHP is throttled manually by the operator, from the surface water pump supply. Operations at the AHP is strictly manually, however water level and flow as indicated shall be monitored by the Operator. Operator shall set alarm points for water level and flow, with the SCADA system initiating an alarm condition if flow or level fall outside the selected range.

F. Ground Water Pumps (GWP-101 through GWP-109)

Up to nine ground wells will be outfitted with pumps to supply ground water to the hatchery. Each ground well supply line is equipped with a flow meter located within the hatchery building. Each ground well pump is operated by a dedicated VFD located in the hatchery building main electrical room, in the MCC lineup. The VFDs will be networked to the SCADA system to allow the operator to input settings and manually start/stop and set flow.

Each ground well will have a level sensor feeding its VFD. The VFD shall be programmed to throttle back, and shutdown if required, to prevent drawing the well level down below a set point. Set point shall be within the VFD and settable from the SCADA system.

Each ground well pump shall be operated independently of any other, with the operator selecting which combination of pumps to use and set the flow for each through the SCADA system, or locally at MCC lineup.

G. Ground Water Supply Treatment (Vendor Supplied System)

Water from all ground well supplies are combined at a single header and then routed through a UV disinfection unit and then to the chiller system. No SCADA control or monitoring of the UV disinfection is required.

H. Chilled Ground Water Supply (Chiller System)

Water from the UV unit is then chilled in a vendor supplied chiller system. The chiller shall be equipped with a PLC control unit scheme, networked to the SCADA system using Modbus TCP communications. The chiller control settings will be integrated with the SCADA system to allow the operator to make the identical settings through SCADA as available through the local chiller control panel. All alarms and status information available at the local control panel will also be integrated into the SCADA system.

I. Energy Recovery Pumps (ERP-401 & ERP-402)

Spent chilled water from the chiller system shall flow into the Energy Recover pump station provided by the Contractor. The pump station will consist of a sump and two submersible pumps. The pumps shall operate in a primary/secondary fashion, with one pump running at a time, pumping water back to the chiller system at a rate to maintain a settable sump water level. A single two-VFD controller shall be provided as indicated on the plans, to operate the pumps as a primary and automatic secondary pump scheme.

The VFDs shall be networked on the control network and monitored by SCADA. The Operator shall be able to set the sump level set point through SCADA and locally through the VFD control panel.

J. Process Water Reuse Systems (RM-100. RM-200, RM-300 & RM-400)

Four process water reuse modules shall be provide as indicated by the engineering plans. Each reuse module will be configured as either a two tank or three tank scheme, provided by a specialty vendor contracted by the Contractor. Operation of the reuse modules will be controlled through the Pentair LC-10 Control Panel. Contractor shall install the Pentair provided reuse modules and LC-10 controllers as designed, consisting of a package system of circular tanks, reuse pumps and VFDs, instrumentation, other miscellaneous controllers, and centralized controllers called the LC-10.

K. Pentair LC-10 Control Panel

Three LC-10 controllers will be provided, to operate the Pentair reuse modules and other equipment, with each dedicated to various systems as indicated on the engineering plans. Each LC-10 will be networked to the SCADA system, with the SCADA system programmed to retrieve status and alarm information, as well as allow operator to make setting changes to the LC-10 systems, as can be performed at the LC-10 control panel.

L. Instrumentation

Miscellaneous Contractor suppled instrumentation shall be connected to the SCADA system through the networked I/O bricks as indicated on the plans, allowing SCADA to monitor, display, and log the various instrumentation data.

1.4 SCADA-HMI Overview

A. Introduction

The MRS hatchery will first and foremost be operable manually without a functioning SCADA system. Individual controllers, VFDs, and standalone equipment will have local control panels allowing operators to manually adjust flow and other settings locally. The lack of an operable SCADA system deprives operating personnel of a central location where all facility status information is displayed, along with loss of data logging functions. In some instances, discrete instrumentation information where no local display is available, will not be available to the hatchery personnel.

The facility SCADA will be comprised of a set of distributed I/O brick/cabinets, with network switches, for distributing the network and digitizing standalone instrumentation, interfacing discrete signal interfacing with vendor equipment, digital linking vendor supplied and standalone PLC or digital controlled systems, all standalone and embedded VFDs throughout the project, and providing a central monitor to display operational information (i.e flow, temperature, water quality, levels, etc), displaying alarm and event data, and initiating an automatic phone dialer command to alert hatchery personnel.

The SCADA system is a tool for hatchery personnel to manually make setting changes to integrated controllers, displaying facility operational data, and logging data for later retrieval and analysis. SCADA itself performs no facility automation functions.

B. HMI PC

1. Hardware

The main SCADA-HMI enclosure will be located in the hatchery electrical room as indicated on the plans. The cabinet will contain the main HMI PC, network devices, terminal blocks, I/O bricks, and accessory equipment. This cabinet will also contain a UPS to provide continuous power to the SCADA PC and network equipment.

The main SCADA-HMI PC and screen will be installed in the SCADA cabinet. The PC shall be a panel mount unit with a 17" color touch screen display running a Windows operating system, as indicated on the plans. The PC shall operate on DC power, have a 240 GB solid state hard drive, and USB ports for connecting a keyboard and mouse. A touch screen PC unit listed on the plans, or approved equal, shall be provided and integrated into the SCADA cabinet.

A remote HMI terminal shall be located in the Hatchery superior office.

2. Wonderware HMI Application

The HMI application shall be developed using Wonderware Intouch and shall run on the SCADA PC described above. The HMI application shall have numerous screens dedicated for special purpose and facility systems. Screens shall consist of color graphics developed to logically display information to hatchery personnel. The screens will be reviewed by the Owner, or Owner representative and approved. CONTRACTOR shall work with Owner to arrange and modify screens to meet Owner and operating personnel needs.

3. Data Historian

A separate data historian application shall be developed and installed on the SCADA PC, using DreamReport for Wonderware. This application runs separate from the HMI application, but interfaces with Intouch to use tags available in INtouch and log the data in separate data files. DreamReport will also provide the ability to retrieve and display logged data.

4. Touch Screen Display

As indicated, the main SCADA PC will have an embedded 17" touch screen display, mounted on the SCADA cabinet front door. A separate fold down keyboard and mouse will be mounted just below the screen, on the outside of the cabinet door. Access to the keyboard and mouse will be available without having to open the SCADA cabinet door. Through panel USB ports shall be embedded in the cabinet door to allow the keyboard, mouse, and operator supplied jump drive to connect to the SCADA PC without having to open the enclosure door.

C. Control Network (Ethernet)

Networking distributed SCADA equipment and vendor supplied systems requires a dedicated and reliable Ethernet network. The control network will consist of network switches (mounted in common I/O brick enclosures) will be linked with multimode fiber optic or Cat 6 cable.

D. I/O Bricks

Modbus I/O bricks will be distributed around the facility to allow analog and discrete signals to be connected and digitized. The I/O bricks will be connected to the control network and be assigned a separate IP address. The I/O bricks will communicate with Wonderware Intouch using Modbus TCP protocol.

E. Serial Modbus Communication

For those digital devices, such as VFDs, which cannot be network directly and assigned a dedicated IP address, they will use serial Modbus (RS485 or RS422) communication protocol. The SCADA cabinet will contain several Modbus gateways to allow daisy chaining Modbus cables out to various devices, allowing the HMI application to communicate with these devices via serial Modbus.

F. Vendor Supplied Systems

There will be many third party standalone control systems (such as reuse modules (LC-10), chiller system, microscreen drum filters, etc.) which must be integrated into the facility SCADA system. This will require either networking the master controllers or interfacing with discrete analog and discrete signals.

G. Instrumentation

An assortment of standalone instrumentation will be provided by the CONTRACTOR, and will include level sensors in each off the ground wells and other locations, flow meters, and other sensors. Each of these will use either discrete or analog (4-20mA) signals and connect to one of the distributed I/O bricks.

H. Solar System

Contractor shall provide the solar panels and inverter as indicated on the engineering plans and as specified elsewhere. The inverter shall be equipped with a means to network to the SCADA system, to allow remote monitoring of alarms and status from the HMI. The solar system inverter shall either have TCP Modbus network or serial Modbus capability.

1.5 SYSTEM ARCHITECTURE

A. The SCADA system shall be configured as described above and shown on the engineering plans.

1.6 CONTRACTOR SUBMITTALS

A. Submittals shall be submitted in accordance with Section 01 33 00 – Contractor Submittals.

B. Detailed control system narrative, including descriptive text with illustrations detailing operations of the SCADA interface and manual control functions. Descriptions shall include, but not be limited to, interface screens with snap-shots, description of any pop up screens, navigation means for getting to various screens, troubleshooting screens dedicated to troubleshooting network and I/O issues, local/remote and automatic/manual operations, pumps on and pumps off, gate raise and gate lower, valve open and valve close, alarm list and alarm explanation.

C. Documented listing of the Wonderware Intouch application.

D. Control network diagram depicting the automated control system devices and addressing schemes, including all directly communicated IP VFD or vendor supplies stand-alone control systems. Device IP address assignments shall be depicted on the diagram. This diagram shall be considered confidential and not widely available to other Contractor employees.

E. List of I/O assignment for each I/O brick, and a short description of the function. The list of I/O assignment shall be provided to OWNER in Excel format.

F. List of alarm points, both discrete and analog, and the range of normal operation as appropriate, provided to OWNER in Excel format.

G. Submit the following shop drawings and manufacturers' data:

1. Control, network, and I/O schematic diagrams.
2. Control, network, and I/O panel outline and layout drawings
3. Control, network, and I/O panel internal layout and wiring diagrams
4. Control, network, and I/O panel internal and external wiring diagrams, showing field termination points.
5. HMI configuration.
6. Bill of materials for all material provided or assembled by the CONTRACTOR
7. Communication block diagram
8. Control and HMI hardware descriptions and configuration layout listing I/O bricks/modules located throughout the facility.
9. Control and HMI software descriptions basic configuration
10. HMI screen display pages
11. O&M manuals
12. All software shall be delivered in hard copy printouts and on two universal serial bus (USB) jump drives.

1.7 SOFTWARE DOCUMENTATION

A. Overview description of the SCADA system configuration and operations relating to control software and HMI application prepared by Contractor's Integrator. Provide explanation for each HMI screen page and how it is to be understood and operated. Include how setpoints can be changed and entered using the HMI to local control systems. Level of details shall be suitable for the technician assigned to operate the equipment under normal conditions. How alarms, current and historical, will be accessible to the operator, and how historical data will be searched and displayed.

B. Printout of HMI coding fully annotated with network numbers and descriptions, addresses of all contacts and coils, I/O numbers, and verbal description of each rung's function or how each function block works. Program shall liberally use subroutines to breakout functions and communications that operate on an interrupt time cycle. The drawings and logic/function code shall correlate by using the same device labeling convention in both HMI application and on the drawings.

C. Two CD copies of software documentation information outlined above.

D. All documentation shall be written in English.

1.8 SYSTEM INTEGRATOR (EMPLOYEE OR SUB) QUALIFICATIONS

Integrator of the automated control system shall be located in U.S.A. and shall be available for direct telephone contact during normal working hours of the OWNER. It is preferred that the Integrator is located within the same time zone as the OWNER (Pacific Time). All communications, verbal or written, between OWNER and Integrator shall be in English.

Integrator shall have specialized experience and knowledge in the design, assembly, testing, installation and service of SCADA-based control systems of a similar scale and complexity to this Project.

1.9 SOFTWARE LICENSE TRANSFER

A. All drawings and documentation shall become the property of the OWNER. All commercial application software (HMI, data logging, alarming, etc.) purchased for the Project shall be licensed in the name of the OWNER and become the property of the OWNER. Any restrictive "revocable use" language or "license to use" terms will not be acceptable. One licensed copy of each commercial development software shall be provided and installed on a Windows based computer or server provided by the CONTRACTOR. This computer or server may be the same computer used as the historian or HMI terminal services computer, provided the computer has the ability to log onto more than one account.

B. Application software, documentation, control algorithms, and programming specifically generated for this Project shall not be copyrighted, encrypted, nor coded, nor be considered "intellectual property" of the designer/supplier. The OWNER reserves the right to use any or all software application developed under this contract in operating, maintaining, updating, or troubleshooting as necessary. OWNER may alter any PLC, HMI, or control application provided by CONTRACTOR as deemed necessary after the Warranty Period has expired.

C. Supplier shall maintain and archive a copy of all PLC and HMI programs as a backup, available to the OWNER, for the life of the system. System updates that may be necessary to enhance program efficiencies or correct program errors shall be provided and installed at no extra cost to the OWNER as soon as such updates are identified and become available.

D. All program updates relating to HMI, PLC, and controls shall be calibrated, debugged, and tested using system simulation equipment at the factory prior to customer delivery.

1.10 TRANSIENT IMMUNITY

A. All electronics shall be immune from false operation or failure from high voltage, high frequency transients which may be conducted in the control circuitry and power supplies. To reduce transients coupled from external sources, shielded cables shall be used for connecting to external low-voltage signals. Surge suppression devices shall be included on all inductive devices. The CONTRACTOR shall assume, however, that high voltage, high frequency transients will persist in the external circuitry. The CONTRACTOR shall isolate these circuits by means of solid state optically coupled or transformer coupled isolation amplifiers.

B. All inductive devices, such as relays and solenoids shall be provided with surge suppression devices to limit surge voltages which may be generated when the coil circuits are interrupted. All electronics shall be designed and tested for surge withstand capability in accordance with IEEE standard 472 (ANSI C37.90a).

C. AC power circuits shall be surge protected to meet the requirements of IEEE 587.

1.11 WARRANTY

A. CONTRACTOR shall warranty the SCADA system functionality for one full year from the date of commissioning, and shall provide technical support to field troubleshoot and correct as required to address any functions which have been specified, or are inherently required to meet specified functionality, that have not been met. This includes software alternations or modifications as well as hardware modifications or changes required. Onsite support, if required, will be coordinated with the OWNER and costs associated with the integration technical support shall be the responsibility of the CONTRACTOR. CONTRACTOR shall not be responsible for costs associated with OWNER employees participating in the troubleshooting and modifying as required.

B. CONTRACTOR shall schedule with the OWNER one full day site visit by the Integrator six months post commissioning to address specific operational requirements and needs of the OWNER. The site visit will allow the OWNER and Integrator to coordinate minor modifications to address minor software application inadequacies to the PLC and HMI, improving and correcting any “bugs”. The intent is to allow “tweaking” of the various applications to address unforeseen or anticipated operational “quirks” which, if addressed, would improve facility operation, flexibility, and safety. OWNER will provide CONTRACTOR and Integrator with a list of functional alterations requested two weeks prior to the site visit.

C. Warranty for all control hardware shall be for two years post commissioning. CONTRACTOR shall bare the expense of any replacement or repair of control hardware that fails to perform within its specification, or fails to meet specified functional requirements, two years post commissioning of the facility. Control hardware selected by the CONTRACTOR which fails to meet specified functional requirements shall be replaced with devices or hardware that will meet the requirements, and shall be physically replaced by the CONTRACTOR at CONTRACTOR’s expense.

PART 2 -- PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Hardware, including that from sub suppliers, which is new, shall be of the highest quality, reliable, complete, tested, fully documented, properly installed, and which has been proven in a power plant environment or industrial environment. All hardware shall be the latest offering by respective manufacturers at the time of bid award.

B. All devices shall be rated for continuous duty. This particularly applies to processors, power supplies, displays, and data storage devices.

C. All components shall be suitable for outdoor operation at temperatures between 10 and 110 degree Fahrenheit. The value of resistors, capacitors, and other passive components shall be marked on the device. Documentation shall be provided for the specific hardware furnished. The intent, operation, and design of the hardware shall be easily understood. Documentation of a general or generic nature is not acceptable. All documentation shall be clear, concise, and complete with references as appropriate.

D. Power Supplies shall be high efficiency switched power supplies rated for at minimum 150% of the final total load placed on the power supply, not the design load. Power supply input and output voltage rating shall be rated as required.

E. Interposing Relays shall be used to protect the I/O brick input and output modules from external shorts. Interposing relays control power shall be sourced by the device operating the relay. Interposing relays controlled by the PLC shall use 24 VDC coils. All interposing relay contacts shall be rated for 120 VAC (10 A) and 24 VDC (5A) minimum. Interposing relays shall be of the socketed type and replaceable without removing any wiring.

2.2 SCADA Network Hardware

A. Network Switches

Network switches shall be Moxa EDS or approved equal. All network switches shall be configured as shown on the plans, and manufactured by the same manufacturer. Mixing of network switches within the control network will not be allowed.

B. I/O Bricks

All I/O modules shall be Moxa ILogix 1200 series or approved equal. All I/O bricks/modules shall be from the same manufacturer and configured as shown on the engineering plans. I/O hardware modules shall include the modules identified on the plans and supplemented by the CONTRACTOR as laid out by the Integrator.

2.3 HUMAN-MACHINE INTERFACE TERMINAL

A. A touchscreen PC embedded in the SCADA cabinet door shall be a iPC-Plus Series Industrial PCs 17.0" SXGA (1280x1024), Intel Quad Core i7-3610QE, 16 GB DRAM, 240 GB SATA Solid State Drive, SATA DVD-R/W drive installed, Windows 7 Professional (32 bit), 24 Volt DC, manufactured by COMARK/Nematron.

B. HMI software shall be the latest version of Wonderware Intouch.

C. Functional Requirements: HMI terminal shall include functions and related screen displays, as follows:

1. Overall Hatchery Status;
2. Ground Water Supply;
3. Surface Water Supply;
4. Surface Water Treatment System, including booster pumps;
5. Pentair LC-10 Control panels (Qty=3) handling all reuse systems;
6. Chiller System, including energy recover pumps;
7. Solar System;
8. Maintenance and troubleshooting screens;
9. Alarm and event logging screen, with alarm history
10. Data Trending:
11. Alarm Messages (System alarms as listed herein and as required by the integration design).

2.4 CONTROL PANEL FABRICATION

A. The SCADA enclosure shall be a stand-alone floor-mounted control cabinet as shown on the engineering plans. Network switch enclosures shall also be configured and assembled as indicated.

B. Individual controllers as specified herein shall be fabricated and supplied as indicated on the engineering plans, and integrated with the SCADA system.

C. Control wiring and termination facilities shall be in accordance with the following requirements:

   1. Provide the required electrostatic and magnetic shielding to reduce noise for low-level signal circuits. Both wiring and instruments associated with low-level signal circuits shall be equipped to provide such shielding.

   2. Instrumentation, communication and transducer cables shall use stranded copper conductors of minimum No. 16 AWG, as specified in Section 26 05 19.

   3. Provide interposing relays to protect the I/O modules input and output channels.

4. All wiring in and out of the control panel shall terminate on high density terminal blocks manufactured by Phoenix Contact or approved equal, fused as appropriate.

5. All spare I/O shall be wired to terminal blocks for future uses.

6. The control branch circuits shall be protected by 250-volt fuses having the required interrupting capacity. All fuses shall be of indicating type.

7. Each branch circuit shall be identified with a nameplate.

8. Provide a copper ground bus with a compression lug at each end for field connection.

9. Provide a separate instrument (signal) ground bus, electrically insulated from the panel and floating, with a single-point ground connection to the ground bus.

10. Provide LED light fixture controlled by door switch for interior lighting.

11. Provide sufficient bending space for external wiring and cables at the bottom of the cabinet.

12. Provide 20% spare terminal block points.

13. Contractor shall prepare and submit for review detail fabrication and layout drawings for each control panel, including a list of bill of materials used and wiring internal diagrams.

D. INSTRUMENT LOOP POWER SUPPLY

1. Provide DC power supplies of sufficient rating required for the level sensors, flow sensors and signal transmitters located external to the control panel and as depicted on the plans. Loop power supplies shall be rated at least 2 times maximum calculated full load current.

E. AUXILIARY RELAYS AND SWITCHES

1. Unless otherwise noted, all relays shall be dust-tight construction and contacts shall have a minimum rating of 125VDC, 5 A. This includes all control, level, pressure, temperature, flow, and limit switches, as well as contacts on relays and other devices.

2. All pushbuttons shall be of the heavy-duty oil-tight type in accordance with Section 26 05 02 – Miscellaneous Electrical Devices.

F. CIRCUIT BREAKERS

1. Internal power distribution circuit breakers shall be provided for AC and DC control circuits.

G. TERMINAL BLOCKS

1. Terminal Blocks for signal and lower power control shall use screw type high density terminals, knife switch or fused, for all internal PLC control cabinet wiring, such as available from Phoenix Contact or approved equal. Source circuits shall use fused terminals or circuit breakers rated for the application. Analog circuits shall use fused terminals to protect field devices. Integrator shall design in each cabinet a minimum of 20% spare terminals or each type when laying out the quantity of terminals required for the application.

2. Terminal blocks for power circuits, 125 VDC and 120/240 VAC: Rated for 600 volts, 20 Amps, molded block type, DIN-rail mountable, screw connected, suitable for 24 – 8 AWG conductors.

3. Arrange the terminal blocks by inputs and outputs for field wiring. Terminal blocks used for internal wiring shall not be co-mingled with external terminal blocks.

4. Manufacturer: Phoenix Contact or approved equal.

PART 3 -- EXECUTION

3.1 FACTORY ACCEPTANCE TESTS

A. Perform factory acceptance simulation testing (FAT), which may be performed on site, to demonstrate as a whole the hardware and software comprising the ACS meets the requirements listed herein, and include the PLC panels, historian, control network hardware, simulated VFD, motor starter operation, and HMI. The FAT shall include at the factory one of the VFDs depicted on the plans and included in the VFD lineup, to verify communication capability between the PLC and VFD. CONTRACTOR shall assemble in the factory the main PLC, all PLC remote chassis, all network switches, Historian, one VFD, all HMIs, and a test computer with necessary application simulating all other non-present field devices.

B. The FAT shall demonstrate the HMI interface and the functionality of the SCADA system and control network. The test computer shall be used to simulate, via communications, field input and output quantities during system testing, which may require interposing tags within the PLC program. The test computer shall have an interface to allow for selecting and setting field device (sensors, motor starters, and VFDs) values feeding SCADA. All HMI screens shall be available during FAT for OWNER inspection and feedback. Simulation shall include VFD drive and motor starter operation.

C. I/O channel testing shall also be part of the FAT, and performed separately and prior to system testing. CONTRATOR shall allow OWNER to witness checkout of all I/O channels by monitoring the HMI maintenance screen and verifying the I/O operation, for all main and remote PLC I/O channels. CONTRACTOR shall apply discrete I/O signals (both analog and discrete) to verify all I/O channels are properly displayed on the HMI maintenance screens.

D. Upon completion of the FAT, CONTRACTOR shall provide OWNER with a report documenting how the function requirements were demonstrated. A copy of the simulation application developed for the FAT shall be provided to the OWNER.

E. Submit test procedures detailing step-by-step test procedures and course of action dealing with failed test items. Submit procedures at least 2 weeks in advance of the scheduled test.

F. Representatives of the OWNER will witness all factory tests. Notify at least 4 weeks in advance of each scheduled test.

G. Shipment of control panels is contingent upon acceptance of the factory test by the OWNER.

3.2 ON-SITE TECHNICAL ASSISTANCE AND CERTIFICATION

A. Provide qualified system integrator during installation and startup of automation and control equipment in accordance with Section 01 75 00 – Startup. Various manufacturer's field service engineers (such as for VFDs, HMI screens, or other provided systems) shall also be provided to assist in assembly, connections, adjustments, programming, software loading and updates, and coordinate field interconnection and testing of all associated equipment and devices provided.

B. Provide the following testing procedures 2 weeks in advance of any site testing:

1. Individualized startup and commissioning procedures for all stand-alone equipment and systems furnished.

2. Provide an I/O and communication tag checkout procedure, verifying all I/O and communications with the PLC are working and correctly assigned.

3. Provide an alarm list checkout sheet to be used during all phases of commission and checkout.

4. Perform individual equipment and stand-alone system checkout under the witness of the OWNER or OWNER Representative.

5. Perform PLC I/O field verification, testing all I/O channels for correct wiring and calibration and communications with network devices, witnessed by the OWNER or OWNER Representative.

6. System wide commissioning and operational checkout shall begin after commissioning and testing of the individual equipment and stand-alone systems, and I/O checkout. Facility wide automation and control verification shall demonstrate system operation in both the manual mode through the HMI and under SCADA control.

7. Submit three copies each of manufacturer's field test reports delineating services provided, calibration and settings, and the manufacturer's certification of installation.

- END OF SECTION -

SECTION 28 23 00 - VIDEO SURVEILLANCE SYSTEM

PART 1 -- GENERAL

1.1 SECTION INCLUDES:

A. Requirements for stand-alone video surveillance system with video terminal and digital video recorder.

1.2 SUBMITTALS

A. The following shall be submitted in accordance with Section 01 33 00 – Contractor Submittals:

1. Manufacturer’s technical data
2. Camera and housing outlines
3. Video terminal details
4. Installation and wiring instruction
5. Programming and operating instructions

PART 2 -- PRODUCTS

2.1 VIDEO SURVVEILLANCE SYSTEM AND CAMERAS

A. Video surveillance system shall be provided to deliver live streaming images of the Hatchery project including hatchery building, shop building, and intake pump house. Number of cameras to be furnished shall be as shown on the engineering plans. The cameras will be mounted on a swivel base, adjusted to the angle of view desired by the Owner, and then secured fixed into position.

B. Live video shall be available over a network connection to the DVR base unit, requiring password login using a standard computer browser.

C. Video cameras shall be dome cameras and shall provide color images using CCD-based image sensor and provide clear images under the existing site condition without extra lighting. Images may switch to black-and-white when available light is low. Image compression shall be jpeg and image size shall be 640x480 VGA, as minimum. Playback shall be at controlled speed or frame-by-frame. Connection of cameras to DVR shall be analog using coax connection.

D. System shall be complete with network interface switch, power supplies, coaxial cables, Ethernet connectors, mounting accessories, camera dome housing. DVR system shall include self-contained network interface and IP address for interface with Hatchery project local control network. System shall be capable of storing at least three weeks’ worth of live video for all cameras provided simultaneously. Access of recorded video shall be through the local interface or over the network through a password accessible account.

E. Video cameras shall be Pelco Spectra IV env pnd gry 35x d/n smk – Part # SD435-PG-EO, including wall mount Part # IWPG and power supply Part # WCS1-4.

2.2 CAMERA HOUSING

A. Camera housing shall be designed for outdoor installation with impact-resistant clear dome with space heater.

B. Mounting brackets and pipes shall be included.

2.3 VIDEO TERMINAL

A. Monitoring terminal shall be complete with video processor with keyboard, color monitor, and joy stick camera controller.

B. Monitoring terminal shall be a product of the video camera manufacturer. A liquid crystal display shall be provided that is a minimum of 24” in size. Location of the video display terminal shall be located in the supervisor’s office.

2.4 POWER SUPPLY

A. Power supplies for the video cameras shall be provided as stand-alone units. Power supplies shall operate from a 24 VDC central power supply provided by CONTRACTOR.

PART 3 -- EXECUTION

3.1 SITE INSTALLATION SUPPORT

A. CONTRACTOR shall provide technical support for programming, installation and commissioning of the video system.

B. CONTRACTOR shall adjust each camera position to the desired view angle acceptable to the Owner and fix them into position.

C. CONTRACTOR shall demonstrate the video surveillance system and features to the owner, demonstrating remote access capability.

- END OF SECTION -

SECTION 28 31 00 - FIRE ALARM SYSTEM

PART 1 -- GENERAL

1.1 SECTION INCLUDES

A. Multi-zone fire alarm system, including control panel, smoke and heat detectors, manual pull stations, door switches, and horn/strobes.

1.2 REFERENCED STANDARDS

A. NFPA 72A Protective signaling Systems

B. NFPA 72E Automatic Fire Detectors

C. NFPA 70 National Electrical Code, Article 760

1.3 QUALITY ASSURANCE

A. UL Listed for intended application.

1.4 SUBMITTALS

A. The following shall be submitted in accordance with Section 01300.

B. Submit the following:

1. Equipment brochures and product data.

2. Electrical connection and schematic diagrams.

3. Sensor layouts.

4. Control panel external wiring diagram.

5. Warranties and certification.

6. Operations and maintenance data.

1.5 OPERATION REQUIREMENTS

A. Normal Mode: When conditions are normal (no alarm and no trouble detected) only green power-on LED shall be on.

B. Supervisory Alarm Mode: The supervisory mode shall be activated if an abnormal condition is detected in the alarm circuit (i.e., open circuit). Light emitting diodes (LEDs) shall illuminate and audible alarm sound. Supervisory alarm mode shall continue until the abnormal condition is cleared and the reset switch is operated. Contact shall be provided for interface by external devices.

C. Alarm Mode: The alarm mode shall be activated if any of the initiating devices operates. LEDs indicating the initiating zones shall illuminate and the alarm relay operate. Alarm mode shall continue until the initiating device is reset and the front panel reset switch is operated. Contacts shall be provided for external control interface and for alarm message generation for auto-dialer furnished by others. Alarm messages shall be transmitted to remote site via auto-dialer.

D. Trouble Alarm Mode: The trouble alarm mode shall be activated if the system experiences abnormal operating conditions, such as AC power loss, low battery, battery open lead, or ground fault. Trouble alarm shall be indicated by a front panel LED accompanied by audible tones. The trouble relay shall operate. The audible tone shall be silenced by operating the trouble silence switch. The trouble LED shall be reset only after the trouble source has been cleared. Contact shall be provided for interface by external devices.

E. Drill Mode: The drill mode shall be used to test signaling circuits manually. No audible alarms shall be generated and no auxiliary relays shall operate under the drill mode.

F. Test Mode: The test mode shall be used to verify the operation of panel alarm initiating devices and the integrity of field wiring. A combination of audible pulses shall be used to indicate the success of the tests.

G. HVAC Interface: Contractor to provide a standalone HVAC shutdown contactor rated to power all Hatchery building HVAC loads, including supply louvers and exhaust fans. Upon a fire alarm condition in the main hatchery building or administrative office area, the fire alarm control panel shall initiate a contact closure to energize the HVAC shutdown contactor to remove power from all HVAC systems. The shutdown contactor shall have opr

PART 2 -- PRODUCTS

2.1 GENERAL

A. Acceptable Manufacturers:

1. Edwards Signals.

2. GE Security.

3. Simplex.

2.2 FIRE ALARM CONTROL PANEL

A. Fire alarm control panel shall be a five-zone unit for Class B power limited signal circuits.

B. Panel LED Indications:

1. Power On.

2. Battery Power.

3. Alarm.

4. Equipment Trouble.

5. Battery Low or Trouble.

C. Momentary Contact and Switch Functions:

1. Reset.

2. Trouble Silence.

3. Lamp Test.

D. Alarm Relays

1. Equipment Trouble.

2. Alarm activation.

3. Contact outputs for remote interface rated for 5 Amp resistive at 125VDC.

E. Enclosure: NEMA 1, wall-mounted.

F. Initiating and signaling circuits:

1. 2-wire Class B initiating circuits.

2. 2-wire Class B signaling circuits.

3. 2-wire dry contact initiating circuit (door switches).

4. Designed for operation on 24VDC circuits.

G. Power Supply: Integral float type battery charger with standby sealed lead-calcium type battery suitable for 24-hour stand-alone operation, mimuum.

H. Model: Edwards E-FS502, or similar.

2.3 SMOKE DETECTORS

A. LED alarm indication.

B. Designed for 2-wire Class B circuit application.

C. UL listed.

D. Tamper resistant twist lock installation.

E. Smoke detection based on light scattering photoelectric principle.

F. Heat detection by thermal element, rate-of-rise and/or fixed..

G. Equipped with auxiliary relay.

H. Field adjustable sensitivity.

I. Nominal 24VDC operation.

J. Operating Temperature: 32 to 100 degrees F.

K. Operating Humidity: 0% to 95% RH.

L. Model: Edwards 2432B, or approved equal.

2.4 MANUAL FIRE STATION

A. Single action break glass type.

B. Red die cast body.

C. UL listed.

D. Contact Rating: 3 Amp at 125 VAC.

E. Model: Edwards 270-SPO, or approved equal.

2.5 HORN/STROBE

A. Surface mount, indoor use, combination electronic horn and strobe.

B. Clear lens for strobe.

C. Sound level output: 90 dBA.

D. Strobe rate: 1 flash per second.

E. UL listed.

F. Operating voltage: 24 VDC.

G. Model: Edwards 867STRR-AQ, or approved equal.

2.6 AUDIBLE ALARM

A. Vibrating, polarized type.

B. Surface mounting.

C. 24VDC operation.

D. Suitable for Class B, 2-wire, supervised system.

E. 96 dbA output at 3 feet.

F. Model: Edwards 894B-226, or approved equal.

2.7 END OF LINE DEVICE

A. As required for loop termination for smoke alarm and horn circuits.

B. Resistor value: per fire alarm system manufacturer.

2.8 DOOR SWITCHES

A. Magnetically-actuated dry contacts to signal door open/close status.

PART 3 -- EXECUTION

3.1 GENERAL

A. Comply with directions of local fire marshal.

B. Install in accordance with manufacturer's instructions.

C. Comply with referenced standards for installation and wiring requirements.

D. Provide certification by manufacturers for proper installation.

3.2 FIELD QUALITY CONTROL

A. Provide manufacturer's field service representatives to verify proper installation and calibration of sensors.

B. Provide name, address, and phone number of local service organizations authorized by the manufacturers.

C. Local service shall be available for 24-hour emergency service calls.

3.3 CHECKOUT, STARTUP, AND TRAINING

A. Calibrate detectors and control circuits.

B. Provide field representatives to demonstrate fire alarm system is properly installed and ready for operation.

C. Demonstrate fire and trouble alarm signals are properly interfaced with external systems for remote signaling.

D. Provide training to OWNER operating and maintenance staff.

- END OF SECTION -

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SECTION 28 25 00 – CARD KEY SYSTEM, DOOR ACESS

PART 1 -- GENERAL

1.1 SECTION INCLUDES:

A. Requirements for hardware and software, along with a dedicated PC, to implement a project wide door card key reader and access system.

1.2 SUBMITTALS

A. The following shall be submitted in accordance with Section 01 33 00 – Contractor Submittals:

1. Manufacturer's technical data
2. Main Controller (Either PC or dedicated controller with PC interface)
3. IP Reader/Controller
4. Electric Door Latch
5. Contactless Card Reader
6. Software and license (if required) installed
7. Door reader and security software CD and instruction manual

1.3 DEFINITIONS

A. Access control system is an integrated solution that consists of hardware and software designed to control entry into selected areas and manage movement of people/vehicles within. The system is designed to increase security by defining access permissions based on area and time for each user and maintaining a log of all events.

B. Components of an access control system:

1. **Software:** Used to adjust all parameters of the system, control hardware, display events related to movement of users, alarms, and operation of hardware devices. The software is also used for storing all events in the database and generating reports based on requirements defined by an operator.
2. **Electromechanical hardware:**
    a) Electric door locks
3. **Electronic hardware:**
    a) IP-Controllers: receive settings from software and control the electromechanical hardware of the system.
    b) Contactless readers: read unique numbers of identification cards/tags and forwards the numbers to controllers.
    c) Fingerprint readers: scan fingerprint images, compare them with the templates stored in the internal reader database (or on a smart card) and send the verification results to controllers.
4. **System users:**
    a) Operators: responsible for administrating the system, creating new users, issuing cards and performing other regular daily tasks.
    b) Installers: responsible for installing, programming, maintaining and troubleshooting the system.

c) Users: regular staff of the company, with permanent or long-term ID cards (or PINs), who use the system to gain access to certain building areas as configured by operators.
d) Visitors: people that are not employed by the end-user company, but still have rights to access certain areas (contractors, visitors, delivery people, etc.).
e) Vehicles (or other equipment): are accounted for and their in/out movements are controlled and tracked by the system, in order to prevent unauthorized vehicles from entering parking areas, or valuable equipment from being taken without authorization.

PART 2 -- PRODUCTS

2.1 SOFTWARE

a) There shall be no limitations on the number of PC workstations, readers and alarm inputs.
b) The number of cards/users shall be limited only by memory available in hardware.
c) At least 3 active cards per user shall be supported.
d) At least 8 access levels per user shall be supported.
e) Access levels should be assigned to a user, not to a card, in order to help issue a new card in a fast and easy manner, without reassigning access levels.
f) The software shall support at least 4000 holiday dates and have automatic holiday rescheduling feature.
g) The software shall have the ability to perform scheduled automatic database maintenance and backup tasks at user selected intervals and ability to configure the amount of history stored in the active database.
h) The software shall have the ability to produce the following report types: system and alarm event reports, user reports, hardware configuration settings, access level reports, employee time & attendance reports.
i) The reports shall be available in Adobe PDF and MS Excel formats.
j) Report filters must be convenient and user friendly: allow operator preview user photos, content of access levels, hardware settings and time zone configuration.
k) The software shall support an unlimited number of building floor plans.
l) Floor plan viewing interface shall have convenient zoom in/out controls by mouse wheel.
m) The software shall allow operator to conveniently edit floor plans by “dragging and dropping” hardware devices to selected plan areas.
n) The software shall allow assigning custom icons to each floor plan in order to help operators identify floor plans quickly. The software shall have a wide selection of default icons as well.
o) The software shall support “full-screen” mode that would take up 100% of the monitor area and prevent operators from starting or accessing any other programs.
p) All configuration and user changes shall be sent to controller immediately. The software shall display the progress in percent as the changes are being downloaded. The downloading shall be done in background and not affect the normal use of the software in any way.
q) The floor plans shall display real-time status of system hardware and allow operators to immediately see the effects caused by configuration changes.

r) Dynamic search function shall be present in all windows of the program: search results shall be narrowed automatically as a key phrase is being entered. I.e. after entering characters “xy” the program shall locate and display all records containing these characters, and after typing in more characters shall refresh the results automatically.
s) The software shall use an industry standard database engine released not earlier than 2005 and currently supported by the manufacturer.
t) The software shall have the ability to automatically display photos and additional information about users as they enter/exit through doors.
u) The software shall be available in English.
v) The software shall have a modern interface, attractively designed and convenient to use.
w) The software shall be adapted for operators who have not received any special training related to management of integrated security systems. Graphical user interface shall be intuitive. Introducing the system to a new operator shall not take more than 1 hour.
x) In order to reduce the amount of work done by an operator, the software shall incorporate an option to copy objects: users, doors, floor plans, time schedules, access levels and holidays.
y) The software shall facilitate integration with other systems of the building.
z) The software shall have the ability to transfer entry and exit events to HR systems with the purpose of work time calculation.
aa) The software shall store information and provide reports about visitors and appointments.

2.2 HARDWARE

a) The hardware shall support open architecture. Communication protocols shall be available to system integrators and software development companies in order to protect end-users from being constrained to a single brand of hardware or software.
b) The hardware shall support all industry standard readers that output information in Wiegand or Clock/Data formats (up to 128 bits).
c) The IP-reader/controller shall be of the four door configuration, unless otherwise approved, able to manage operation of four doors and associated card readers and door latches, in one enclosure.
d) Each IP-reader/controller shall have a standard RJ-45 network port for communication with software and other controllers.
e) IP-reader/controller shall support standard Ethernet 10/100BaseT network and TCP/IP communication protocol.
f) Systems using Ethernet converters, adapters, or terminal servers that enable network connectivity for legacy controllers by tunneling RS-232/485 serial data over Ethernet shall not be acceptable.
g) Each IP-reader/controller shall have at least 32Mb SDRAM operating memory and 8 MB Flash memory for database and events.
h) All IP-reader/controllers shall use a 32Bit 100Mhz RISC processor (or better) in order to enable fast execution of advanced functions.
i) Controllers and IP-readers shall use Linux operating system and accept firmware upgrades via network, unless approved by Owner.

j) All system parameters including card numbers, PINs, access levels, time schedules, holidays and operations modes shall be stored in IP-reader/controller memory and not affected in case of a power loss.
k) IP-reader/controller shall have enough memory to store at least 1,000 users.
l) In case communication with the host PC is interrupted, the IP-reader/controller must have enough memory to store at least 1000 latest events (FIFO buffer).
m) Operation of IP-reader/controller shall be completely independent of the PC or “Master controller”. Should the PC or the communication link fail, the users should not be affected in any way and all functions should continue working, provided the IP-Read/Controller has power.
n) IP-reader /controller shall have the following inputs and outputs:
    1. Door contact input
    2. Auxiliary alarm input
    3. Tamper sensor and tamper input
    4. Relay and power for controlling electric door locks.
    5. General purpose auxiliary output relay.
o) In case the main PC/controller of the system fails, IP-readers/controllers shall accept a connection from a laptop in order to diagnose the problem, change settings or control peripheral devices.
p) In case of an alarm IP-readers/controllers shall initiate communication and provide timely notifications to operators.
q) The system shall support biometric readers.

PART 3 -- EXECUTION

3.1 SITE INSTALLATION SUPPORT

A. CONTRACTOR shall provide technical support for programming, installation and commissioning of the card key and door access system.

- END OF SECTION -

SECTION 31 05 19 - GEOTEXTILES

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide geotextiles, complete and in place, in accordance with the Contract Documents.

B. **Definitions:** The following definitions apply to the WORK of this Section:

1. Fabric: Geotextile, a permeable geosynthetic comprised solely of textiles.

2. Minimum Average Roll Value (MinARV): Minimum of series of average roll values representative of geotextile provided.

3. Maximum Average Roll Value (MaxARV): Maximum of series of average roll values representative of geotextile provided.

4. Nondestructive Sample: Sample representative of finished geotextile, prepared for testing without destruction of geotextile.

5. Overlap: Distance measured perpendicular from overlapping edge of one sheet to underlying edge of adjacent sheet.

6. Seam Efficiency: Ratio of tensile strength across seam to strength of intact geotextile, when tested according to ASTM D 4884.

7. Woven geotextile: A geotextile fabric composed of polymeric yarn interlaced to form a planar structure with uniform weave pattern.

8. Nonwoven geotextile: A geotextile fabric composed of a pervious sheet of polymeric fibers interlaced to form a planar structure with uniform random fiber pattern.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. The following standards are referenced in this Section:

ASTM D 4355	Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture, and Heat in a Xenon-Arc Type Apparatus
ASTM D 4491	Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextiles
ASTM D 4595	Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method

ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile
ASTM D 4833	Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
ASTM D 4884	Standard Test Method for Strength of Sewn or Thermally Bonded Seams of Sewn Geotextiles
ASTM D 4886	Standard Test Method for Abrasion Resistance of Geotextiles (Sand Paper/Sliding Block Method)

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.

B. Shop Drawings

1. Manufacturer material specifications and product literature.

2. Installation drawings showing geotextile sheet layout, location of seams, direction of overlap, and sewn seams.

3. Description of proposed method of geotextile deployment, sewing equipment, sewing methods, and provisions for holding geotextile temporarily in place until permanently secured.

C. Samples

1. Geotextile: One-piece, minimum 18-inches long, taken across full width of roll of each type and weight of geotextile. Label each with brand name and furnish documentation of lot and roll number from which each sample was obtained.

2. Field Sewn Seam: 5-foot length of seam, 12-inches wide with seam along center, for each type and weight of geotextile.

3. Securing Pin and Washer: 1 each.

D. Certifications

1. Certification from geotextile manufacturer that products satisfy the indicated requirements.

2. Field seam efficiency test results.

PART 2 -- PRODUCTS

2.1 WOVEN GEOTEXTILE

A. Woven geotextile shall be composed of polymeric yarn interlaced to form a planar structure with uniform weave pattern. Products shall be calendared or finished so that yarns will retain their relative position with respect to each other.

B. Polymeric yarn shall be long-chain synthetic polymers (polyester or polypropylene) with stabilizers or inhibitors added to make filaments resistant to deterioration due to heat and ultraviolet light exposure.

C. **Sheet Edges:** Selvaged or finished to prevent outer material from separating from sheet.

D. **Unseamed Sheet Width:** Minimum 6 feet.

E. Nominal Weight per Square Yard: 6.

F. Physical Properties: Conform to requirements below.

PHYSICAL PROPERTY REQUIREMENTS FOR WOVEN GEOTEXTILE		
Property	**Requirement**	**Test Method**
Apparent Opening Size (AOS)	No. 10 to No. 100 U.S. Standard Sieve Size	ASTM D 4751
Water Permittivity	0.02 to 3.34 sec.$^{-1}$, MinARV	ASTM D 4491 (Falling Head)
Vertical Waterflow Rate	10 to 150 gpm/sq ft, MinARV	
Wide Width Strip Tensile Strength	60 to 1,500 lb/in.-width, MinARV	ASTM D 4595
Wide Width Strip Elongation	14 to 60 percent, MaxARV	
Trapezoidal Tear Strength	30 to 200 lb, MinARV	ASTM D 4533
Puncture Strength	50 to 250 lb, MinARV	ASTM D 4833
Abrasion Resistance	5 to 25 percent loss, 250 cycles, MaxARV	ASTM D 4886
Ultraviolet Radiation Resistance	70 to 90 percent strength retention, MinARV after 500 hours	ASTM D 4355

2.2 NONWOVEN GEOTEXTILE

A. Nonwoven geotextile shall be composed of a pervious sheet of polymeric fibers interlaced to form a planar structure with uniform random fiber pattern. Products shall be calendared or finished so that yarns will retain their relative position with respect to each other.

B. Polymeric yarn shall be long-chain synthetic polymers (polyester, polypropylene, or polyethylene) with stabilizers or inhibitors added to make filaments resistant to deterioration due to heat and ultraviolet light exposure.

C. **Geotextile Edges:** Selvaged or finished to prevent outer material from separating from sheet.

D. **Unseamed Sheet Width:** Minimum 6-feet.

E. **Nominal Weight per Square Yard:** 12 ounces.

F. **Physical Properties:** Conform to requirements below.

PHYSICAL PROPERTY REQUIREMENTS FOR NONWOVEN GEOTEXTILE		
Property	**Requirement**	**Test Method**
Apparent Opening Size (AOS)	No. 100 to No. 140 U.S. Standard Sieve Size	ASTM D 4751
Water Permittivity	1.2 $sec.^{-1}$, MinARV	ASTM D 4491 (Falling Head)
Vertical Waterflow Rate	90 gpm/sq ft, MinARV	
Wide Width Strip Tensile Strength	300 MinARV	ASTM D 4595
Wide Width Strip Elongation	70 percent, MaxARV	ASTM D 4595
Trapezoidal Tear Strength	120 lb, MinARV	ASTM D 4533
Puncture Strength	130 lb, MinARV	ASTM D 4833
Ultraviolet Radiation Resistance	90 percent strength retention, MinARV after 500 hours	ASTM D 4355

2.3 SEWING THREAD

A. Sewing thread shall be polypropylene, polyester, or Kevlar thread with durability equal to or greater than durability of geotextile sewn.

2.4 SECURING PINS

A. **Securing pins shall be steel rods or bars conforming to the following:**

1. 3/16-inch diameter.

2. Pointed at one end; head on other end, sufficiently large to retain washer.

3. Minimum Length: 12-inches.

B. Steel washers for securing pins shall be:

1. Outside Diameter: Not less than 1-1/2 inches.

2. Inside Diameter: 1/4-inch.

3. Thickness: 1/8-inch.

C. Steel Wire Staples

1. U-shaped.

2. 10-gauge.

3. Minimum 6-inches long.

PART 3 -- EXECUTION

3.1 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver each roll with sufficient information attached to identify manufacturer and product name or number.

B. Handle products in manner that maintains undamaged condition.

C. Do not store products directly on ground. Ship and store geotextile with suitable wrapping for protection against moisture and ultraviolet exposure. Store geotextile in a way that protects it from elements. If stored outdoors, elevate and protect geotextile with waterproof cover.

3.2 LAYING GEOTEXTILE

A. Notify the ENGINEER whenever geotextiles are to be placed. Do not place geotextile prior to obtaining ENGINEER's approval of underlying materials.

B. Lay and maintain geotextile smooth and free of tension, folds, wrinkles, or creases.

3.3 ORIENTATION ON SLOPES

A. Orient geotextile with long dimension of each sheet parallel to direction of slope.

B. Geotextile may be oriented with long dimension of sheet transverse to direction of slope only if sheet width, without unsewn seams, is sufficient to cover entire slope and anchor trench and extend at least 18-inches beyond toe of slope.

3.4 JOINTS

A. Unseamed Joints

1. Unseamed joints shall be overlapped to the following dimensions unless otherwise indicated:

    a. Foundation/Subgrade Stabilization: Minimum 18-inches.

    b. Riprap: Minimum 18-inches.

    c. Drain Trenches: Minimum 18-inches, except overlap shall equal trench width if trench width is less than 18-inches.

    d. Other Applications: Minimum 12-inches.

B. Sewn seams shall be used wherever stress transfer from one geotextile sheet to another is necessary. Sewn seams, as approved by ENGINEER, also may be used instead of overlap at joints for applications that do not require stress transfer.

1. Seam efficiency shall be minimum 70 percent, verified by preparing and testing minimum of one set of nondestructive samples per acre of each type and weight of geotextile provided. Test according to ASTM D 4884.

2. Type: "J" type seams are preferred, but flat or butterfly seams are acceptable.

3. Stitch Count: Minimum 3 to maximum 7 stitches per inch.

4. Stitch Type: Double-thread chainstitch, Type 401, Federal Standard No. 751a.

5. Stitch Location: 2-inches from geotextile sheet edges, or more if necessary to develop required seam strength.

6. Sewing Machines: Capable of penetrating 4 layers of geotextile.

3.5 SECURING GEOTEXTILE

A. Secure geotextile during installation as necessary with sand bags or other means approved by ENGINEER.

B. Securing Pins

1. Insert securing pins with washers through geotextile, midway between edges of overlaps and 6-inches from free edges.

2. Spacing

Slope	**Maximum Pin Spacing, feet**
Steeper than 3:1	2
3:1 to 4:1	3
Flatter than 4:1	5

3. Install additional pins across each geotextile sheet as necessary to prevent slippage of geotextile or to prevent wind from blowing geotextile out of position.

4. Push each securing pin through geotextile until washer bears against geotextile and secures it firmly to subgrade.

3.6 PLACING PRODUCTS OVER GEOTEXTILE

A. Notify ENGINEER before placing material over geotextile. Do not cover installed geotextile prior to receiving authorization from the ENGINEER to proceed.

B. If tears, punctures, or other geotextile damage occurs during placement of overlying products, remove overlying products as necessary to expose damaged geotextile. Repair damage as indicated below.

3.7 INSTALLING GEOTEXTILE IN TRENCHES

A. Place geotextile in a way that will completely envelope granular drain material to be placed in trench and with indicated overlap at joints. Overlap geotextile in direction of flow. Place geotextile in a way and with sufficient slack for geotextile to contact trench bottom and sides fully when trench is backfilled.

B. After granular drain material is placed to grade, fold geotextile over top of granular drain material, unless otherwise indicated. Maintain overlap until overlying fill or backfill is placed.

3.8 RIPRAP APPLICATIONS

A. Overlap geotextile at each joint with upstream sheet of geotextile overlapping downstream sheet.

B. Sew joints where wave runup may occur.

3.9 GEOTEXTILE-REINFORCED EARTH WALL APPLICATIONS

A. Sew exposed joints; extend sewn seams minimum 3-feet behind face of wall.

B. Protect exposed geotextile from damage and deterioration until permanent facing is applied.

3.10 SILT FENCE APPLICATIONS

A. Install geotextile in one piece or continuously sewn to make one piece, for full length and height of fence, including portion of geotextile buried in toe trench.

B. Install bottom edge of sheet in toe trench and backfill in a way that securely anchors geotextile in trench.

C. Securely fasten geotextile to a wire mesh backing and each support post in a way that will not result in tearing of geotextile when fence is subjected to service loads.

D. Promptly repair or replace silt fence that becomes damaged.

3.11 REPAIRING GEOTEXTILE

A. Repair or replace torn, punctured, flawed, deteriorated, or otherwise damaged geotextile. Repair damaged geotextile by placing patch of undamaged geotextile over damaged area plus at least 18-inches in all directions beyond damaged area. Remove interfering material as necessary to expose damaged geotextile for repair. Sew patches or secure them with pins and washers, as indicated above for securing geotextile, or by other means approved by ENGINEER.

3.12 REPLACING CONTAMINATED GEOTEXTILE

A. Protect geotextile from contamination that would interfere, in ENGINEER's opinion, with its intended function. Remove and replace contaminated geotextile with clean geotextile.

- END OF SECTION -

SECTION 31 10 00 - SITE CLEARING

PART 1 -- GENERAL

1.1 DESCRIPTION OF WORK

A. The work includes furnishing all material, equipment and labor to perform site preparation activities as shown on the Drawings and as specified herein.

1.2 GENERAL INFORMATION

A. This section covers clearing and grubbing areas as required for mobilization, excavation, topsoil placement, areas designated for replanting, and work where not specifically covered. Before commencing any work under this section, all existing utilities will be marked by the CONTRACTOR and protected during construction. Certain portions of the project area may contain artifacts that are considered to be archeologically sensitive.

B. CONTRACTOR shall be responsible for maintenance of the hatchery access road during construction.

C. Contract shall be responsible for construction of a temporary access road to the site for use by the OWNER and CONTRACTOR during construction.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION

3.1 CLEARING OPERATIONS

A. **General**:

1. The areas to be cleared include all areas which are to form foundations for both gravel and asphalt pavements, all areas to receive surcharge fill, walks, buildings, shelters, tanks, topsoil and other landscaped areas, and other structures and paving materials.

2. Vegetative matter including grasses, trees, brush, roots, etc. shall be completely removed from the area within the project footprint.

3. Trees to be removed shall be cut as close to the ground level as possible. Stumps are to be pulled.

4. Trees to remain shall be enclosed in tree protection fencing installed along the drip line of the trees to ensure that they are not disturbed by clearing and construction activities.

5. All trees, snags, brush, and other timber to be removed shall be felled onto the area designated to be cleared. The clearing away of down timber, vines, and vegetative growth will be performed in such manner as to remove all evidence of their presence from the surface of the areas involved, and shall be inclusive of sticks and branches, vines and grasses, weeds, and growing crops.

6. Brush and other vegetation removal will be cut off at ground level and the roots removed by grubbing methods described in this specification.

7. CONTRACTOR shall provide a 7-day notification to OWNER prior to commencing site preparation activities.

8. Improvements: Storm drainage and structures shall be protected and kept open. Materials shall be prevented from entering waterways.

3.2 GRUBBING OPERATIONS

A. Grubbing consists of the elimination of organic matter occurring below ground surface and of stumps, trunks, canes and stems of timber, root clumps, vegetative matter, and other debris remaining as a result of the clearing work. In areas to be grubbed for excavation, all stumps will be completely removed and the area grubbed through the use of a spike-tooth harrow or other method that will extract organic matter below the surface with no displacement of the soils to a depth of not less than 4 inches.

3.3 AREAS TO BE GRUBBED

A. The areas are as follows: all areas which are to form foundations for both gravel and asphalt pavements, walks, pads, buildings, embankments, ponds, shelters, tanks, topsoil and other landscaped areas, and other structures and paving material.

3.4 OWNERSHIP AND DISPOSAL OF MATERIALS

A. Unless otherwise directed, all materials, items, and debris (hereinafter collectively referred to as "material") involved, occurring or resulting from the clearing, grubbing, and cleanup work, shall become the property of the CONTRACTOR to be disposed of in conformance with the following: all material will be removed from the project area and will not be deposited on any property owned or controlled by the OWNER will any such material be left in an unsightly condition nor at any location which is visible to users of any public highway, road, or access point. Written permission to place material on private property or on land not owned or controlled by the OWNER will be obtained by the CONTRACTOR from the OWNER or other responsible party prior to placing the material thereon and evidence of such permission shall be furnished. The permit is to be in writing and will be so phrased as to absolve the OWNER from all responsibility and releases them from liabilities and claims in connection with the placement of material on such property.

3.5 PRESERVATION AND TRIMMING OF TREES, SHRUBS AND OTHER VEGETATION

A. Roots of trees outside of the excavation limits shall be protected from severe injury during all construction-related operations. All roots impacted by these operations will be cleanly cut so as to be flush with adjacent soil surface, using a hand-saw or other approved method. Injury to vegetation outside the designated clearing and grubbing area is to be avoided. All damaged trees other than those to be cleared and grubbed shall be repaired within 10 working days from date of original damage. Tree roots and limbs to be cut and repairs to damaged trees are to be performed under the supervision of a professional arborist.

B. A minimal amount of low hanging or unsound branches shall be removed as required from trees and shrubs, which are to remain in-place, utilizing approved tree surgery techniques. Branches over roadways and structures will be trimmed in conformance with good tree surgery practice to provide at least a 20-foot clearance above grade.

3.5 FILLING, BACKFILLING AND RESHAPING

A. Except in areas to be excavated, stump holes and other holes created during grubbing will be backfilled and compacted with compacted structural fill material specified in SECTION 31 23 00. All areas lying outside the clearing and grubbing limits on which work under this specification has been performed and all areas which have been disturbed by other operations in connection with this contract shall be smoothed and reshaped to blend them to surrounding contours or contiguous undisturbed areas; shaping requiring hand tools may be required. Fill material shall not be placed against tree trunks above original ground lines.

- END OF SECTION -

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SECTION 31 23 19 - DEWATERING

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall dewater trench and structure excavations, in accordance with the Contract Documents. The CONTRACTOR shall secure all necessary permits to complete the requirements of this Section of the Specifications.

B. Responsibility for Dewatering System Development. The CONTRACTOR shall review the available subsurface data for the project site prior to bidding. It is the CONTRACTOR's responsibility to evaluate the subsurface conditions at the project site with respect to required dewatering facilities and develop a comprehensive dewatering plan that meets the construction needs and project requirements.

1. The CONTRACTOR shall be fully responsible to contract the services of qualified dewatering professional engineers or hydro geologists to obtain recommendations and plans for development of a project dewatering plan.

2. The CONTRACTOR shall accept sole responsibility for development of dewatering plans that allow for safe and effective installation of the project facilities.

3. Water extracted from construction dewatering facilities must be of sufficient quality (i.e., total suspended solids (TDS) and turbidity (NTU)) before it can be discharged to an approved receiving body of water. The CONTRACTOR shall be required to provide temporary clarification and settling equipment to insure that all construction discharge water meets the discharge water quality requirements of:

   a. NPDES Stormwater Discharge permits as determined and issued by the State of Washington, Department of Ecology.

4. The CONTRACTOR's Dewatering facilities shall also comply with the requirements of the approved Erosion & Sediment Control (ESC) Plan as approved by the State of Washington, Department of Ecology.

C. The WORK described in this Section shall also be coordinated with Specification 02 15 00 – Cofferdams and Protective Works.

1.2 CONTRACTOR SUBMITTALS

A. Prior to commencement of excavation, the CONTRACTOR shall submit a detailed plan and operation schedule for dewatering of excavations. The CONTRACTOR shall submit the following information, at a minimum, in accordance with Section 01 33 00 – Contractor Submittals.

1. A dewatering plan that includes details regarding the anticipated types and locations of various dewatering facilities and appropriate design calculations required to substantiate the dewatering plan.

2. Review by OWNER or ENGINEER of the proposed dewatering system by the CONTRACTOR will only be with respect to the basic principles of the methods the Contractor intends to employ. Review by OWNER or ENGINEER does not relieve the Contractor of the full responsibility for the adequacy of the dewatering system, relative to both water quantity and water quality, and for conforming to applicable local, state, and Federal regulations.

3. The CONTRACTOR may be required to demonstrate the system proposed, meets water quantity requirements for the proposed excavation methods and also water quality for the proposed discharge water. CONTRACTOR shall verify that adequate equipment, personnel, and materials are provided to safely dewater the excavations at all project locations.

1.3 QUALITY CONTROL

A. It shall be the sole responsibility of the CONTRACTOR to control the rate and effect of the dewatering in such a manner as to avoid all objectionable settlement and subsidence.

B. All dewatering operations shall be adequate to assure the safety of the CONTRACTOR's workers and subcontractors and to assure the structural and civil integrity of the finished project. Dewatering operations shall be the sole responsibility of the CONTRACTOR.

C. Where critical structures, facilities, or roads exist immediately adjacent to areas of proposed dewatering, reference points shall be established and observed at frequent intervals to detect any settlement which may develop. The responsibility for conducting the dewatering operation in a manner which will protect adjacent structures and facilities rests solely with the CONTRACTOR. The cost of repairing any damage to adjacent structures and restoration of facilities shall be the responsibility of the CONTRACTOR.

1.4 DEFINITIONS

A. **Hydrostatic Groundwater Level**: The groundwater level at any location at the time of construction and prior to dewatering activities.

PART 2 -- PRODUCTS

2.1 DEWATERING DISCHARGE LOCATIONS

A. General. Unless specifically noted otherwise, construction dewatering liquid shall not be allowed to be discharged to the existing gravel road nor into any water body unless specifically authorized by the OWNER and any regulatory agencies, or as allowed for in this specification.

2.2 EQUIPMENT

A. Products. Dewatering, where required, may include the use of drilled extraction wells, well points, dewatering sumps with submersible or other appropriate pumps, temporary pipelines for water disposal, rock or gravel placement, and other means. Standby pumping equipment shall be maintained on the Work Site at all times during excavation and construction WORK.

B. Temporary Overland Piping. The CONTRACTOR shall provide sufficient above grade piping to route dewatering water to the treatment and/or discharge locations. Piping shall be adequately restrained at all bends and tees, and wherever necessary.

C. Water Clarification and Solids Settling Equipment. All construction dewatering liquid which is collected by the CONTRACTOR and rerouted via pumps or gravity flow to an alternate discharge location must meet the State of Washington Department of Ecology NPDES discharge requirements. CONTRACTOR shall provide any temporary water clarification or solids settling equipment required to insure that turbidity (NTU) and total suspended solids (TSS) levels of the discharge water meet the State of Washington requirements. Construction dewatering liquid which meets these criteria shall be routed by enclosed drainage pipe to an acceptable surface dewatering location, as determined by the State and OWNER

D. Acceptable Construction Dewatering Discharge Locations. See Part 3 below.

2.3 DEWATERING AND OBSERVATION WELLS

A. General. If the CONTRACTOR's dewatering plan calls for the use of dewatering wells or observation wells, all such wells shall be constructed in accordance with all Washington Department of Ecology (Ecology) state guidelines for dewatering well construction. Each well shall have an appropriate sanitary seal as required by Ecology guidelines.

B. Materials. Wells shall be constructed of materials suitable for the intended application and durable enough to last for at least one year of dewatering observation.

PART 3 -- EXECUTION

3.1 GENERAL REQUIREMENTS

A. The CONTRACTOR shall provide all equipment necessary for dewatering. It shall have on hand, at all times, sufficient pumping equipment and machinery in good working condition and shall have available, at all times, competent workmen for the operation of the pumping equipment. Adequate standby equipment shall be kept available at all times to insure efficient dewatering and maintenance of dewatering operation during power failure.

B. Dewatering for structures and pipelines shall commence when groundwater is first encountered, and shall be continuous until such times as water can be allowed to rise in accordance with the provisions of this Section or other Contract requirements.

C. At all times, site grading shall promote drainage. Surface runoff shall be diverted from excavations and towards areas of acceptable discharge or water storage. Water entering the excavation from surface runoff shall be collected in shallow ditches around the perimeter of the excavation, drained to sumps, and be pumped or drained by gravity from the excavation to maintain a bottom free from standing water.

D. Dewatering shall at all times be conducted in such a manner as to preserve the undisturbed bearing capacity of the subgrade soils at proposed bottom of excavation.

E. If foundation soils are disturbed or loosened by the upward seepage of water or an uncontrolled flow of water, the affected areas shall be excavated and replaced with drain rock and acceptable structural backfill material.

F. The CONTRACTOR shall maintain the water level a minimum of 2 feet below the bottom of excavation in all work areas where groundwater occurs during excavation construction, forming and concrete pouring, concrete curing, backfilling, and completion of the rough final grading in the project vicinity. For instances where no backfilling of final rough grading of a new structure or facility are required, the CONTRACTOR shall maintain water levels below the bottom of the excavation for no less than 6 days after the forms are removed from a concrete structure, unless other specific written permission is provided by the OWNER's on-site representative.

G. Flotation shall be prevented by the CONTRACTOR by maintaining a positive and continuous removal of water. The CONTRACTOR shall be fully responsible and liable for all damages which may result from failure to adequately keep excavations dewatered.

H. If well points or drilled wells are used, they shall be adequately spaced to provide the necessary dewatering. Drilled wells shall be set with sand-filter packing around the well (or other acceptable means) used to prevent pumping of fine sands or silts from the subsurface. A continual check by the CONTRACTOR shall be maintained to ensure that the subsurface soil is not being removed by the dewatering operation.

I. The CONTRACTOR shall dispose of water from the WORK in a suitable manner without damage to adjacent property. CONTRACTOR shall be responsible for obtaining any permits that may be necessary to dispose of water. No water shall be drained into work built or under construction without prior consent of the ENGINEER. Water shall be filtered using an approved method to remove sand and fine-sized soil particles before disposal into any drainage system.

J. The release of groundwater to its static level shall be performed in such a manner as to maintain the undisturbed state of the natural foundation soils, prevent disturbance of compacted backfill and prevent flotation or movement of structures, pipelines, and sewers.

K. Dewatering of trenches and other excavations shall be considered as incidental to the construction of the WORK and all costs thereof shall be included in the various contract prices in the Bid Forms, unless a separate bid item has been established for dewatering.

3.2 LOCATION OF DEWATERING FACILITIES

A. Approved Construction Water Discharge Locations

1. Possible acceptable discharge dewatering locations may include the emergent wetland on the south side of the site, provided that no additional trees are removed and that all discharge pipelines are hand placed to the discharge location, above grade and properly secured with stakes, sand-bags or other approved anchoring methods, or the sidechannel on the southwest side of the site.

3.3 INSTALLATION AND OPERATION

A. Maintaining Groundwater Levels. Prior to any excavation below the hydrostatic groundwater level, the dewatering system is to be placed into operation to lower the water levels as required and then will be operated continuously 24 hours per day, 7 days per week until all facilities and structures affected by the dewatering have been satisfactorily constructed; including placement of fill materials to an elevation above the hydrostatic groundwater level. In any event, the CONTRACTOR shall maintain the water levels low enough to fulfill the requirements of this Section and not allow the water level to rise until the constructed facilities are substantially complete that the water can be allowed to rise without damaging any facility and its foundation, or surrounding areas and structures.

B. Dewatering System Monitoring. The CONTRACTOR shall provide continuous on-site superintendence during all normal work-hours of dewatering. The CONTRACTOR shall provide an automated monitoring system that will alarm the CONTRACTOR's Superintendant during non work-hours and non work days for a failure of the dewatering system. The CONTRACTOR's automated monitoring plan shall be submitted to the ENGINEER for approval.

C. Stand-by Power Source. The CONTRACTOR shall provide complete standby equipment and power sources available for immediate operation as may be required, to adequately maintain the dewatering on a continuous basis in the event that all or any part of the dewatering system may become inadequate or fail.

D. Sheet-Piling. The CONTRACTOR may use sheet-piling in areas with no excavation restrictions, at their option, to help achieve the dewatering requirement as specified in this Section. If the Contractor uses sheet-piling, he shall submit a sheet-pile design by a Professional Engineer, registered in the state of Washington.

E. Inadequate Performance of Dewatering System. When the dewatering system does not meet the specified requirements, and as a consequence results in loosening or disturbance of adjacent foundation's strata, instability of the slopes, or damage to the foundations or structures occur, the CONTRACTOR shall, at his own expense, supply all materials, labor and perform all work required for restoration of foundation soil, slopes, foundation, or structures, to the satisfaction of the OWNER's on-site Representative.

3.4 SHUT-DOWN AND REMOVAL OF DEWATERING FACILITIES

A. An adequate weight of backfill material to prevent flotation of pipes or structures will be in place before any dewatering systems are shut off.

B. Dewatering Sumps. At the completion of the dewatering work, all dewatering sumps installed by the CONTRACTOR, shall be removed and the holes backfilled with clean, native material. If sumps are installed with corrugated inert plastics which do not allow for easy removal, then the CONTRACTOR shall cut off and remove at least the top 6-ft (below ground level) of such sump, and then abandon-in-place the remaining sump and backfill the interior with native soil material and cobble. Any steel or other metallic materials used in dewatering sump construction shall be completely removed by the CONTRACTOR prior to the final completion of the project.

C. Dewatering Wells. At the completion of the project, any dewatering or observation wells that were installed by the CONTRACTOR shall be removed entirely prior to the final completion of the project, unless noted otherwise in the Contract Drawings.

1. Alternatively, the CONTRACTOR may choose to remove only the top 6-ft (below ground level) of the dewatering or observation well casing and materials and abandon-in-place the remaining well components in complete conformance with all Ecology, groundwater protection and well abandonment guidelines and according to any additional requirements of the USFS.

D. Observation Wells. At the completion of the project, the CONTRACTOR shall remove all of the new observation wells installed for construction dewatering purposes, unless noted otherwise in the Contract Drawings

- END OF SECTION -

SECTION 31 25 00 EROSION AND SEDIMENT CONTROL

PART 1 -- GENERAL

1.1 DESCRIPTION OF WORK

A. Work includes furnishing all labor, materials and equipment required for the installation and maintenance of both permanent and temporary erosion control measures as shown on the drawings and as specified herein. Refer to Section 31 37 00 for specifications regarding Riprap material and execution.

B. The following soil erosion control measures are required, and shall be in place while potential for erosion exists from construction activities at the site and disposal area, during the duration of the contract and warranty period;

1. Protect and stabilize soils susceptible to erosion. This includes areas were vegetative cover cannot be achieved due to soils, slopes or time of year.

2. Prevent sediment or sediment laden water from entering all creeks and the storm drain systems or to be discharged from the construction site in accordance with the Washington Department of Ecology, USEPA and other applicable regulations.

3. Allow no mud, dirt rocks, etc., to be transported onto roads by motor vehicles or stormwater run-off.

1.2 REFERENCES

U.S. DEPARTMENT OF AGRICULTURE (USDA) AMS Seed Act (1940; R 1988; R 1998) Federal Seed Act

Washington State Department of Transportation Standard Specifications for Construction 2016.

Washington Department of Ecology, Best Management Practices for Erosion and Sediment Control

1.3 SUBMITTALS

A. Submit soil erosion control plans for acceptance in accordance with the provisions of SECTION 01 33 00.

PART 2 -- PRODUCTS

2.1 SPECIAL RESTRICTIONS

A. The contractor shall be aware of and conform to measures necessary for the control of erosion and sediment runoff according to applicable regulations.

2.2 MULCH MATERIAL

A. Wood or grass straw cellulose fiber: The following mulch materials are acceptable for use:

1. Grass mulch, a grass straw cellulose fiber manufactured by Grass Fiber, Inc., Junction City, Oregon 97448. or Equal

2. Silva-fiber, a wood cellulose fiber manufactured by Weyerhaeuser, Tacoma, Washington 98477. or Equal

3. Spray Mulch X-80, a wood cellulose fiber manufactured by Pacific Wood Fibers, Redmond, Washington 98052. or Equal

4. Grass straw: J_TAC manufactured by Reclamare Company, Seattle, Washington 9819 or Equal 0

2.2 SEED

A. Use a seed mix as recommended by local county extension agencies (must be acceptable to the OWNER) that shall allow for a quick growing species and conforms with other specification requirements established elsewhere, providing a temporary cover which shall not compete with the grasses sown later for permanent cover.

2.3 FERTILIZER

A. Fertilizer applied within 50 feet of water bodies shall be a non-phosphorus type.

B. In addition to inorganic fertilizers; an acceptable phosphorus type fertilizer is 14-19-19 with 50% slow release Ureaform or Isobutylidene Diurea (IDBU).

2.5 SILT FENCE

A. Posts shall be 2x2 wood, at least 6 feet long, or 1-1/2 inch steel T shaped.

B. Fabric shall have the following properties:

Parameter	Standard Method	Value
Grab tensile strength	ASTM D 4632	100 lb
Burst strength	ASTM D 3786	200 psi
Apparent opening size	ASTM D 4751	Between 200 and 70 sieve size

C. Fastners shall be galvanized clips

2.6 SPECIALTIES

A. **Erosion mat:** TC Mirafi Miramat TM8

B. **Filter Fabric:**

PHYSICAL PROPERTY	TEST	REQUIREMENTS
Filtering Efficiency	VTM-51	75% (min.)
Tensile Strength at 20% (max.) Elongation*	VTM-52	Extra Strength-50 lbs./lin. in. (min.) Standard Strength-30 lbs./lin. in. (min.)
Flow Rate	VTM-51	0.3 gal./sq. ft. /min. (min.)

*Requirement reduced by 50 percent after 6 months of installation.

C. Synthetic filter fabric shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of 6 months of expected usable construction life at a temperature range of 0 degrees F to 120 degrees F.

D. Wire fabric 2" x 2" x 14 gauge.

E. **Plastic sheeting:** Clear polyethylene plastic with a minimum thickness of 6 mils.

PART 3 -- EXECUTION

3.1 SURFACE PREPARATION

A. Grass seed mixtures

1. Free area to be seeded of weeds, debris and other matter detrimental or toxic to the growth of grass or other approved cover crop.

2. Scarify top of surface soil directional along the contours of the final grade. Form minor ridges and irregularities on roadbed cut and fill slopes to retard erosion, and improve germination.

3.2 FERTILIZER

A. Apply fertilizer as per supplier's recommendations and uniformly to areas that are receiving grass seed mixtures.

3.3 SEEDING

A. Grass seed mix shall have a minimum of 100 pounds of seed per acre. Mix 2 parts sand or dolomite to 1 part seed mix for uniform broadcast.

B. Rake in lightly, covering seed to a depth of about 2-3 times their thickness.

C. Hydroseed rocky terrain and slopes greater than 10%.

D. Bonding agents: Use tackifier per supplier recommendations, to apply grass seeding to disturbed areas.

E. Watering: Apply water as required. Control rate of water applications to provide adequate moisture without causing run-off.

3.4 MULCH MATERIALS

A. Immediately following seeding, apply mulch to a thickness of 1/8 inches.

B. If using dry grass-straw mulch provide a uniform, 2-inch minimum cover. Anchor straw by working by hand or with equipment (rollers, cleat tracks, etc.).

C. Mulching should immediately follow seeding and fertilizing except for the following conditions:

1. When mulch is punched in the soil by mechanical means such as modified sheepsfoot rollers or serrated discs.

2. When it is necessary to hold down the mulch with wire netting or like material.

3. On slopes steeper than 1-1/2 horizontal to 1 vertical where a slurry mixture would tend to run down the slope.

D. Mulch shall be applied to all disturbed areas with a 2:1 or less slope.

E. Mulch shall be spread uniformly at a rate of 2 tons/acre for grass straw cellulose fiber or 1 ton per acre of wood fiber mulch.

3.5 PLASTIC SHEET COVERING

A. Install covering and maintain tightly in place by using sandbags or tires on ropes with a maximum 10 foot grid spacing in all directions.

B. Tape or weigh down all seams along the full length of the covering. Leave a minimum overlap of 12 inches for all seams.

C. For seams parallel to the slope contour, the uphill sheet shall overlap the downhill sheet.

D. Do not allow drainage from areas covered by plastic sheeting to discharge directly onto unprotected, disturbed areas of the construction site.

3.6 SILT FENCE

A. Construct silt fence to the lengths and at the locations where shown on the plans or as noted in submittal.

B. Cut fabric in a continuous length to avoid the use of joints. Where joints are unavoidable, overlap splice a minimum of 6 inches.

C. On sloped grades, fastened the silt fence filter fabric to the uphill side posts.

D. Do not extend the fabric more than 30 inches above the original ground surface.

E. Do not attach fabric to trees.

F. When extra strength filter fabric and closer post spacing are used, the wire mesh support fence may be eliminated.

3.7 EROSION BLANKET

A. Erosion mat shall be installed on all disturbed slopes with a steepness of 2:1 or greater.

B. Site Preparation: Grade surface of installation areas so ground is smooth and compact. Prepare surface by loosening 2” to 3” of topsoil. Spread seed before mat installation. Remove all large rocks, dirt clods, stumps, roots, grass clumps, trash and other obstructions from lying in direct contact with the soil surface and the mat.

1. Initial and terminal anchor trenches are required at the mat ends. Initial and terminal anchor trenches should be a minimum 12” deep and 6” wide while intermittent trenches need be only 6” deep and 6” wide.

C. Channel Installation: Excavate initial and terminal trenches, 12” deep and 6” wide, across the channel at the upper and lower end of the lined channel sections and excavate intermittent trenches, 6” wide and deep, across the channel at 40’ intervals. Excavate longitudinal trenches 6” deep and wide along channel edges in which to bury the outside mat edges. Place the first mat at the downstream end of the channel. Place the end of the first mat in the initial trench and pin it at 1” intervals along the bottom of the trench. Mat shall be placed upside down in the trench – loops against the ground – with the roll on the downstream side of the trench. Once pinned and backfilled, the mat shall be deployed by wrapping over the top of the trench and unrolling upstream with the loops now facing up. If the channel is wider than 12’, place ends of adjacent rolls in the terminal trench, overlapping the adjacent rolls a minimum of 6”. Side slope shingling shall be avoided. Pin at 1’ intervals, backfill and compact. Unroll mat in the upstream direction until reaching the first intermittent trench. Unroll the mat back over itself, positioning the roll on the downstream side of the trench, and allowing the mat to conform to the trench. Then pin the mat (two layers) to the bottom of the trench, backfill and compact. Continue up the channel repeating this step at other intermittent trenches, until reaching the upper terminal trench. At the upper terminal trench, allow the mat to conform to the trench, secure with pins or staples, backfill, compact and then bring the mat back over the top of the trench and onto the existing mat, 2’ to 3’ overlap in the downstream direction, and pin at 1’ intervals across the mat. When starting installation of a new roll, begin in a trench or shingle-lap end of rolls a minimum of 1’ with upstream mat on top to prevent uplifting. Place the outside edges of the mat(s) in longitudinal trenches, pin, backfill and compact.

D. Slope Installation: Place mat 2’ to 3’ over the top of the slope and into an excavated trench measuring at least 6” deep and wide. Pin the mat at 1’ intervals along the bottom of the trench, backfill and compact. Unroll the mat down the slope maintaining intimate contact between the soil and the smooth side of the mat (loops up). Overlap adjacent rolls a minimum of 6”. Pin the mat to ground using staples or pins in a 3’ pattern.

E. Securing Devices: 11 gauge, 6” x 1” x 6” metal staples of 18” pins, having 3/16” shank diameter and an attached 1-1/2” washer, for fastening the mat to the ground. Drive staples or pins so that the top of the staple or washer is flush with ground surface. Staple or pin each mat every 3’ along its center. Longitudinal overlaps must be a minimum of 3” and uniform along the entire length of the overlap and stapled or pinned every 3’ along the overlap length. Roll ends may be spliced by overlapping 1’ with the upstream mat placed on top of the downstream mat. This overlap should be secured by staples or pins at 1’ spacing across the mat.

3.9 REPAIR/RESTORATION

A. **Vegetated slopes:** Areas which fail to establish vegetative cover adequate to prevent erosion shall be reseeded as soon as such areas are identified. Contractor shall obtain approval from the CSR prior to reseeding.

B. **Plastic sheet covering:** Re-secure sheeting where wind or water have loosened the sheeting and left exposed earth.

C. **Sediment fence:** Do not allow accumulation of sediment behind fence to exceed 9-inch depth. Remove and regrade sediment into slopes. Repair and re-establish sediment fences as needed.

D. **Erosion mat:** Re-secure mat where wind or water has loosened the blanket and left exposed earth.

3.10 RE-INSTALLATION

A. Re-install temporary soil erosion control measures when they cease to function as originally intended.

3.11 MAINTENANCE AND REMOVAL

A. Temporary erosion control devices shall be removed only after they have performed their intended function and removal has been recommended by the CSR.

B. **Maintenance:** Maintain the soil erosion control features (including replacement and upgrading of the facilities when needed) through the warranty period.

C. Repair soil erosion control devices as necessary to ensure proper function.

D. **Removal:** Remove sediment fences in their entirety when no longer required by the CSR.

E. All pipes, end sections, drainage curbs, sand bags, sediment fences and other materials which are removed from temporary erosion control devices and not incorporated into the permanent work shall become the property of the Contractor and shall be removed from the area.

- END OF SECTION -

SECTION 31 25 29 - EROSION AND SEDIMENT CONTROL TURBIDITY CURTAIN

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide instream trapping devices specifically designed to limit sediment transport impacts within a body of water. Turbidity curtains and other instream sediment trapping devices shall provide sedimentation protection for in-stream, bank, or upslope ground disturbance or from dredging or filling within a waterway.

B. WORK shall include furnishing all labor, materials, and equipment required for the installation and maintenance of instream sediment trapping devices, complete and in place, in accordance with the Contract Documents

C. CONTRACTOR shall be responsible for following all applicable Federal, State, and local codes and regulations, including the State of Washington Department of Ecology requirements and best management practices.

1.2 CONTRACTOR SUBMITTALS

A. Submittals shall be in accordance with Section 01 33 00 - Contractor Submittals.

B. **Product Data:** Manufacturer's catalog sheets on turbidity curtain fabrics.

PART 2 -- PRODUCTS

2.1 FABRIC

A. Strong heavy-weight material with ultraviolet light (UV) inhibitors.

B. Tensile strength shall be sufficient to withstand predicted flows.

C. Seams and line attachments shall be sewn or vulcanized welded into place.

D. Materials shall be of bright colors to attract attention of boaters or swimmers using areas near the work site.

E. Flotation devices shall be flexible, buoyant units contained in an individual flotation sleeve or collar attached to the curtain.

2.2 ANCHORS

A. In-stream anchors shall have a floating anchor buoy or other identifying mark.

B. Shoreline turbidity curtain anchors shall be 2- by 4-inch or 1.33-lbs/lineal foot metal stakes.

C. Bottom anchors shall hold the curtain in position and may be any of the following types: plow, fluke, mushroom, or a grappling hook.

PART 3 -- EXECUTION

3.1 PREPARATION

A. Provide erosion control barriers at the indicated locations and as required preventing erosion and silt loss from the Site.

B. CONTRACTOR shall not commence clearing, grubbing, earthwork, or other activities which may cause erosion until barriers are in place.

3.2 INSTALLATION

A. For manufactured products, install per manufacturer’s instructions.

B. Install turbidity curtains parallel to flow of the watercourse.

C. Turbidity curtain shall extend the entire depth of the watercourse.

D. In areas heavily impacted by wind generated wave action; turbidity curtains should have slack to follow the rise and fall of the water level without submerging.

E. Set upstream anchor points first, then unfurl the fabric, letting the flow carry the fabric to the downstream anchor points.

3.3 MAINTENANCE AND REMOVAL

A. Follow manufacturer instructions for fabric and material repair.

B. Remove materials at low flows and in a manner to scoop and trap sediments within the fabric.

C. Regularly inspect and repair or replace damaged components of the barrier. Unless otherwise directed, maintain the erosion control system until the disturbed area is permanently stabilized or upon final acceptance; then remove erosion and sediment control systems promptly.

D. Dewater and dispose of sediments on the Site, if a location is indicated on the Drawings, or at an approved site arranged by the CONTRACTOR which is not in or adjacent to a stream or floodplain.

- END OF SECTION -

SECTION 31 30 00 – EARTHWORK AND TRENCHING

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall perform earthwork as indicated and required for construction of the WORK, complete and in place, in accordance with the Contract Documents.

B. The CONTRACTOR shall also reference the Geotechnical Exploration Report completed by The Wallace Group on June 15, 2016.

1.2 CONTRACTOR SUBMITTALS

A. The CONTRACTOR shall submit material gradations and samples of materials proposed for the WORK in conformance with the requirements of Section 01 33 00 – Contractor Submittals. Sample sizes shall be as recommended by the testing laboratory and approved by the OWNER.

B. CONTRACTOR's Detailed Excavation Plan

1. The CONTRACTOR, prior to beginning any trench or structure excavation 5 feet deep or deeper, shall submit to the OWNER and shall be in receipt of the OWNER's written acceptance of the CONTRACTOR's detailed plan showing the design of shoring, bracing, sloping of the sides of excavation, or other provisions for worker protection against the hazard of caving ground during the excavation of such trenches or structure excavation.

2. The OWNER's acceptance of said plan will be for verification of submittal of the plan with this requirement.

PART 2 -- PRODUCTS

2.1 FILL AND BACKFILL MATERIAL REQUIREMENTS

A. **General**

1. Fill, backfill, and embankment materials shall be selected or shall be processed and be clean fine earth, rock, gravel, or sand, free from grass, roots, brush, other vegetation and organic matter.

2. Fill and backfill materials that are to be placed within 6 inches of any structure or pipe shall be free of rocks or unbroken masses of earth materials having a maximum dimension larger than 3 inches.

B. **Suitable Materials**

1. Materials not defined below as unsuitable will be considered as suitable materials and may be used in fills, backfilling, and embankment construction, subject to the indicated requirements.

2. If acceptable to the OWNER, some of the material listed as unsuitable may be used when thoroughly mixed with suitable material to form a stable composite.

3. Mixing or blending of materials to obtain a suitable composite is the CONTRACTOR's option but is subject to the approval of the OWNER.

4. The CONTRACTOR shall submit certification to the OWNER that the chloride concentration in imported materials within the pipe zone does not exceed 100 ppm, when tested in accordance with the requirements of AASHTO T291-94 – Standard Method of Test for determining Water-Soluble Chloride Ion Content in Soil.

5. Suitable materials may be obtained from on-Site excavations, may be processed on-Site materials, or may be imported.

6. If imported materials are required by this Section or are required in order to meet the quantity requirements of the WORK, the CONTRACTOR shall provide the imported materials as part of the WORK.

C. **Types of Suitable Materials**. The following types of suitable materials are defined:

Type C (Civil Fill) (Not for use beneath concrete foundations): Civil Fill may consist of imported materials or natural on-site inorganic materials. Civil Fill may be a combination of Type GF, or native material, or any mixture thereof as approved by the OWNER, except as shown. Some mixing, removal of oversized particles (greater than 4-inch diameter) and/or removal of other unsuitable material may be required.

Type DRC (Drain-rock Coarse): Crushed rock or gravel meeting the requirements of Washington State Department of Transportation (WSDOT) Specification 9-03.17 Class A – Foundation Material.

Type GF (Granular Fill 3/4-inch minus): Angular crushed rock, stone or gravel, and sand conforming to the requirements listed in WSDOT specification 9-03.9(3) – Crushed Surfacing, top course and keystone.

Type BD (Pipe Bedding): Gravel backfill for pipe zone bedding and initial backfill conforming to the requirements in WSDOT specification 9-03.12(3) – Gravel Backfill for Pipe Zone Bedding.

Type SN (Sand Fill & Tank Bedding): Sand material conforming to the requirements in WSDOT specification 9-03.1(2) B – Grading, Class 2 shall be utilized as fill material under and around the circular tanks as illustrated in the Contract Documents.

Boulders: Boulders for placement along Klocke Road site frontage shall be in accordance to WSDOT specification 9-03.11(4) for Habitat Boulders, three man size minimum. Native material boulders for placement at surface water intake sheetpile weirs shall be 8-inch cobbles in accordance to WSDOT specification 9-03.11(2) for Streambed Cobbles.

Riprap: See Section 31 37 00 Riprap.

Schedule: Earth materials shall be as indicated in the Contract Drawings. Where clear definition in the drawings is not defined, the following schedule may be used to define acceptable fill materials.

Work Area	Material Type
Pipe trench – pipe zone bedding	BD
Pipe trench – pipe zone cover	BD, or C providing all materials greater than 1 inch are removed.
Pipe trench - fill or backfill	GF, C, or an approved mixture.
Under structures where groundwater is removed to allow placement of concrete	DRC, underlain by subgrade separation geotextile
Under all other foundations and structures unless noted otherwise	GF
Replace over excavation	GF or DRC, underlain by subgrade separation geotextile
Backfill around structures unless noted otherwise	DRC
Within 12” of finished grade, unless noted otherwise	GF
Asphalt and concrete pavement aggregate base	GF
Under and around fiberglass circular tanks	SN

D. **Unsuitable Materials.**

1. Soils which, when classified under ASTM D 2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System), fall in the classifications of PT, OH, CH, MH, or OL shall be classified as unsuitable materials.

2. In addition to the materials identified as unsuitable in the table above, a material shall be classified as unsuitable if one of the following conditions is present;

    a. Soils which cannot be compacted sufficiently to achieve the density specified for the intended use.

    b. Materials that contain hazardous or designated waste materials including petroleum hydrocarbons, pesticides, heavy metals, and any material which may be classified as hazardous or toxic according to applicable regulations.

2.2 MATERIALS TESTING

A. Samples

1. Soils testing of samples submitted by the CONTRACTOR will be performed by a testing laboratory of the OWNER's choice and at the CONTRACTOR's expense.

2. The OWNER may direct the CONTRACTOR to supply samples for testing of any material used in the WORK.

B. Particle size analysis of soils and aggregates will be performed using ASTM D 422 - Standard Test Method for Particle-Size Analysis of Soils.

C. Determination of sand equivalent value will be performed using ASTM D 2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.

D. Unified Soil Classification System

1. References in this Section to soil classification types and standards shall have the meanings and definitions indicated in ASTM D 2487.

2. The CONTRACTOR shall be bound by applicable provisions of ASTM D 2487 in the interpretation of soil classifications.

E. Testing for sulfate, resistivity, and pH shall be performed in accordance with WSDOT testing requirements.

F. Testing for chloride shall be performed in accordance with AASHTO T291-94 – Standard Method of Test for determining Water-Soluble Chloride Ion Content in Soil.

2.3 IDENTIFICATION TAPE

A. Unless otherwise indicated, identification tape shall be placed above buried pipelines that are not comprised of magnetic components at least in part.

B. Identification tape shall be 6-inches wide, yellow in color, composed of polyethylene, and provided with an integral metallic wire.

C. Tape shall be labeled with CAUTION – BURIED UTILITIES.

PART 3 -- EXECUTION

3.1 EXCAVATION AND BACKFILLING - GENERAL

A. General

1. Except when specifically provided to the contrary, excavation shall include the removal of materials, including obstructions that would interfere with the proper execution and completion of the WORK.

2. The removal of such materials shall conform to the lines and grades indicated or ordered.

3. The CONTRACTOR shall furnish, place, and maintain supports and shoring that may be required for the sides of excavations.

4. Excavations shall be sloped or otherwise supported in a safe manner in accordance with applicable state safety requirements and the requirements of OSHA Safety and Health Standards for Construction (29CFR1926).

B. Removal and Exclusion of Water

1. The CONTRACTOR shall remove and exclude water, including stormwater, groundwater, irrigation water, and wastewater, from excavations.

2. Dewatering wells, wellpoints, sump pumps, or other means shall be used to remove water and continuously maintain groundwater at a level at least 2 feet below the bottom of excavations before the excavation WORK begins at each location as required in accordance with Section 31 23 19 - Dewatering.

3. Water shall be removed and excluded until backfilling is complete and field soils testing has been completed.

3.2 OVER-EXCAVATION

A. Non Indicated

1. When ordered to over-excavate areas deeper and/or wider than required by the Contract Documents, the CONTRACTOR shall over-excavate to the dimensions ordered and backfill to the indicated grade. The CONTRACTOR shall be compensated for the non-indicated excavation in accordance with the Contract Documents.

B. Neither Indicated nor Ordered

1. Any over-excavation carried below the grade that is neither ordered or nor indicated shall be backfilled and compacted to the required grade with the indicated material as part of the WORK at no additional cost to the OWNER.

3.3 ROCK EXCAVATION

A. It is expected that all excavation can be accomplished using conventional equipment appropriate for the scope of the project as follows:

1. 200 Class Excavator.

B. If material is encountered which the CONTRACTOR believes cannot be excavated by conventional equipment, the OWNER shall be notified immediately. The CONTRACTOR shall provide performance tests of the specified conventional or equivalent equipment. If the OWNER confirms in writing that the conventional equipment cannot perform at the production rates indicated, the excavation will be considered rock excavation.

C. Explosives and Blasting: Blasting will not be permitted.

3.4 DISPOSAL OF EXCESS EXCAVATED MATERIAL

A. The CONTRACTOR shall be responsible for the removal and disposal of excess excavated material at an approved off-site location.

B. The CONTRACTOR shall obtain required permits and landowner and agency approvals for disposal of excess excavated material off-Site and shall submit copies of related documents to the OWNER for information prior to disposal. CONTRACTOR shall pay costs associated with the removal and disposal.

3.5 BACKFILL

A. General

1. Backfill shall not be dropped directly upon any structure or pipe.

2. Backfill shall not be placed around or upon any structure until the concrete has attained sufficient strength to withstand the loads imposed.

3. Backfill around water-retaining structures shall not be placed until the structures have been tested, and the structures shall be full of water while backfill is being placed.

B. Except for drainrock materials being placed in over-excavated areas or trenches, backfill shall be placed after water is removed from the excavation and the trench sidewalls and bottom have been dried to a moisture content suitable for compaction.

C. Pre-Placement Conditions

1. Immediately prior to placement of backfill materials, the bottoms and sidewalls of trenches and structure excavations shall have any loose, sloughing, or caving soil and rock materials removed.

2. Trench sidewalls shall consist of excavated surfaces that are in a relatively undisturbed condition before placement of backfill materials.

D. Layering

1. Backfill materials shall be placed and spread evenly in layers.

2. When compaction is achieved using mechanical equipment, the layers shall be evenly spread such that when compacted, each layer shall not exceed 6 inches in thickness.

E. During spreading, each layer shall be thoroughly mixed as necessary in order to promote uniformity of material in each layer.

F. Moisture Content

1. Where the backfill material moisture content is below the optimum moisture content, water shall be added before or during spreading until the proper moisture content is achieved.

2. Where the backfill material moisture content is too high to permit the indicated degree of compaction, the material shall be dried until the moisture content is satisfactory.

3.6 STRUCTURE, ROADWAY, AND EMBANKMENT EXCAVATION AND BACKFILL

A. Excavation Beneath Structures and Embankments

1. Except where indicated otherwise for a particular structure or where ordered by the OWNER, excavation shall be carried to an elevation 12 inches below the bottom of the footing or slab and brought back to grade with compacted materials acceptable for placement beneath structures.

2. The area where a fill or embankment is to be constructed shall be cleared of vegetation, roots, and foreign material.

3. Where indicated or ordered, areas beneath structures or fills shall be over-excavated.

4. When such over-excavation is indicated, both the over-excavation and the subsequent backfill to the required grade shall be performed by the CONTRACTOR.

5. After the required excavation or over-excavation for fills and embankments has been completed, the exposed surface shall be scarified to a depth of 6 inches, brought to optimum moisture content, and rolled with heavy compaction equipment to obtain 95 percent of maximum density.

B. Excavation Beneath Paved Areas

1. Excavation under areas to be paved shall extend to the bottom of the aggregate base or subbase, if such base is called for; otherwise it shall extend to the paving thickness.

2. After the required excavation has been completed, the top 12 inches of exposed surface shall be scarified, brought to optimum moisture content, and rolled with heavy compaction equipment to obtain 95 percent of maximum density.

3. The finished subgrade shall be even, self-draining, and in conformance with the slope of the finished pavement.

4. Areas that could accumulate standing water shall be regraded to provide a self-draining subgrade.

C. Notification of OWNER

1. The CONTRACTOR shall notify the OWNER at least 3 Days in advance of completion of any structure or roadway excavation and shall allow the OWNER opportunity for review of WORK.

D. Compaction of Fill, Backfill, and Embankment Materials

1. Each layer of backfill materials as defined herein, where the material is graded such that 10 percent or more passes a No. 4 sieve, shall be mechanically compacted to the indicated percentage of density.

2. Equipment that is consistently capable of achieving the required degree of compaction shall be used, and each layer shall be compacted over its entire area while the material is at the required moisture content.

3. Each layer of coarse granular backfill materials with less than 10 percent passing the No. 4 sieve shall be compacted by means of at least 2 passes from a vibratory compactor that is capable of obtaining the required density in 2 passes.

E. Flooding, ponding, and jetting shall not be used for backfill around structures, for final backfill materials, or aggregate base materials.

F. Heavy Equipment

1. Equipment weighing more than 10,000 pounds shall not be used closer to walls than a horizontal distance equal to the vertical depth of the fill above undisturbed soil at that time.

2. Hand-operated power compaction equipment shall be used where the use of heavier equipment is impractical or restricted due to weight limitations.

G. Layering

1. Embankment and fill material shall be placed and spread evenly in approximately horizontal layers.

2. Each layer shall be moistened and aerated as necessary.

3. Unless otherwise approved by the OWNER, no layer shall exceed 6 inches of compacted thickness including areas below structural footings or hydraulic structures.

H. Compaction Requirements

1. The following compaction requirements shall be in accordance with ASTM D 1557 - Test Method for Laboratory Compaction Characteristics of Soils Using Modified Effort (56,000 ft - lbf/ft^3) (2,700 kN-m/m^3) where the material is graded such that ten (10) percent or more passes a No. 4 sieve and in accordance with ASTM D 4253 - Test Method for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table, and D 4254 - Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density, where the material is coarse granular backfill materials with less than ten (10) percent passing the No. 4 sieve:

Location or Use of Fill or Backfill	**Percentage of Maximum Dry Density**	**Percentage of Relative Density**
Embankments and fills not	90	55

identified otherwise		
Embankments and fills beneath paved areas or structures	95	70
Backfill beneath structures and hydraulic structures	95	70
Topsoil	80	NA
Aggregate base or subbase	95	NA

3.7 PIPELINE AND UTILITY TRENCH EXCAVATION AND BACKFILL

A. Exploratory Excavations

1. The CONTRACTOR shall excavate and expose buried points of connection to existing utilities as indicated or requested by the OWNER.

2. Data, including dates, locations excavated, and dimensioned sketches, shall be submitted to the OWNER within one week of excavation.

3. Damage to utilities from excavation activities shall be repaired by the CONTRACTOR in accordance with the Contract Documents.

B. General

1. Unless otherwise indicated or ordered, excavation for pipelines and utilities shall be open-cut trenches with minimum widths as indicated in the Contract Documents.

C. Trench Bottom

1. Except where pipe bedding is required, the bottom of the trench shall be excavated uniformly to the grade of the bottom of the pipe.

2. Excavations for pipe bells and welding shall be made as required.

3. Where pipe bedding is required, the bottom of the trench shall be excavated uniformly to the grade of the bottom of the pipe bedding.

D. Open Trenches

1. The maximum amount of open trench permitted in any one location shall be the length necessary to accommodate the amount of pipe installed and tested in a single Day or that allowed by the OWNER.

2. Trenches shall be fully backfilled at the end of each Day or, in lieu thereof, shall be covered by heavy steel plates adequately braced and capable of supporting

vehicular traffic in those locations where it is impractical to backfill and the area fenced off with construction fencing and warning tape at the end of each Day.

3. These requirements for backfilling or use of steel plate will be waived in cases where the trench is located further than 100 feet from any traveled roadway or occupied structure; in such cases, however, barricades and warning lights meeting appropriate safety requirements shall be provided and maintained.

E. Embankments, Fills and Structural Backfills

1. Where pipelines are to be installed in embankments, fills, or structure backfills, the fill shall be constructed to a level at least one foot above the top of the pipe before the trench is excavated.

2. Upon completion of the embankment or structural backfill, a trench conforming to the appropriate detail may be excavated and the pipe may be installed.

F. Trench Shield

1. If a moveable trench shield is used during excavation operations, the trench width shall be wider than the shield such that the shield is free to be lifted and then moved horizontally without binding against the trench sidewalls and causing sloughing or caving of the trench walls.

2. If the trench walls cave or slough, the trench shall be excavated as an open excavation with sloped sidewalls or with trench shoring, as indicated and as required by the pipe structural design.

3. If a moveable trench shield is used during excavation, pipe installation, and backfill operations, the shield shall be moved by lifting the shield free of the trench bottom or backfill and then moving the shield horizontally.

4. The CONTRACTOR shall not drag trench shields along the trench causing damage or displacement to the trench sidewalls, the pipe, or the bedding and backfill.

G. Placing and Spreading Of Backfill Materials

1. Each layer of coarse granular backfill materials with less than 10 percent passing the No. 4 sieve shall be compacted by means of at least 2 passes from a vibratory compactor that is capable of achieving the required density in 2 passes and that is acceptable to the OWNER.

2. Where such materials are used for pipe zone backfill, vibratory compaction shall be used at vertical intervals of the lesser of:

   a. one-half the diameter of the pipe; or

   b. 6 inches, measured in the compacted state.

3. In addition, these materials shall be subjected to vibratory compaction at the springline of the pipe and the top of the pipe zone backfill, regardless of whether that dimension is less than 6 inches or not.

4. Each layer of backfill material with greater than 10 percent passing the No. 4 sieve shall be compacted using mechanical compactors suitable for the WORK.

5. The material shall be placed and compacted under the haunch of the pipe and up each side evenly so as not to move the pipe during the placement of the backfill.

6. The material shall be placed in lifts that will not exceed 6 inches when compacted to the required density within 18 inches of the top of the pipe. Material above 18 inches of the pipe shall be placed in lifts that will not exceed 9 inches when compacted to the required density. Material within 18 inches of the finish grade over the trench in paved areas shall be placed in lifts that will not exceed 6 inches when compacted to the required density unless noted otherwise or approved by the OWNER.

H. Mechanical Compaction

1. Backfill around and over pipelines that is mechanically compacted shall be compacted using light, hand-operated vibratory compactors and rollers that do not damage the pipe.

2. After completion of at least 2 feet of compacted backfill over the top of pipeline, compaction equipment weighing no more than 8,000 pounds may be used to complete the trench backfill.

I. Pipe And Utility Trench Backfill

1. Pipe Zone Backfill

a. Definitions

1) The pipe zone is defined as that portion of the vertical trench cross-section lying between a plane below the bottom surface of the pipe and a plane at a point above the top surface of the pipe as indicated.

2) The bedding is defined as that portion of pipe zone backfill material between the trench subgrade and the springline of the pipe.

3) The cover is defined as that portion of the pipe zone backfill material between the bedding and a level line a minimum of 12 inches above the pipe or as indicated.

b. Final Trim

1) After compacting the bedding, the CONTRACTOR shall perform a final trim using a stringline for establishing grade, such that each pipe section when first laid will be continually in contact with the bedding along the extreme bottom of the pipe.

2) Excavation for pipe bells and welding shall be made as required.

c. The pipe zone shall be backfilled with the indicated backfill material.

d. Pipe zone backfill materials shall be manually spread evenly around the pipe, maintaining the same height on both sides of the pipe such that when compacted the pipe zone backfill will provide uniform bearing and side support.

e. The CONTRACTOR shall exercise care in order to prevent damage to fittings or fitting coatings and to the pipe itself during the installation and backfill operations.

2. Trench Zone Backfill

a. After the pipe zone backfill has been placed, backfilling of the trench zone may proceed.

b. The trench zone is defined as that portion of the vertical trench cross-section lying as indicated between a plane above the top surface of the pipe and a plane at a point 18 inches below the finished surface grade, or if the trench is under pavement, 18 inches below the bottom of pavement.

3. Final Backfill

a. Final backfill is defined as backfill in the trench cross-sectional area within 18 inches of finished grade, or if the trench is under pavement, backfill within 18 inches of the bottom of pavement.

J. Identification Tape

1. Install identification tape as indicated.

K. Trench Shield

1. If a moveable trench shield is used during backfill operations, the shield shall be lifted to a location above each layer of backfill material prior to compaction of the layer.

2. The CONTRACTOR shall not displace the pipe or backfill while the shield is being moved.

L. Compaction Requirements

1. The following compaction test requirements shall be in accordance with ASTM D 1557 - Test Method for Laboratory Compaction Characteristics of Soils Using Modified Effort (56,000 ft - lbf/ft^3) (2,700 kN-m/m^3) where the material is graded such that 10 percent or more passes a No. 4 sieve, and in accordance with ASTM D 4253 - Standard Test Method for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table, and D 4254 - Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density where the material is coarse granular backfill materials with less than 10 percent passing the No. 4 sieve.

Location or Use of Fill or Backfill	Percentage of Maximum Dry Density	Percentage of Relative Density
Pipe embedment backfill for flexible pipe.	95	70
Pipe bedding and over-excavated zones under bedding for flexible pipe, including trench plugs.	95	70
Pipe zone backfill portion above embedment for flexible pipe	95	70
Pipe embedment backfill for rigid pipe	90	55
Pipe zone backfill portion above embedment for rigid pipe.	95	70
Pipe bedding and over-excavated zones under bedding for rigid pipe.	95	70
Final backfill, beneath paved areas or structures.	95	70
Final backfill, not beneath paved areas or structures.	90	55
Trench zone backfill, beneath paved areas and structures, including trench plugs.	95	70
Trench zone backfill, not beneath paved areas or structures, including trench plugs.	95	70

3.8 FIELD TESTING

A. General:

1. Field soils testing will be performed by a testing laboratory in accordance with the Contract Documents.

B. Density

1. Where soil material is required to be compacted to a percentage of maximum density, the maximum density at optimum moisture content will be determined in accordance with Method C of ASTM D 1557.

2. Where cohesionless, free draining soil material is required to be compacted to a percentage of relative density, the calculation of relative density will be determined in accordance with ASTM D 7382.

3. Field density in-place tests will be performed in accordance with ASTM D 1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method, ASTM D 2922 - Standard Test Methods for Density of Soil and Soil-Aggregate in Place By Nuclear Methods (Shallow Depth), or by such other means acceptable to the OWNER.

C. Remediation

1. In case the test of the fill or backfill shows non-compliance with the required density, the CONTRACTOR shall accomplish such remedy as may be required to ensure compliance.

2. Subsequent testing to show compliance shall be in accordance with the Contract Documents.

- END OF SECTION -

SECTION 31 37 00 - RIPRAP

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide riprap, including associated earthwork, complete and in place, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

ASTM C 88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 535	Standard Test Method for Resistance to Degradation of Large Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
AASHTO T 85	Standard Method of Test for Specific Gravity and Absorption of Coarse Aggregate
AASHTO T 210	Method of Test for Aggregate Durability Index.

1.3 CONTRACTOR SUBMITTAL

A. Furnish submittals in accordance with Section 01 33 00 – Contractor Submittals.

B. Testing certificates from a qualified testing agency shall be submitted prior to acceptance of the rock source to verify the conformity to the requirements of the Contract Documents.

PART 2 -- PRODUCT

2.1 STONES FOR RIPRAP

A. Stones shall be graded in size to produce a reasonably dense mass. Riprap shall consist of dense, natural rock fragments. Stones shall be resistant to weathering and to water action; free from overburden, spoil, shale, and organic material; and shall meet the gradation requirements below. Shale and stones with shale seams are not acceptable.

B. Riprap shall conform to the size types as follows:

1. Type I (6-inch Average Size):

Diameter	Percentage Passing
12-inch	95 - 100
6-inch	25 - 75
3-inch	0 - 10

2. Type II (12-inch Average Size):

Diameter	Percentage Passing
18-inch	95 - 100
12-inch	25 - 75
6-inch	0 - 5

3. Type III (18-inch Average Size):

Diameter	Percentage Passing
24-inch	95 - 100
18-inch	25 - 75
13-inch	0 - 5

4. Type IV (24-inch Average Size):

Diameter	Percentage Passing
30-inch	95 - 100
24-inch	25 - 75
18-inch	15 - 25
12-inch	0 - 5

C. The greatest dimension of 50 percent of the stones shall be at least two-thirds but not more than 1-1/2 times the diameter of the average size. Neither the breadth nor thickness of any piece of riprap shall be less than one-third its length. Material shall be of shapes which will form a stable protection structure of required depth. Rounded boulders or cobbles shall not be used.

D. Stones shall consist of durable, sound, hard, angular rock meeting the following requirements for durability absorption ratio, soundness test, and abrasion test:

Durability Absorption Ratio	**Acceptability**
Greater than 23	Passes
10 to 23	Passes only if Durability Index is 52 or greater
Less than 10	Fails
Durability Absorption Ratio	Durability Index (Coarse) % absorption + 1

E. The durability index and percent absorption shall be determined by AASHTO T 210 and AASHTO T 85, respectively. The minimum apparent specific gravity of the stones shall be 2.5 as determined by AASHTO T 85.

F. Stones shall have less than 10 percent loss of weight after five cycles, when tested per ASTM C 88.

G. Stones shall have a wear not greater than 40 percent, when tested per ASTM C 535.

H. Control of gradation shall be by visual inspection. The CONTRACTOR shall furnish a sample of the proposed gradation of at least 5 tons or 10 percent of the total riprap weight, whichever is less. If approved, the sample may be incorporated into the finished riprap at a location where it can be used as a frequent reference for judging the gradation of the remainder of riprap.

I. The acceptability of the stones will be determined by the ENGINEER prior to placement. Any difference of opinion between the ENGINEER and the CONTRACTOR shall be resolved by dumping and checking the gradation of two random truckloads of stones. Arranging for and the costs of mechanical equipment, a sorting site, and labor needed in checking gradation shall be the CONTRACTOR’s responsibility.

2.2 GEOTEXTILE FABRIC

A. Geotextile fabric shall conform to the requirements of Section 31 05 19 - Geotextiles.

2.3 FILTER MATERIAL

A. Filter material shall be clean and free from organic matter. It shall be crushed rock or gravel, durable and free from slaking or decomposition under the action of alternate wetting or drying. The material shall be uniformity graded and shall conform to the following gradation:

1. Type 1

Size	Percentage Passing
3-inch	85 – 100
1-1/2 inch	45 – 75
3/4-inch	10 – 25

PART 3 -- EXECUTION

3.1 SURFACE PREPARATION

A. Surfaces to receive riprap shall be smooth and firm, free of brush, trees, stumps, and other objectionable material, and shall be brought to the line and grade indicated.

B. If a boulder is encountered during excavation of areas where large riprap is to be placed, the CONTRACTOR shall excavate around the boulder. If the boulder is larger than the largest allowable stone size for that area, the CONTRACTOR shall break up the boulder to an acceptable size or remove it entirely.

C. Prior to placement of the geotextile, the surface shall be prepared to a smooth condition free of debris, depressions, or obstructions which may damage the geotextile. The geotextile shall be overlapped a minimum of 2-feet at longitudinal and transverse joints. Upstream sheets shall overlap downstream sheets. For slope placement, each strip shall overlap the next downhill strip. The geotextile shall be anchored using key trenches or aprons at the crest and toe of the slope. Pins may be used in securing the geotextile during installation. In no instance shall the geotextile be left exposed to sunlight longer than 7 Days. Overexposed geotextile shall be removed and replaced.

3.2 PLACEMENT OF FILTER BLANKET

A. Area of riprap placement shall be excavated to the bottom of the filter blanket as indicated and in accordance with Section 31 30 00 – Earthwork. After the excavation has been completed, the top 12-inches of exposed surface shall be scarified, brought to optimum moisture content, and compacted to 95 percent of maximum density. The finished grade shall be even, self-draining, and in conformance with the slope of the finished grade.

B. Placement of filter material shall be in accordance with Section 31 30 00. Filter material shall be placed, spread, and compacted in lifts not to exceed 12-inches.

C. The CONTRACTOR shall remove any portion of the filter blanket that has been disturbed to the degree that the layers become mixed. Replace the removed portion with the required sizes.

D. Filter material shall be placed as follows, unless otherwise indicated.

   1. For Type II, III and IV riprap, use 12-inches of Type 1 filter material.

   2. For Type I riprap, use 6-inches of Type 2 filter material.

E. No filter material is required if riprap is placed directly on bedrock.

3.3 PLACEMENT OF RIPRAP

A. Placement of riprap shall begin at the toe of the slope and proceed up the slope. The stones may be placed by dumping and may be spread by bulldozers or other suitable equipment as long as the underlying material is not displaced. Stones shall be placed so as to provide a minimum of voids. Smaller stones shall be uniformly distributed throughout the mass. Sufficient hand work shall be done to produce a neat and uniform surface, true to the lines, grades, and sections indicated.

B. Where riprap is placed over a geotextile fabric, the riprap shall be placed so as to avoid damage to the geotextile. Stones shall not be dropped from a height greater than 3-feet, nor shall large stones be allowed to roll downslope.

- END OF SECTION -

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SECTION 32 31 13 – CHAIN LINK FENCING AND GATES

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide chain link fencing and gates and appurtenant WORK, complete and operable, in accordance with the Contract Documents.

B. **Single Manufacturer**: Chain link fencing, gates, accessories, fittings, and fastenings shall be products of a single manufacturer.

C. Entrance gate shall have motor operated slide operator with accompanying controls, card key reader, sensor, and intercom. Coordinate gate operator and controls with project Section 28 50 00 - Card Key System, Door Access.

1.2 CONTRACTOR SUBMITTALS

A. **General:** Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.

B. Shop Drawings

1. Manufacturer’s technical data, product specifications, standard details, certified product test results, installation instructions and general recommendations.

2. Scale layout of fencing, gates, and accessories. Drawings shall show fence height, post layout, including sizes and sections; post setting and bracing configuration, details of gates and corner construction, barbed wire support arms and other accessories which may be necessary.

C. **Samples:** Samples of proposed fence components, at least 12-inches long, to illustrate the selected color and finish.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Dimensions indicated herein for roll-formed pipe and H-sections are outside dimensions, excluding coatings.

B. Fence fabric height shall be as indicated on the Contract Documents.

C. Fencing materials shall be hot-dip galvanized after fabrication.

D. Provide main entrance gate slide actuator and controls as specified.

2.2 STEEL FABRIC

A. Fence fabric shall be No. 9 gauge steel wire, 2-inch mesh, with top selvages knuckled and bottom selvages twisted and barbed.

B. **Fabric Finish**: Fabric shall be fusion bonded epoxy coated / polyester powder coated with a deep forest green color.

2.3 FRAMING AND ACCESSORIES

A. **Steel Framework, General**: Unless otherwise indicated, framework components shall be fabricated of galvanized steel conforming to ASTM A 53 - Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless, or ASTM A 123 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products, with not less than 1.8 ounces zinc per square feet of coated surface.

1. All fittings and accessories from approximately 1-inch above grade to the bottom of the buried members shall be galvanized in accordance with ASTM A-153 - Zinc Coating (Hot-Dip) on Iron and Steel Hardware, with zinc weights per Table I of that standard, except that no coating shall be less than 1.8-ounce zinc per square foot of coated surface.

B. **End, Corner and Pull Posts**: Posts shall be one-piece without circumferential welds, 3-inch schedule 40 pipe, 5.79 pounds per linear foot.

C. **Line Posts**: Line posts shall be spaced no more than 10-feet on center and shall be 2-1/4 inch “H” column section, 4.1-pounds per linear foot, or schedule 40, 2-1/2 inch pipe, 3.65-pounds per linear foot.

D. **Gate Posts**: Gate posts shall be 4-inch schedule 40 pipe, 9.1-pounds per linear foot.

E. **Top Rail**: Top railing shall be provided in manufacturer’s longest lengths, with expansion type couplings, approximately 6-inches long, for each joint. Fence design shall provide positive, secure attachment of top rail to each gate post, corner post, pull post and end post. Top rail and braces shall be 1-5/8 inch schedule 40 pipe, 2.27-pounds per linear foot, or 1-1/2 inch “H” column section, 2.00-pounds per linear foot.

F. **Tension Wire**: Tension wire shall be located at the bottom of the fabric and shall consist of No. 7 gauge coated coil spring wire of metal and finish to match fabric. Tension wire shall be interlaced with the fabric or attached to the fabric along the extreme bottom of the fence. Tension wire attachment shall be with fabric tie wires at a spacing of no more than 24-inches apart.

G. **Fabric Tie Wires**: Fabric tie wires shall be No. 9 gauge galvanized steel wire of the same finish as the fabric. Aluminum ties shall not be used. Ties shall be spaced 14-inches apart on posts and 24-inches apart on rails.

H. **Post Brace Assembly**: Post brace assembly shall be manufacturer’s standard adjustable brace assembly provided at each end post, gate post and at both sides of each corner post and intermediate brace post. Material used for brace shall be same as top rail. Truss bracing between line posts shall be achieved with 0.375-inch diameter rod and adjustable tensioner.

I. **Post Tops**: Post tops shall be weather-tight closure caps, designed for containment of top rail and positive permanent attachment to post. One cap shall be provided for each post.

J. **Stretcher Bars**: Stretcher bars shall be one-piece lengths equal to the full height of the fabric, with minimum cross-section of 3/16-inch by 3-1/2 inch. One stretcher bar shall be provided for each gate and end post, and 2 for each corner and intermediate brace post.

K. **Stretcher Bar Bands**: Stretcher bar bands shall be one-piece fabrications designed to secure stretcher bars to end, corner, intermediate brace, and gate posts. Bands shall have a minimum cross-section of 1/8-inch by 3/4-inch. Stretcher bar bands shall be spaced no more than 15-inches on center.

2.4 GATES

1. **Fabrication**: Perimeter frames of gates shall be fabricated from same metal and finish as fence framework. Gate frames shall be assembled by welding or with fittings and rivets for rigid, secure connections. Welds shall be ground smooth. Gate frames and any ungalvanized hardware, shall be hot-dip galvanized after fabrication. Horizontal and vertical members shall be provided to ensure proper gate operation and attachment of fabric, hardware and shall be hot-dip galvanized after fabrication.

   a. Fabric for gates shall match fence fabric, unless otherwise indicated. Fabric shall be installed with stretcher bars at all perimeter edges. Stretcher bars shall be attached to gate frame with stretcher bar bands spaced no more than 15-inches on center.

   b. Each gate shall be diagonally cross-braced with a 3/8-inch diameter adjustable length truss rod to ensure frame rigidity without sag or twist.

   c. Where barbed wire is indicated above gates, vertical members shall be extended and fabricated as required to receive barbed wire supporting arms.

2. **Swing Gates**: Perimeter frames of swing gates shall be constructed of the same pipe or “H” column members as the top rails and shall be fabricated by welding. Welds shall be ground smooth prior to finish coating process being applied.

3. Hardware and accessories shall be provided for each gate, fusion bonded epoxy coated, and in accordance with the following:

   a. Hinges: Hinges shall be of size and material to suit gate size, non-lift-off type, offset to permit 180-degree gate opening. Three hinges shall be provided for each leaf 6-feet or more in height

   b. Latch: Latch shall be forked type or plunger-bar type, permitting operation from either side of the gate, with padlock eye as an integral part of the latch.

   c. Keeper: Keeper shall be provided which automatically engages the gate leaf and holds it in the open position until it is manually released.

   d. Double Gates: Gate stops shall be provided for double gates, consisting of mushroom type flush plate with anchors, set in concrete, and designed to engage center drop rod or plunger bar. Locking device and padlock eyes shall be provided as an integral part of the latch, permitting both gate leaves to be locked with a single padlock.

4. **Slide Gate and Motorized Gate Operator**: Where shown on the contract drawings Contractor shall install motorized gate operators for controlled access entering the facility and automatic operation for exiting the facility.

   a. Operation: The electrical gate operator shall be activated by the following methods:

      i. Wireless transmitter: The motorized gate operator shall be activated by a wireless transmitter for entering and leaving the facility. The Contractor shall provide the Owner with (3) transmitters, and provide the owner with information for the purchase of additional transmitters.

      ii. Through intercom from the entrance gate to the administration office area.

      iii. Pedestal Mounted Keypad: The contractor shall install a pedestal mounted Keypad with integral light at the entrance to the facility. The Keypad shall allow the users to enter a (4) four digit code for entry into the facility. The code shall be user adjustable.

      iv. Card key access per Section 28 50 00, with a card key reader located at the entrance gate.

      v. Timer Operation: The motorized gate operator shall contain and integral Timer that allows the Owner to set the time and interval that the gate opens and stays open for operating hours each day.

      vi. Vehicle Detector with Sensing Loop: When exiting the facility if the gate is closed the operator shall be activated a vehicle detector loop that opens the gate. The gate shall be closed when a second vehicle detector loop senses that the vehicle has passed through the gate.

      vii. Fire Department key station, allowing first responders to use a key to initiate gate open operation.

      viii. Manual Override: The motorized gate operator shall have a manual disconnect so the Owner can use a crank handle to operate the gate manually.

   b. Intercom:

      i. A two-way intercom system shall be provided at the slide entrance gate, mounted such that an entering vehicle can access from the drivers side window. The intercom shall communicate a unit in the administration office area and shall communicate by copper wire. Radio communications shall not be used. Through the intercom, the unit in the office area shall be capable of initiating slide gate operation.

   c. Motor Size:

      i. The electric motor shall be sized by the manufacturer to operate the gate size as shown on the Contract Drawings.

   d. AC Drive

i. The AC drive unite shall allow for programmable speeds and a programmable soft start and soft-stop features.

e. Overload Protection

i. Motors shall be protected against overload by either a thermal or a current sensing overload device.

f. Gear Reducer

i. The self-enclosed gear-head gearbox shall be manufactured as a single unit, and shall consist of a hardened steel, machine cut worm and mating bronze gear running in oil bath. Oil shall be a #634 specialty oil with a fluid pour point of –44 degrees F. The gearbox shall contain an adjustable clutching device, and manual disconnect by crank handle

g. Gear Box Heater

i. The operator shall include interal gearbox heater and a heater strip for the control box

h. Limits

i. The operator shall be equipped with an integral limit system, providing accurate settings to control the open and close positions of the gate, and shall not be affected by manual operation or motor removal.

i. Control Circuit

i. Operator shall have U.L. Listed Controls

j. Control Wiring

i. The Contractor shall supply all wiring and conduit for the installation of the motorized operator.

2.5 RELATED ITEMS

A. **Concrete:** Concrete shall be provided according to Section 03 30 00 - Cast-In-Place Concrete.

B. Nuts, bolts and screws shall be steel, minimum size 3/8-inch diameter, hot-dip galvanized after fabrication.

2.6 MANUFACTURERS

A. **Manufacturer's Qualifications**: Chain link fencing and gates shall be products of a single manufacturer which has been successfully engaged in the production of such items for a period of at least 5 years.

B. **Installer's Qualifications**: Installation of the chain link fence shall be by the manufacturer or by a firm accepted and licensed by the manufacturer.

C. Manufacturers, or equal

1. American Fence Corp.

2. Anchor Fence, Inc.

3. United States Steel

PART 3 -- EXECUTION

3.1 INSPECTION

A. Prior to commencing installation, require Installer to inspect all areas and conditions within which WORK of this Section will be performed. Dimensions and clearances shall be verified. Final grading shall be completed and all earth, brush, or other obstructions which interfere with the proper alignment and construction of fencing shall be removed.

3.2 INSTALLATION

A. **General**: Unless otherwise indicated, all posts shall be set in concrete. Gate and related posts, corner posts, and other critical elements shall be provided with concrete foundations which are designed by an engineer to safely accommodate the loads to which they will be subjected. The soils report is appended to the Contract Documents and contains information regarding soil properties in the vicinity of the Site.

B. **Excavation**: Holes for posts shall be drilled or hand excavated to the diameters and spacings indicated, in firm, undisturbed or compacted soil. Post foundations which are not designed by an engineer shall comply with the following:

1. Holes shall be excavated to a diameter not less than 12-inches or not less than 5 times the largest dimension of the item being anchored, whichever is larger.

2. Depth for holes shall be not less than 40-inches; excavated approximately 4-inches lower than the post bottom, with bottom of posts set not less than 36-inches below finish grade surface.

C. **Setting Posts**: Line posts shall be spaced at not more than 10-foot intervals, measured from center to center of the posts, parallel to the ground slope. Posts shall be set plumb and shall be centered in holes, 4-inches above the bottom of the excavation, with posts extending not less than 36-inches below finish grade surface.

1. Corner posts shall be installed where changes in the fence lines equal or exceed 15 degrees, measured horizontally.

2. Each post shall be properly aligned vertically and its top aligned parallel to the ground slope. Posts shall be maintained in proper position during placement and finishing operations.

D. Concrete

1. Concrete for footings may be placed without forms, providing the ground is firm enough to permit excavation to neat line dimensions. Prior to placing concrete, the

earth around the hole shall be thoroughly moistened. Remove soil and debris from excavation prior to filling the hole with concrete.

2. Encasement concrete for footings shall be placed immediately after mixing in a manner such that there will be no concentration of the large aggregates. The concrete shall be consolidated by tamping or vibrating.

3. Concrete footings shall have a neat appearance and shall be extended 2-inches above grade and troweled to a crown to shed water.

4. A minimum of 7 days shall elapse after placing the concrete footings before the fence fabric or barbed wire is fastened to the posts.

E. **Bracing**: Bracing shall be provided at all ends, corners, gates, and intermediate brace posts. Corner posts and intermediate brace posts shall be braced in both directions. Horizontal brace rails shall be set midway between the top rail and the ground, running from the corner, end, intermediate brace or gate post to the first line post. Diagonal tension members shall connect tautly between posts below horizontal braces.

1. Braces shall be so installed that posts remain plumb when diagonal rod is under proper tension.

F. **Intermediate Brace Posts**: Where straight runs of fencing exceed 500-feet, intermediate brace posts shall be installed, spaced equally between ends or corners; with additional posts provided as required, such that the spacing between intermediate brace posts does not exceed 500-feet. Intermediate brace posts shall be equivalent in size to corner posts and shall be braced with horizontal brace rails and diagonal tension members in both directions.

G. **Top Rails**: Top rails shall be run continuously through post caps, bending to radius for curved runs. Expansion couplings shall be provided as recommended by the fencing manufacturer.

H. **Center Rails**: Center rails shall be provided where indicated. Rails shall be installed in one piece, between posts and flush with posts on fabric side, using special offset fittings where necessary.

I. **Tension Wire**: Continuous bottom tension wire shall be stretched tight with turnbuckles at end, gate, intermediate, and corner posts. Tension wire shall be installed on a straight grade between posts, with approximately 2-inches of space between finish grade and bottom selvage, unless otherwise indicated. Tension wire shall be tied to each post with not less than 6 gauge galvanized wire.

J. Fabric

1. Chain-link fabric shall be fastened on the secured side of the posts.

2. Fabric shall be stretched and securely fastened to posts. Between posts, top and bottom edges of the fabric shall be fastened to the top rail and bottom tension wire, respectively.

3. Fabric shall be stretched and anchored in such a manner that it remains in tension after the pulling force is released.

K. **Tie Wires**: Tie wire shall be bent to conform to the diameter of the pipe to which it is attached, clasping pipe and fabric firmly with ends twisted at least two full turns. Ends of wire shall be bent back to minimize hazard to persons or clothing.

1. Fabric shall be tied to line posts with tie wires spaced at 12-inches on center.

2. Fabric shall be tied to rails and braces with tie wires spaced at 24-inches on center.

3. Fabric shall be tied to tension wires, with hog rings spaced 24-inches on center.

L. **Stretcher Bars**: Fabric shall be fastened to end, corner, intermediate brace, and gate posts with stretcher bars. Bars shall be threaded through or clamped to fabric at 4-inches on center and secured to posts with stretcher bar bands spaced no more than 15 inches on center.

M. **Fasteners:** Nuts for tension bands and hardware bolts shall be installed on the side of fence opposite the fabric side. Ends of bolts shall be peened or the threads scored to prevent removal of nuts.

N. All epoxy coating that is damaged during construction of the fencing shall be repaired by application of the manufacturers recommended liquid epoxy field repair methods.

3.3 GROUNDING

A. Fences crossed by powerlines of 600 volts or more shall be grounded at or near the point of crossing and at distances not exceeding 150-feet on each side of the crossing.

B. Fences, gates and appurtenances enclosing electrical equipment areas, gas yards, or other hazardous areas shall be electrically continuous and grounded.

C. Ground conductor shall consist of No. 8 AWG solid copper wire. Grounding electrodes shall be 3/4-inch by 10-foot long copper-clad steel rod. Electrodes shall be driven into the earth so that the top of the electrode is at least 6-inches below grade.

1. Where driving is impracticable, electrodes shall be buried a minimum of 12-inches deep and radically from the fence. Top of electrode shall be not less than 2-feet or more than 8-feet from the fence.

D. Ground conductor shall be clamped to the fence and electrodes with bronze grounding clamps so as to create electrical continuity between fence posts, fence fabric, and ground rods. After installation, the total resistance of fence to ground shall not be greater than 25 ohms.

- END OF SECTION -

SECTION 33 11 21 - PVC PRESSURE PIPE, RUBBER JOINTS (AWWA C900/C905 MODIFIED)

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide polyvinyl chloride (PVC) pressure pipe, complete in place, in accordance with the Contract Documents.

B. **Pipe Material Group No. 19**. The piping system defined in this section is referred to in the Pipe Schedule on the Drawings as Piping Material Group No.19.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

AWWA C104/A21.5	Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C110/A21.10	Ductile-Iron and Gray-Iron Fittings 3-in Through 48-in for Water and Other Liquids
AWWA C111/A21.11	Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C600	Installation of Ductile-Iron Water Mains and Appurtenances
AWWA C900	Polyvinyl Chloride (PVC) Pressure Pipe 4-in Through 12-in for Water Distribution
ASTM D 2584	Test Method for Ignition Loss of Cured Reinforced Resins
PPI Technical Report TR 3/4	Policies and Procedures for Developing Recommended Hydrostatic Design Stresses for Thermoplastic Pipe Materials
AWWA Manual M23	PVC Pipe - Design and Installation

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.

B. **Shop Drawings:** Drawings of pipe, fittings, and appurtenances. Design calculations to demonstrate compliance of pipe and fittings with this Section. Manufacturer's literature for metallic locating tape.

C. **Certifications:** A certified affidavit of compliance for pipe and other products or materials under this Section and the following supplemental requirements:

1. Hydrostatic proof test reports.

2. Sustained pressure test reports.

3. Burst strength test reports.

D. The CONTRACTOR shall be responsible for performing and paying for sampling and testing as necessary for the certifications.

1.4 QUALITY CONTROL

A. **Inspection:** Pipe shall be subject to inspection at the place of manufacture. The CONTRACTOR shall notify the ENGINEER in writing of the manufacturing starting date not less than 14 Days prior to the start of any phase of the pipe manufacture.

B. During manufacture of the pipe, the ENGINEER shall be given access to all areas where manufacturing is in process and shall be permitted to make all inspections necessary to confirm compliance with the Specifications.

C. **Tests:** Materials used in manufacture of the pipe shall be tested in accordance with the requirements of this Section and the referenced standards, as applicable.

D. The CONTRACTOR shall perform said material tests. The ENGINEER shall have the right to witness testing; provided, that the CONTRACTOR'S schedule is not delayed for the convenience of the ENGINEER.

E. In addition to those tests specifically required, the ENGINEER may request additional samples of any material for testing by the OWNER. The additional samples shall be furnished as a part of the WORK.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Piping System 19 PVC pressure pipe shall conform to the applicable requirements of AWWA C900/905 DR 25 subject to additional requirements herein.

2.2 PIPE DESIGN CRITERIA

A. **General:** PVC pressure pipe wall thickness for internal pressure shall be designed in accordance with the requirements of AWWA M23, as applicable, and the supplemental requirements in this Section.

B. **Determination of External Loads:** The dead (earth) loads shall be computed using the following two equations for trench or embankment conditions, as applicable:

1. Trench Condition:

$$W_d = HwB_c$$

Where: W_d = earth load in pounds per linear foot

H	=	height of soil cover, feet
w	=	130 lb/cu ft
B_c	=	outside diameter of pipe, feet

2. Positive Projecting Embankment Condition:

$$W_c = C_c w B_c^2$$

Where:	W_c	=	Earth load in pounds per linear foot
	C_c	=	Calculation coefficient (based on $r_{sd}P$ of 0.75)
	Ku	=	0.19
	w	=	130 lb/ft^3
	B_c	=	Outside diameter of pipe, feet

C. The truck live loads shall be determined using the method recommended by AASHTO in "Standard Specifications for Highway Bridges." For depths of cover less than 10 feet HS-20 live loads shall be added to the earth loads to determine the total load. For depths of cover 3 feet or less, HS-20 live load plus impact shall be included.

D. **Deflection Control:** The deflection of the pipe after installation, as determined from the Modified Iowa Formula outlined in AWWA M23, shall not exceed 0.03 times the outside diameter. If the calculated deflection exceeds 0.03 times the outside diameter the pipe class shall be increased or the quality of the pipe zone backfill shall be improved to achieve a higher modulus of soil reaction, E'. For purposes of calculation, values of E' shall be 1100 psi at 90 percent Standard Proctor; 1500 psi at 95 percent Standard Proctor; and 2500 psi at 100 percent Standard Proctor. Similarly, the deflection lag factor shall be 1.5.

2.3 PIPE

A. The pipe shall be of the diameter indicated, shall be furnished complete with rubber gaskets, and all specials and fittings shall be provided as required in the Contract Documents. The dimensions and pressure classes for Dimension Ratios for large PVC pressure pipe with Cast-Iron Pipe Equivalent O.D.'s shall conform to the requirements of AWWA C900/905.

B. **Additives and Fillers:** Unless otherwise allowed in alternate qualification procedures of PPI-TR3, compounds which have a Hydrostatic Design Basis (HDB) of 4000 psi at 73.4 degrees F and for water shall not contain additives and fillers that exceed the recommended values in Table 1, Part Y of PPI-TR3 (e.g., allowable content range for calcium carbonate is 0.0-5.0 parts per hundred of resin). If requested by the ENGINEER, the additive and filler content shall be determined using the pyrolysis method as specified in ASTM D 2584.

C. **Joints:** Joints for the buried PVC pipe shall be either an integral bell manufactured on the pipe or a separate coupling both employing a rubber ring joint. The bell and coupling shall be the same thickness as of the pipe barrel, or greater thickness. The sealing ring groove in the coupling shall be of the same design as the groove in cast iron fittings and valves available from local water works supply distributors. Where indicated, restrained joint pipe shall be ductile iron pipe. No restrained joint PVC pipe will be allowed.

D. **Joint Deflection:** Deflection at the joint shall not exceed 1.5 degrees or the maximum deflection recommended by the manufacturer. No deflection of the joint shall be allowed for joints that are over-belled or not belled to the stop mark.

2.4 FITTINGS

A. Fittings shall be ductile iron and shall conform to the requirements of AWWA C110, Class 250 per Section 33 92 20, mechanical joint, except where flanges are indicated

B. Each fitting shall be clearly labeled to identify its size and pressure class.

PART 3 -- EXECUTION

3.1 GENERAL

A. Laying, jointing, testing for defects and for leakage shall be performed in the presence of the ENGINEER, and shall be subject to approval before acceptance. Material found to have defects will be rejected and the CONTRACTOR shall promptly remove such defective materials from the Site.

B. Installation shall conform to the requirements of AWWA M23, instructions furnished by the pipe manufacturer, and to the supplementary requirements herein. Wherever the provisions of this Section and the aforementioned requirements are in conflict, the more stringent provision shall apply.

3.2 HANDLING AND STORAGE

A. **Handling:** Pipe, fittings and accessories shall be carefully inspected before and after installation and those found defective shall be rejected. Pipe and fittings shall be free from fins and burrs. Before being placed in position, pipe, fittings, and accessories shall be cleaned, and shall be maintained in a clean condition. Proper facilities shall be provided for lowering sections of pipe into trenches. Under no circumstances shall pipe, fittings or any other material be dropped or dumped into trenches.

B. **Storage:** Pipe should be stored, if possible, at the Site in unit packages provided by the manufacturer. Caution should be exercised to avoid compression damage or deformation to bell ends of the pipe. Pipe should be stored in such a way as to prevent sagging or bending and be protected from exposure to direct sunlight by covering with an opaque material while permitting adequate air circulation above and around the pipe. Gaskets should be stored in a cool, dark place out of the direct rays of the sun, preferably in original cartons.

3.3 TRENCHING AND BACKFILL

A. Trench excavation and backfill shall conform to the requirements of Section 31 30 00 - Earthwork.

3.4 INSTALLATION

A. Bell-and-spigot pipe shall be laid with the bell end pointing in the direction of laying. Pipe shall be graded in straight lines, taking care to avoid the formation of any dips or low points. Pipe shall not be laid when the conditions of trench or weather are unsuitable. At the end of each day's work, open ends of pipe shall be closed temporarily with wood blocks or bulkheads.

B. Pipe shall be supported at its proper elevation and grade, care being taken to secure firm and uniform support. Wood support blocking will not be permitted. The full length of each section of pipe and fittings shall rest solidly on the pipe bed, with recessed excavation to accommodate thrust blocks, bells, joints, and couplings. Anchors and supports shall be provided where indicated and where necessary for fastening work into place. Fittings shall be independently supported.

C. Short lengths of pipe shall be used in and out of each rigid joint or rigid structure. Piping that does not allow sufficient space for proper installation of jointing material shall be replaced by one of proper dimensions. Blocking or wedging between bells and spigots will not be permitted.

D. Joints shall be installed according to manufacturer's recommendations. Trenches shall be kept free of water until joints have been properly made. The maximum combined deflection at any coupling shall be in accordance with the manufacturer's recommendations.

E. Pipe shall be cut by means of saws, power driven abrasive wheels, or pipe cutters, which will produce a square cut. No wedge-type roller cutters will be permitted. After cutting, the end of the pipe shall be beveled using a beveling tool, portable type sander, or abrasive disc.

3.5 INSTALLATION OF COPPER WIRE

A. Polyvinyl chloride pipelines shall be provided with No. 10 AWG bare copper wire laid along the top of the pipe and held in place with ties or hitches of the same kind of wire spaced not more than 13-feet apart, or metallic locating tape laid along the centerline of the pipe trench at a depth of 18-inches below finish grade. In such case, the CONTRACTOR shall furnish manufacturer's literature, completely describing the tape proposed to be furnished. No tape shall be used prior to receipt of written approval of the ENGINEER.

- END OF SECTION –

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SECTION 33 42 15 – POLYETHYLENE CORRUGATED NON-PRESSURE PIPE

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide all 18- to 60-inch inside diameter polyethylene (PE) pipe of profile wall construction and with water tight bell joints for use in gravity flow applications and all appurtenant work, complete in place, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

ASTM D 1248	Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D 1557	Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3)
ASTM D 2321	Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications
ASTM F 477	Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F 2306	Corrugated Profile Wall Polyethylene (PE) Pipe for Gravity Flow Sewer and Drain Pipe

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Contractor Submittals.

B. Shop Drawings

1. Certified dimensional drawings of pipe and fittings.
2. Layout drawings for pipe, joints, bends, special fittings, and appurtenances.
3. Material testing reports.

C. **Certificates:** Manufacturer's certificates for all materials indicating conformance to the Contract Documents.

1.4 QUALITY CONTROL

A. **Testing:** All materials testing shall be based upon applicable ASTM test methods referenced herein. A report of the test results shall be furnished.

B. Costs of such tests shall be borne by the CONTRACTOR as part of the WORK.

C. The pipe shall be tested for dimensions, ring stiffness constant (RSC), flattening, and joint tightness, in accordance with the requirements of ASTM F 2306. A report of the test results shall be furnished.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Pipe furnished under this section shall be marked in accordance with the requirements of ASTM F 2306.

B. The CONTRACTOR shall furnish certification that the pipe was manufactured, sampled, tested, and inspected in accordance with ASTM F 2306 and has met the requirements of that standard.

2.2 PIPE AND FITTINGS

A. All pipe and fittings shall be made of high density, high molecular weight polyethylene pipe material meeting the requirements of cell classification 435400C as described in ASTM D3350, except that carbon black content shall not exceed 4%. Clean rework material generated by the manufacturers own production may be used so long as the pipe or fittings produced meet all of the requirements of ASTM 2306.

B. Pipe and fitting classifications shall be

C. Pipe and fittings shall be joined by the use of water-tight integral bell couplers with a gasket compressed between the spigot and belled ends of the pipe or by thermal welding of the bell and spigot pipe ends. Elastomeric gaskets shall comply with the requirements of ASTM F 477. Material used for thermal welding shall meet the requirements established for the pipe base material.

D. **Acceptable Manufacturer:** ADS N-12 WT or equal.

PART 3 -- EXECUTION

3.1 GENERAL

A. All laying, jointing, testing for defects and for leakage, shall be performed in the presence of the ENGINEER, and shall be subject to its approval before acceptance. All material found to have defects will be rejected and the CONTRACTOR shall promptly remove such defective material from the Site.

3.2 HANDLING AND STORAGE

A. **Handling:** Pipe, fittings, and accessories shall be carefully inspected before and after installation and those found defective shall be rejected. Pipe and fittings shall be free from fins and burrs. Before being placed in position, pipe, fittings, and accessories shall be cleaned and shall be maintained in a clean condition. Proper facilities shall be provided for lowering sections of pipe into trenches. Under no circumstances shall pipe, fittings, or any other material be dropped or dumped into trenches.

B. After unloading and before installation, pipe shall be stored on flat, level ground with no rocks, timbers or other objects under the pipe. The maximum stacking height for various diameters of pipe is:

18- to 21-inch diameter	4 rows
24- to 30-inch diameter	3 rows
33- to 48-inch diameter	2 rows
54-inch and larger	1 row

3.3 INSTALLATION

A. Installation shall conform to the requirements of ASTM D 2321 and the applicable requirements of Section 31 30 00 – Earthwork and Trenching, instructions furnished by the pipe manufacturer, and to the requirements herein. Wherever the requirements are in conflict, the more stringent shall apply.

B. The minimum backfill compaction in the pipe zone shall be 90 percent of maximum density per ASTM D 1557.

C. Bell-and-spigot pipe shall be laid with the bell end pointing in the direction of laying. Pipe shall be graded in straight lines, taking care to avoid the formation of any dips or low points. Pipe shall not be laid when the conditions of trench or weather are unsuitable. At the end of each day's work, open ends of pipe shall be closed temporarily with watertight plugs or bulkheads.

D. Pipe shall be supported at its proper elevation and grade, care being taken to secure firm and uniform support. Wood support blocking will not be permitted. The full length of each section of pipe and fittings shall rest solidly on the pipe bed, with recessed excavation to accommodate bells, joints, and couplings. Anchors and supports shall be provided where necessary and where indicated.

E. Where unstable trench walls or trench bottom is encountered, such as may be found by excavation below ground water, this condition shall be stabilized before laying the pipe. Depending on the severity of the condition, the CONTRACTOR may elect to use tight sheeting, stay bracing, a trench box, well points, an underdrain, removal of the unstable soil and replacement with a suitable foundation material, or a combination of methods.

3.4 FIELD JOINTING

A. With the gasket properly placed in the spigot groove, the gasket shall be stress-relieved by passing a screwdriver under the gasket and then around the circumference of the spigot.

B. The pipe ends shall be wiped clean and a thin coat of lubricant applied to both the outside surface of the spigot end with the gasket in place, and the inside surface of the bell end. Lubricant other than that furnished with the pipe shall not be used. The end of the pipe shall then be forced into the bell end of the adjoining pipe. A backhoe bucket or a cable winch may be used, but the force shall be steady, not an impact force, and shall be evenly distributed so as not to damage the pipe end.

C. The pipe shall not be deflected either vertically or horizontally in excess of the recommendations of the manufacturer.

D. If thermal welding is used to joint bell and spigot ends, the joint shall be assembled in accordance with the manufacturer's recommended procedure.

- END OF SECTION -

SECTION 33 92 10 - STEEL PIPE, SPECIALS AND FITTINGS (AWWA C200, MODIFIED)

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide steel pipe, specials, and fittings, complete and in place, in accordance with the Contract Documents.

B. A single pipe manufacturer shall be made responsible for furnishing steel pipe, specials, fittings, and appurtenances such as bolts and gaskets for the WORK.

C. **Pipe Material Group No. 8**. This piping system is referred to in the Pipe Schedule on Contract Sheet GM-1 as Piping Material **Group No. 8. (Note that steel pipe of 14-inch diameter and larger, as called out on the Contract Drawings, shall be based upon inside diameter dimensions, per Part 2.1.A of this Section.)**

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.

B. Shop Drawings

1. Certified dimensional drawings of fittings and appurtenances.

2. Joint and pipe/fitting wall construction details which indicate the type and thickness of cylinder; the position, type, size, and area of reinforcement; coating and lining holdbacks, manufacturing tolerances; and other pertinent information required for the manufacture of the product.

3. Details for elbows, wyes, tees, outlets, connections, test bulkheads, and nozzles or other specials that indicate amount and position of reinforcement. Fittings and specials shall be properly reinforced to withstand the internal pressure, both circumferential and longitudinal, and the external loading conditions as indicated in the Contract Documents.

4. Material lists and steel reinforcement schedules that describe materials to be utilized. Submit metallurgical, chemical, and physical test reports from each heat of steel to verify the steel conforms to the Specifications.

5. Line layout and marking diagrams which indicate the specific number of each pipe and fitting, the location of each pipe, and the direction of each fitting in the completed line. In addition, the line layouts shall include:

a. The pipe station and invert elevation at every change in grade or horizontal alignment

b. The station and invert elevation to which the bell end of each pipe will be laid

c. Elements of curves and bends, both in horizontal and vertical alignment

d. The limits within each reach of restrained and/or welded joints or of concrete encasement

e. Location and dimensional allocations for each valve, fitting, and appurtenance identified in the Contract Documents

6. Full and complete information regarding location, type, size, and extent of welds shall be shown on the Shop Drawings. The Shop Drawings shall distinguish between shop and field welds. Shop Drawings shall indicate by welding symbols or sketches the details of the welded joints and the preparation of parent metal required to make them. Joints or groups of joints in which welding sequence or technique are especially important shall be carefully controlled to minimize shrinkage stresses and distortion.

7. Rubber gasket joint design and details

8. Drawings showing the location, design, and details of bulkheads for hydrostatic testing of the pipeline, and details for removal of test bulkheads and repair of the lining.

9. Details and locations of closures for length adjustment and for construction convenience.

10. Detail drawings indicating the type, number, and other pertinent details of the slings, strutting, and other methods proposed for pipe handling during manufacturing, transport, and installation.

11. Manufacturer's written Quality Assurance/Control Program.

C. **Certifications:** The CONTRACTOR shall furnish a certificates of compliance for pipe and other products or materials in:

a. AWWA C200 - Steel Water Pipe 6 in and Larger,

b. AWWA C205 - Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 in and Larger-Shop Applied,

c. AWWA C207 - Steel Pipe Flanges for Waterworks Service - Sizes 4 In Through 144 In., AWWA C208 - Dimensions for Fabricated Steel Water Pipe Fittings,

d. AWWA C219 - Bolted, Sleeve-Type Couplings for Plain-End Pipe,

e. and the following supplemental requirements:

1. Physical and chemical properties of steel.

2. Hydrostatic test reports.

D. Performing and paying for sampling and testing necessary for certification are the CONTRACTOR's responsibility as part of the WORK.

E. **Manufacturer's Qualifications:** Furnish a copy of manufacturer's certification to ISO 9000, SPFA, or LRQA, and documentation of manufacturer's experience in fabricating AWWA C200 pipe.

F. **Design Calculations of Fittings and Specials:** Furnish a copy of design calculations for fittings and specials including miters, welds, and reinforcement, prior to manufacture of pipe, fittings, and specials

1.3 QUALITY ASSURANCE

A. **Pipe Manufacturer Qualifications:** The pipe manufacturer shall be certified to ISO 9000, the Steel Plate Fabricator's Association (SPFA), or Lloyd's Register Quality Assurance (LRQA) and shall be experienced in fabrication of AWWA C200 pipe of similar diameters, lengths, and wall thickness to this WORK. Experience shall be in the production facilities and personnel, not the name of the company that owns the production facility or employs the personnel.

B. **Inspection:** Pipe shall be subject to inspection at the place of manufacture in accordance with the provisions of AWWA C200, C205, and C214 as supplemented by the requirements herein. The CONTRACTOR shall notify the OWNER in writing of the manufacturing start date not less than 14 Days prior to the start of any phase of the pipe manufacture.

C. **Tests:** Except as modified herein, materials used in the manufacture of the pipe shall be tested in accordance with the requirements of AWWA C200, C205, and C214 as applicable.

1. Joint gaskets shall be tested in accordance with AWWA C200.

2. After the joint configuration is completed and prior to lining with cement mortar, each length of pipe of each diameter and pressure class shall be shop-tested and certified to a pressure of at least 75 psig. The test pressure shall be held for 2 minutes and the pipe visually inspected to confirm that welds are sound and leak-free.

3. In addition to the tests required in AWWA C200, weld tests shall be conducted on each 5,000-foot of production welds and at any other times there is a change in the grade of steel, welding procedure, or welding equipment.

4. Fittings fabricated from straight pipe previously passing a hydrostatic test need not have an additional hydrostatic test provided welds are tested by nondestructive means and demonstrated to be sound.

D. Shop Testing of Steel Plate Specials

1. If any special has been fabricated from straight pipe not previously tested and is of the type listed below, the special shall be hydrostatically tested with a pressure equal to 1.5 times the design working pressure or at least 50 psig, whichever is greater: bends, wyes, crosses, tees with side outlet diameter greater than 30 percent of the main pipe diameter, and manifolds.

2. Specials not required to be hydrostatically tested shall be tested by liquid dye penetrant inspection method in accordance with ASTM E 165 - Standard Test Methods for Liquid Penetrant Examination, Method A or the magnetic particle method in ASME Section VIII, Division 1, Appendix VI.

3. Reinforcing plates shall be tested by the solution method using approximately 40 psig air pressure introduced between the plates through a threaded test hole. Test hole shall be properly plugged following successful testing.

4. Any weld defects, cracks, leaks, distortion, or signs of distress during testing shall require corrective measures. Weld defects shall be gouged out and rewelded. After corrections, the special shall be retested.

5. Where welded test heads or bulkheads are used, extra length shall be provided to each opening of the special. After removal of each test head, the special shall be trimmed back to the design points with finished plate edges ground smooth, straight, and prepared for the field joint.

6. Testing shall be performed before joints have been coated or lined.

7. Plates that are not in conformance with the acceptance criteria in ASTM A 578 may only be used in the WORK if the areas that contain the discontinuities are a distance at least 4 times the greatest dimension of the discontinuity away from the weld joint.

E. The CONTRACTOR shall be responsible for performing and paying for said material tests. The OWNER has the right to witness testing conducted by the CONTRACTOR; provided, that the CONTRACTOR's schedule is not delayed for the convenience of the OWNER.

F. In addition to those tests specifically required, the OWNER may request additional samples of any material including mortar lining and coating for testing by the OWNER. The additional samples shall be furnished as part of the WORK.

G. **Welding Requirements:** Welding procedures used to fabricate and install pipe shall be prequalified under the provisions of ANSI/AWS D1.1 - Structural Welding Code-Steel or the ASME Boiler and Pressure Vessel Code, Section 9. Welding procedures shall be required for longitudinal and girth or spiral welds for pipe cylinders, spigot and bell ring attachments, reinforcing plates and ring flange welds, and plates for lug connections.

H. **Welder Qualifications:** Welding shall be done by skilled welders, welding operators, and tackers who have had adequate experience in the methods and materials to be used. Welders shall be qualified under the provisions of ANSI/AWS D1.1 or the ASME Boiler and Pressure Vessel Code, Section 9 by an independent local, approved testing agency not more than 6 months prior to commencing WORK on the pipeline. Machines and electrodes similar to those used in the WORK shall be used in qualification tests.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Lined and coated steel pipe and specials shall conform to AWWA C200 and C205, subject to the following supplemental requirements. The pipe, specials, and fittings shall be of the diameter and class indicated and shall be provided complete with rubber gaskets or welded joints as indicated in the Contract Documents. For pipe, specials, and fittings 14-inches diameter and larger, **the nominal inside diameter after lining** shall not be less than the diameter indicated on the Drawings, allowing for tolerances according to AWWA C200 and C205. Pipe, specials, and fittings smaller than 14-inches diameter may be furnished in standard outside diameters. Pipe minimum wall thicknesses are generally shown on the Contract Drawings. When indicated as a minimum, wall thickness tolerance shall be as allowed by AWWA C200 or the ASTM nominal sheet or plate tolerance, whichever is less.

B. **Markings:** The manufacturer shall legibly mark pipe, specials, and fittings in accordance with the laying schedule and marking diagram. Each pipe, special, and fitting shall be numbered in sequence and said number shall appear on the laying schedule and marking diagram in its proper location for installation. Each pipe, fitting, and special shall be marked at each end with top field centerline.

C. **Handling and Storage:** The pipe, specials, and fittings shall be handled by use of wide slings, padded cradles, or other devices designed and constructed to prevent damage to the pipe coating/exterior. The use of chains, hooks, or other equipment that might injure the pipe coating/exterior will not be permitted. Stockpiled pipe, specials, and fittings shall be supported on padded skids, sand or earth berms free of rock exceeding 3-inches diameter, sand bags, or suitable means so that the pipe including coating and lining coating will not be damaged. Pipe, specials, and fittings shall not be rolled and shall be secured to prevent accidental rolling.

D. The CONTRACTOR shall replace or repair damaged pipe, specials, and fittings.

E. **Strutting:** Adequate strutting shall be provided on specials, fittings, and straight pipe so as to avoid damage to the pipe, specials, and fittings during handling, storage, hauling, and installation. For mortar-lined steel pipe, specials, or fittings the following requirements shall apply:

1. The strutting shall be placed as soon as practicable after the mortar lining has been applied and shall remain in place while the pipe, special, or fitting is loaded, transported, unloaded, installed, and backfilled at the Site.

2. The strutting materials, size, and spacing shall be adequate to support the earth backfill plus any greater loads that may be imposed by the backfilling and compaction equipment.

3. Any pipe, special, or fitting damaged during handling, hauling, storage, or installation due to improper strutting shall be repaired or replaced.

F. **Laying Lengths:** Maximum pipe laying lengths shall be 48-feet with shorter lengths provided as required.

G. **Lining:** The pipe, specials, and fittings shall have smooth, dense interior surfaces and shall be free from fractures, excessive interior surface crazing, and roughness.

H. **Closures and Correction Pieces:** Closures and correction pieces shall be provided as required so that closures may be made due to different headings in the pipe laying operation and so that correction may be made to adjust the pipe laying to conform to pipe stationing indicated.

2.2 MATERIALS

A. **Mortar:** Materials for mortar shall conform to the requirements of AWWA C205; provided, that cement for mortar coating shall be Type II and mortar lining shall be Type II or V. Cement in mortar lining and coating shall not originate from kilns that burn metal-rich hazardous waste fuel, nor shall a fly ash or pozzolan be used as a cement replacement. Add-mixtures shall contain no calcium chloride.

B. **Steel for Cylinder and Fittings:** Pipe, specials, and fittings manufactured under AWWA C200 shall satisfy the following requirements:

1. Minimum yield strength of steel is 42,000 psi.
2. Be manufactured by a continuous casting process
3. Be fully killed
4. Be fine grain practice
5. Have maximum carbon content of 0.25 percent
6. Have maximum sulfur content of 0.015 percent
7. Have minimum elongation of 22 percent in a 2-inch gauge length.
8. Be in accordance with one of the following:
   a. ASTM A 1011 - Steel Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability
   b. ASTM A 283 - Low and Intermediate Tensile Strength Carbon Steel Plates
   c. ASTM A 572 - High Strength Low-Alloy Columbium-Vanadium Structural Steel
   d. ASTM A 1018 - Steel, Sheet and Strip, Heavy Thickness Coils, Hot-Rolled Carbon, Structural, High-Strength Low-Alloy Columbium or Vanadium, and High-Strength Low-Alloy with Improved Formability

2.3 DESIGN OF PIPE

A. **General:** The pipe shall be suitable to transmit both raw water and filtered water under the conditions indicated in the Contract Documents. The steel pipe shall have rubber gasketed or field welded joints as indicated. The pipe shall consist of a steel cylinder, shop-lined, with Portland cement mortar and an exterior coating of

1. Cement mortar in accordance with AWWA C205 for all buried pipe designated as **Pipe Group No. (8)** on the Contract Drawings, and
2. Liquid applied coating systems as identified in Paragraph 2.8.A of this Section for all exposed pipe designated as **Pipe Group No. (8)** on the Contract Drawings,

B. The pipe shall be designed, manufactured, tested, inspected, and marked according to applicable requirements previously stated and, except as hereinafter modified, shall conform to AWWA C200.

C. **Pipe Dimensions:** Pipe shall have finished inside diameters as indicated on the Contract Drawings, and shall all be of minimum wall thickness, as indicated below in this Section.

D. **Fitting Dimensions:** Fittings shall be of the diameter and class indicated.

E. **Joint Design:** Unless indicated otherwise, the standard field joint for steel pipe shall be as indicated in the following table. Butt-strap joints shall be used only where required for closures or where indicated.

<table>
<tr><th>Pipe Diameter</th><th>Application</th><th>Joint Type</th></tr>
<tr><td rowspan="2">36-inches and less</td><td>Non-Restrained and Restrained Areas</td><td>Single Lap-welded Joint (outside weld);
Butt Joint</td></tr>
<tr><td>Closures, Restrained and Non-Restrained</td><td>Butt Strap Joint</td></tr>
</table>

F. Lap joints prepared for field welding shall be in accordance with AWWA C200. The method used to form, shape, and size bell ends shall be such that the physical properties of the steel are not substantially altered. Unless otherwise approved by the ENGINEER, bell ends shall be formed by an expanding press or by being moved axially over a die in such a manner as to stretch the steel plate beyond its elastic limit to form a truly round bell of suitable diameter and shape. Faying surfaces of the bell and spigot shall be essentially parallel except for mitered bells, but the bell slope shall not vary more than 2 degrees from the longitudinal axis of the pipe.

G. For bell-and-spigot ends with rubber gaskets, the clearance between the bells and spigots shall be such that when combined with the gasket groove configuration and the gasket itself, it will provide watertight joints under all operating conditions. The CONTRACTOR shall require the pipe manufacturer to submit details complete with significant dimensions and tolerances and also to submit performance data indicating that the proposed joint has performed satisfactorily under similar conditions. In the absence of a history of field performance, the results of a test program shall be submitted. Unless otherwise approved by the ENGINEER, bell ends shall be formed by an expanding press or by being moved axially over a die in such a manner as to stretch the steel plate beyond its elastic limit to form a truly round bell of suitable diameter and shape. No process will be permitted in which the bell is formed by rolling. Spiral weld seams shall be tested by the visible penetrant method of ASTM E 165 - Methods for Liquid Penetrant Inspection or magnetic particle inspection method of ASME Section VIII, Division 1, Appendix VI, for a minimum distance of 12-inches from each end of each joint after the spigot and bell are formed. Defects shall be repaired.

H. Field joint for steel pipe shall be steel joint rings with rubber gaskets (Carnegie joint) in accordance with AWWA C303. The joints shall have the same or higher pressure rating as the adjoining pipe. The clearance between faying surfaces shall be less than 1/8-inch.

I. Shop-applied interior linings and exterior coatings shall be held back from the ends of the pipe as indicated or as otherwise acceptable to the ENGINEER.

J. Restrained Joints

1. Located where indicated, restrained joints shall be field-welded joints, either single, outside lap-weld, or butt-weld, or butt-straps as indicated. Designs shall include stresses created by the greater of:

   a. Temperature differential of 40 degrees F plus poisson's effect in combination with hoop stress, or;

   b. Thrust due to bulkheads, bends, reducers, and line valves resulting from working pressure in combination with hoop stress.

2. For field welded joints, design stresses shall not exceed 50 percent of the specified minimum yield strength of the grade of steel utilized, or 21,000 psi, whichever is less, for the part being examined when longitudinal thrust is assumed to be uniformly distributed around the circumference of the joint.

2.4 PIPE MINIMUM STEEL WALL (STEEL PLATE) THICKNESS

A. Unless otherwise noted, the minimum steel wall (steel plate) thickness for buried pipe shall be as shown on the Contract Drawings. The minimum steel wall (steel plate) thickness for above grade indoor piping of diameters 12 inches to 24 inches shall be 3/16 (0.188)-inches, unless noted otherwise.

B. Steel wall (steel plate) thickness shall be increased at specials and at harnessed joints as required to be in accordance with AWWA Standards and AWWA Manual M-11 design requirements.

2.5 SPECIALS AND FITTINGS

A. **Design:** Unless otherwise required by the Contract Documents, materials, fabrication and shop testing of specials and fittings shall conform to the requirements stated above for pipe and shall conform to the dimensions of AWWA C208. The minimum thickness of plate for pipe from which specials are to be fabricated shall be the greatest of those determined by the following criteria:

1. Mainline Pipe Thickness: Plate thickness for specials shall not be less than for the adjacent mainline pipe.

2. Minimum Thickness Based on Pipe Diameter

Nominal Pipe Diameter, in	Pipe Manifolds Piping Above Ground Piping Structures
24 and under	3/16-in, UNO on Drawings

Over 24	1/4-in, UNO on Drawings

B. Specials installed on saddle supports shall be designed to limit the longitudinal bending stress to a maximum of 10,000 psi. Design shall be in accordance with the provisions of Chapter 7 of AWWA Manual M11.

C. Reinforcement for wyes, tees, outlets, and nozzles shall be designed in accordance with AWWA Manual M11. Reinforcement shall be designed for the design pressure indicated and shall be in accordance with the Drawings. Specials and fittings shall be equal in pressure design strength and shall have the same lining and coating as the adjoining pipe. Unless otherwise indicated, the minimum radius of elbows shall be 2.5 times the pipe diameter and the maximum miter angle on each section of the elbow shall not exceed 11-1/4 degrees.

D. Moderate deflections and long radius curves may be made by means of beveled joint rings, by pulling standard joints, by using short lengths or pipe, or a combination of these methods; provided that pulled joints shall not be used in combination with bevels. The maximum total allowable angle for beveled joints shall be 5 degrees per pipe joint. Bevels shall be provided on the bell ends. Mitering of the spigot ends will not be permitted. The maximum allowable angle for pulled joints shall be in accordance with the manufacturer's recommendations or the angle which results from a 3/4-inch pull out from normal joint closure, whichever is less. Horizontal deflections or fabricated angles shall fall on the alignment.

E. Vertical deflections shall fall on the alignment and be at locations adjacent to underground obstructions, points of minimum earth cover, and pipeline outlets and structures. The pipe angle points shall match the angle points indicated.

F. Outlets, Tees, Wyes, and Crosses

1. Outlets 12-inches and smaller may be fabricated from Schedule 30 or heavier steel pipe in the standard outside diameters, i.e., 12-3/4 inch, 10-3/4 inch, 8-5/8 inch, 6-5/8 inch, and 4-1/2 inch. Minimum plate thickness for reinforcements shall be 10-gauge.

2. The design of outlet reinforcement shall be in accordance with the procedures given in Chapter 13 of AWWA Manual M11 and the design pressures and factors of safety above.

3. In lieu of saddle or wrapper reinforcement as provided by the design procedure in Manual M11, pipe or specials with outlets may be fabricated entirely of steel plate having a thickness equal to the sum of the pipe wall plus the required reinforcement.

4. Where Manual M11 requires the design procedure for crotch plate reinforcement, such reinforcement shall be provided.

5. Outlets shall be fabricated so that there is always at least a 12-inch distance between the outer edge of the reinforcing plate and any field welded joints. For outlets without reinforcing plates, outlets shall penetrate the steel cylinders so that there is at least a 12-inch clearance between the outlet and any field-welded joints.

6. Tees, wyes, crosses, elbows, and manifolds shall be fabricated so that the outlet clearances and reinforcing plates from any weld joints are a minimum of 5 times cylinder thickness or 2-inches, whichever is greater. Longitudinal weld joints in adjacent cylinder sections shall be oriented so that there is a minimum offset of 5 times cylinder thickness or 2-inches, whichever is greater.

G. **Steel Welding Fittings:** Steel welding fittings shall conform to ASTM A 234 - Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.

H. **Ends for Mechanical-Type Couplings:** Except as otherwise indicated, where mechanical-type couplings are indicated, the ends of pipe shall be banded with Type C collared ends using double fillet welds. Where pipe 12-inches and smaller is furnished in standard schedule thickness and where the wall thickness equals or exceeds the coupling manufacturer's minimum wall thickness, the pipe ends may be grooved.

2.6 JOINTS

A. Unless otherwise noted, the standard field joint for steel pipe shall be a single-welded, fully continuous lap joint around pipe circumference. Location of this lap joint on the interior or the exterior of the pipe joint shall be the CONTRACTOR’s option. Butt-strap joints shall be provided where needed for alignment or fit-up or where shown on the Drawings. Sleeve coupled, mechanical-type coupled, or flanged joints shall be required where shown. The joints furnished shall have the same or higher pressure rating as the abutting pipe. Where butt-straps are used, 5-inch diameter handholes shall be provided on pipes smaller than 24 inches in diameter to facilitate the epoxy lining of the joint.

B. Lap joints for field welding shall be in accordance with ANSI/AWWA C200. The method used to form, shape, and size bell ends shall be such that the physical properties of the steel are not substantially altered. Unless otherwise approved by the OWNER, bell ends shall be formed by an expanding press or by being moved axially over a die in such a manner as to stretch the steel plate beyond its elastic limit to form a truly round bell of suitable diameter and shape. Faying surfaces of the bell and spigot shall be essentially parallel, but in no case shall the bell slope vary more than 2 degrees from the longitudinal axis of the pipe.

C. Shop-applied interior linings and exterior coatings shall be held back from the ends of the pipe as shown or as otherwise acceptable to the OWNER.

2.7 CEMENT-MORTAR LINING

A. **Cement-Mortar Lining for Shop Application:** Unless indicated otherwise, interior surfaces of pipe, specials, and fittings shall be cleaned and lined in the shop with cement mortar lining applied centrifugally in conformity with AWWA C205. During the lining operation and thereafter, the pipe, specials, and fittings shall be maintained in a round condition by suitable bracing or strutting. The lining machines shall be of a type that has been used successfully for similar WORK. Every precaution shall be taken to prevent damage to the lining. If lining is damaged or found defective at the Site, the damaged or unsatisfactory portions shall be replaced with lining conforming to these Specifications.

B. The minimum lining thickness and tolerance shall be in accordance with AWWA C205.

C. The pipe shall be left bare as indicated where field joints occur. Ends of the linings shall be left square and uniform. Feathered or uneven edges will not be permitted.

D. Defective linings, as determined by the OWNER, shall be removed from the pipe wall and shall be replaced to the full thickness required. Defective linings shall be cut back to a square shoulder in order to avoid feather edged joints.

E. The progress of the application of mortar lining shall be regulated in order that handwork, including the repair of defective areas, is cured in accordance with the provisions of AWWA C205. Cement mortar for patching shall be the same materials as the mortar for machine lining, except that a finer grading of sand and mortar richer in cement shall be used when field inspection indicates that such mix will improve the finished lining of the pipe.

F. Specials and fittings that cannot be mechanically lined and coated shall be lined and coated by hand-application using the same materials as used for the pipe and in accordance with the applicable AWWA or ASTM standards and this Section. Coating and lining applied in this manner shall provide protection equal to that for the pipe. Fittings may be fabricated from pipe that has been mechanically lined and/or coated. Areas of lining and coating that have been damaged by such fabrication shall be repaired by hand-application.

G. **Cement-Mortar Lining for Field Application at Joints**; unless otherwise indicated, steel pipe shall be mortar lined at all joints. The materials and design of in-place cement mortar lining shall be in accordance with AWWA C602 and the following supplementary requirements:

1. Pozzolanic material shall not be used in the mortar mix.

2. Admixtures shall contain no calcium chloride.

3. The minimum lining thickness shall be as indicated for shop-applied cement mortar lining, and finished inside diameter after lining shall be as indicated.

4. Temperature and shrinkage cracks in the mortar less than 1/16-inch wide need not be repaired. Pipe, specials, or fittings with mortar cracks wider than 1/16-inch shall be rejected.

H. **Protection of Pipe Lining / Interior:** For pipe, specials, and fittings with plant-applied cement-mortar linings, the CONTRACTOR shall provide a 12-mil polyethylene sheet or other suitable bulkhead on the ends of the pipe and on each opening to prevent drying out of the lining. Bulkheads shall be substantial enough to remain intact during shipping and storage until the pipe is installed.

2.8 EXTERIOR COATING OF PIPE

A. **Exterior Coating of Exposed Piping:** The exterior surfaces of pipe, specials, and fittings that will be exposed to the atmosphere inside structures or above ground shall be thoroughly cleaned and then given a shop coat of primer compatible with the finish coating System No. 2 (moisture-cured urethane) or System 100 (amine cured epoxy) as required by Section 09800 - Protective Coating.

B. **Exterior Coating of Buried Piping:** Pipe for buried service, including bumped heads, shall be coated with a one-inch minimum thickness of reinforced cement-mortar coating. Unless otherwise indicated, exterior surfaces of pipe or fittings passing through structure walls shall be cement-mortar coated from the center of the wall or from the wall flange to the end of the underground portion of pipe or fitting. The coating shall be reinforced with a spiral wire reinforcement or welded wire fabric in accordance with AWWA C205. The welded wire fabric shall be securely fastened to the pipe with welded clips or strips of steel. The wire spaced 2-inches on centers shall extend circumferentially around the pipe. The ends of reinforcement strips shall be lapped 4-inches and the free ends tied or looped to assure continuity of the reinforcement.

2.9 PIPE APPURTENANCES

A. Pipe appurtenances shall be in accordance with the requirements of Division 15 of the Specifications. Access manholes with covers shall be as indicated, installed during fabrication, not in the field. Threaded outlets shall be forged steel suitable for 3000 psi service, and shall be as manufactured by **Vogt**, or equal.

PART 3 -- EXECUTION

3.1 INSTALLATION OF PIPE

A. **Handling and Storage:** Pipe, specials, and fittings shall be carefully handled and protected against damage to lining and coating/interior and exterior surfaces, and impact shocks and free fall. Pipe, specials, and fittings shall not be placed directly on rough ground but shall be supported in a manner that will protect the pipe against injury whenever stored at the Site or elsewhere. Pipe, specials, and fittings shall be handled and stored at the Site in accordance with the requirements stated in Part 2, above. No pipe shall be installed when the lining or coating/interior or exterior surfaces show cracks that may be harmful. Such damaged lining and coating/interior and exterior surfaces shall be repaired or a new undamaged pipe, special, or fitting shall be provided.

B. Pipe damaged prior to Substantial Completion shall be repaired or replaced by the CONTRACTOR.

C. The CONTRACTOR shall inspect each pipe, special, and fitting for damage. The CONTRACTOR shall remove or smooth out any burrs, gouges, weld splatter, or other small defects prior to laying the pipe, special, or fitting.

D. Before placement of pipe, specials, or fittings in the trench, each shall be thoroughly cleaned of any foreign substance that may have collected thereon and shall be kept clean thereafter. For this purpose, the openings of pipes, specials, and fittings in the trench shall be closed during any interruption to the WORK.

E. Pipe, specials, and fittings shall be laid directly on the imported bedding material. No blocking will be permitted, and the bedding shall be such that it forms a continuous, solid bearing for the full length of the pipe, special, or fitting. Note that some steel pipelines, as noted in the Contract Drawings, require the placement of CLSM material within the pipe bed zone and up to the spring-line of the pipe. Excavations shall be made as needed to facilitate removal of handling devices after the item is laid. Bell holes shall be formed at the ends of the pipe to prevent point loading at the bells or couplings. Excavation outside the normal trench section shall be made at field joints as needed to permit adequate access to the joints for field connection operations and for application of coating on field joints.

F. **Installation Tolerances:** Each section of pipe, special, or fitting shall be laid in the order and position on the laying diagram and in accordance with the following:

1. Each section of pipe, special, or fitting having a nominal diameter less than 48-inches shall be laid to line and grade, within plus or minus 2-inches horizontal deviation and plus or minus 1-inch vertical deviation.

2. Each section of pipe, special, or fitting having nominal diameter 48-inches and larger shall be laid to line and grade, within plus or minus 5 percent of diameter horizontal deviation and plus or minus 2.5 percent of diameter vertical deviation.

3. In addition to the horizontal and vertical tolerances above, lay the pipe so that no high or low points other than those on the laying diagram are introduced.

4. After installation, pipe, specials, and fittings shall not show deflection greater than 1.5 percent for mortar-lined and mortar-coated pipe, specials, and fittings; 2.25 percent for mortar-lined and flexible-coated pipe, specials, and fittings; and 3.0 percent for flexible-lined and flexible-coated or bare pipe, specials, and fittings. The allowable deflection shall be based on the design inside diameter.

G. **Test Section:** At the beginning of pipe laying operations, the CONTRACTOR shall perform a test section to demonstrate that the methods and materials to be utilized will satisfy the pipe zone backfill compaction and pipe deflection criteria. The maximum length of the test section shall be 500-feet: The CONTRACTOR shall not proceed with production pipe laying beyond the test section without the OWNER's approval. The entire test section length that does not comply with the Contract Documents shall be reworked as necessary to comply. The OWNER will observe construction of the test section. The OWNER will take measurements and keep records for quality assurance purposes. Any change in means, methods, and trench conditions, including excavation, bedding, and pipe zone materials, insitu soils, water conditions, and backfill and compaction methods will require another successful test section before additional production pipe installation.

H. Exterior Yard Piping on Slopes. Except for short runs that may be permitted by the OWNER, pipes shall be laid uphill if on grades exceeding 10 percent. Pipe that is laid on a downhill grade shall be blocked and held in place until sufficient support is furnished by the following pipe to prevent movement. Bends shall be installed as indicated.

I. Struts in Buried Piping. Struts in pipe smaller than 42-inches may be removed immediately after laying. A laboratory selected and paid by the OWNER may monitor pipe deflection by measuring pipe inside diameter before struts are removed and 24 hours after struts are removed. Pipe deflection shall not exceed 3 percent 24 hours after the struts are removed. After the backfill has been placed, the struts shall be removed and shall remain the property of the CONTRACTOR.

J. **Cold Weather Protection:** No pipe, special, or fitting shall be installed upon a foundation into which frost has penetrated or at any time that there is a danger of the formation of ice or penetration of frost at the bottom of the excavation. No pipe, special, or fitting shall be laid unless it can be established that the trench will be backfilled before the formation of ice and frost occurs.

K. **Pipe, Specials, and Fitting Protection:** The openings of pipe, specials, and fittings with shop-applied mortar lining shall be protected with suitable bulkheads to maintain a moist atmosphere and to prevent unauthorized access by persons, animals, water, or any undesirable substance. The bulkheads shall be so designed to prevent drying out of the interior of the pipe, specials, and fittings. The CONTRACTOR shall introduce water into the pipe to keep the mortar moist if moisture has been lost due to damaged bulkheads. Means shall be provided to prevent the pipe from floating due to water in the trench from any source. Pipe that has floated shall be repaired, including restoration to original condition and profile.

L. **Pipe Cleanup:** As pipe laying progresses, the CONTRACTOR shall keep the pipe interior free of debris. The CONTRACTOR shall completely clean the interior of the pipe of sand, dirt, mortar splatter, and any other debris following completion of pipe laying, pointing of joints, and any necessary interior repairs prior to testing and disinfecting the completed pipeline.

3.2 RUBBER GASKETED JOINTS

A. **Rubber Gasketed Joints (if called for on Contract Drawings):** Immediately before jointing pipe, the spigot end of the pipe shall be thoroughly cleaned, and a clean rubber gasket lubricated with a non-toxic vegetable-based lubricant shall be placed in the spigot groove. The lubricant shall be a compound listed as in compliance with NSF Standard 61. The volume of the gasket shall be "equalized" by moving a metal rod between the gasket and the spigot ring around the full circumference of the spigot ring. The bell of the pipe already in place shall be carefully cleaned and lubricated with the vegetable-based lubricant. The spigot of the pipe section shall then be inserted into the bell of the previously laid joint and telescoped into its proper position. Tilting of the pipe to insert the spigot into the bell will not be permitted. After the pipe units have been joined, a feeler gauge shall be inserted into the recess and moved around the periphery of the joint to detect any irregularity in the position of the rubber gasket. If the gasket cannot be "felt" all around, the joint shall be disassembled. The joint shall be reassembled with a new gasket.

3.3 WELDED JOINTS

A. **General:** Field welded joints shall be in accordance with AWWA C206 - Field Welding of Steel Water Pipe.

B. Where exterior welds are performed, adequate space shall be provided for welding and inspection of the joints.

C. Butt straps shall be as indicated.

D. A heat resistant shield shall be draped over at least 24-inches of coating beyond the holdback on both sides of the weld during welding to avoid damage to the coating by hot weld splatter. Welding grounds shall not be attached to the coated part of the pipe.

E. After the pipe and joint are properly positioned in the trench, the length of pipe between joints shall be backfilled to at least one-foot above the top of the pipe. Care shall be exercised during the initial backfilling to prevent movement of the pipe and to prevent any backfill material from being deposited on the joint.

F. To control temperature stresses, the unbackfilled joint areas of the pipe shall be shaded from the direct rays of the sun by the use of properly supported awnings, umbrellas, tarpaulins, or other suitable materials for a minimum period of 2 hours prior to the beginning of the welding operation and until the weld has been completed. Shading materials at the joint area shall not rest directly on the pipe but shall be supported to allow air circulation around the pipe. Shading of the pipe joints need not be performed when the ambient air temperature is below 45 deg F.

G. **Shrinkage Control Joints:** At intervals not exceeding 300-feet along welded reaches of the pipeline and at the first regular lap-welded field joints outside concrete encasements and structures, the pipe shall be laid with an initial lap of not less than 1-inch greater than the minimum lap dimension. The welding of each such shrinkage control joint shall be performed when the temperature is approximately the lowest during the 24 hour day, after at least 300-feet of pipe have been laid and the joints have been welded ahead of and in back of the shrinkage control joint, and after backfill has been completed to at least 1-foot above the top of the pipe ahead of and in back of the shrinkage control joint. Where shrinkage control joints occur in a traveled roadway or other inconvenient location, the location of the shrinkage control joint may be adjusted, as acceptable to the OWNER.

H. Prior to the beginning of the welding procedure, any tack welds used to position the pipe during laying shall be removed. Any annular space between the faying surfaces of the bell and spigot shall be equally distributed around the circumference of the joint by shimming, jacking, or other suitable means. The weld shall then be made in accordance with AWWA C206. Where more than one pass is required, each pass except the first and final ones shall be peened to relieve shrinkage stresses, and dirt, slag, and flux shall be removed before the succeeding bead is applied.

I. Prior to butt welding, the pipe and joint shall be properly positioned in the trench using line up clamps so that, in the finished joint, the abutting pipe sections shall not be misaligned more than 1/16-inch.

J. Unless double fillet welds are indicated, field welded lap joints may, at the CONTRACTOR'S option, be made on either the inside or the outside of the pipe.

K. **Inspection of Field Welded Joints:** An independent testing laboratory acceptable to the OWNER but paid by the CONTRACTOR shall inspect the joints. Inspection shall be as soon as practicable after the welds are completed.

1. Fillet welds shall be tested by the Magnetic Particle Inspection Method in accordance with ASME Section VIII, Division 1, Appendix VI.

2. Double-welded lap joints shall be air tested by shop drilling and tapping for 1/8-inch or 1/4-inch national pipe thread in the lap or bell end of the pipe. Apply 40 psi of air or other satisfactory gas into the connection between the 2 fillet welds. Test pressure shall be measured with a 4-inch diameter, minimum, pressure gauge with a range no greater than 0 to 100 psi. The air test shall consist of holding the test pressure undiminished for 5 minutes. If the air test fails, paint the welds with a soap solution and mark any leaks indicated by the escaping gas bubbles. Leaking

portions of the welds or defective welds shall be removed and rewelded. The amount of material removed shall be limited to that required to correct the defect. After the repair is made, the joint shall be checked by repeating the original test procedure. Close the threaded openings with pipe plugs or by welding them.

3. Butt welds shall be inspected by radiographic methods in accordance with API Standard 1104.

L. Following tests of the joint, the exterior joint spaces shall be coated in accordance with these specifications after which backfilling may be completed.

M. **Repair of Welds:** Welds that are defective shall be repaired by the CONTRACTOR to meet the requirements of this Specification. Defects in welds or defective welds shall be removed, and that section of the joint shall then be rewelded. Only sufficient removal of defective material that is necessary to correct the defect is required. After the repair is made, the joint shall be checked by repeating the original test procedure. Welds deficient in size shall be repaired by adding weld metal.

3.4 JOINT COATING AND LINING

A. **General:** The interior and exterior joint recesses shall be thoroughly wiped clean and water, loose scale, dirt, and other foreign material shall be removed from the inside surface of the pipe.

B. If required, every joint will be tested by the OWNER's with an electrical detector capable of at least a 12,000 volt output, furnished by the OWNER. The tests will be made using a voltage of 6,000 to 7,000 volts. Holidays shall be repaired by the CONTRACTOR.

C. **Coating Repair:** Coating repair shall be made using tape and primer conforming to AWWA C209. When visual inspection shows a portion of the tape-wrap system has sustained physical damage, the damaged area shall be subjected to an electrical holiday test of 6,000 to 7,000 volts.

D. Following repair of the damaged area, if the holiday test indicates a holiday still exists, the inner wrap shall be exposed and the exposed area shall be wiped clean with xylol solvent or equal, and the area coated with tape primer. A patch of 35-mil thick cold-applied tape of sufficient size to cover the damaged area plus a minimum lap of 2-inches shall then be applied. The patched area shall again be tested for holidays. If none are detected, a second layer of 35-mil thick tape shall then be applied over the first patch. The second layer of tape shall overlap the first layer a minimum of 2-inches.

E. When the area tests show no holiday, a notation shall be applied to the area indicating the test is satisfactory.

F. **Joint Lining:** After the backfill has been completed to final grade, the interior joint recess shall be filled with grout. The grout shall be tightly packed into the joint recess and troweled flush with the interior surface. Excess shall be removed. At no point shall there be an indentation or projection of the mortar exceeding 1/16-inch. With pipe smaller than 24-inches in diameter, before the spigot is inserted into the bell, the bell shall be daubed with grout. The joint shall be completed and excess mortar on the inside of the joint shall be swabbed out.

3.5 INSTALLATION OF PIPE APPURTENANCES

A. **Protection of Appurtenances:** Where the joining pipe is tape-coated, buried appurtenances shall be coated with cold-applied tape in accordance with Section 09810.

B. **Installation of Valves:** Valves shall be handled in a manner to prevent any injury or damage to the valve or any part of it. Joints shall be thoroughly cleaned and prepared prior to installation. The CONTRACTOR shall adjust stem packing and operate each valve prior to installation to verify proper operation.

C. Valves shall be installed so that the valve stems are plumb and in the location indicated.

D. **Installation of Flanged Joints:** Before the joint is assembled, the flange faces shall be thoroughly cleaned of foreign material with a power wire brush. The gasket shall be centered and the connecting flanges drawn up watertight without unnecessarily stressing the flanges. Bolts shall be tightened in a progressive diametrically opposite sequence and torqued with a suitable calibrated torque wrench. Clamping torque shall be applied to the nuts only. Full face reinforced rubber gaskets shall be applied to the inside face of blind flanges with adhesive.

E. **Flexible Coupled Joints:** When installing flexible couplings, care shall be taken that the connecting pipe ends, couplings, and gaskets are clean and free of dirt and foreign matter with special attention given to the contact surfaces of the pipe, gaskets, and couplings. The couplings shall be assembled and installed in conformity with the recommendation and instruction of the coupling manufacturer.

F. Wrenches used in bolting couplings shall be of a type and size recommended by the coupling manufacturer. Coupling bolts shall be tightened so as to secure a uniform annular space between the follower rings and the body of the pipe. Bolts shall be tightened approximately the same amount. Diametrically opposite bolts shall be tightened progressively and evenly. Final tightening shall be done with a suitable calibrated torque wrench set for the torque recommended by the coupling manufacturer. Clamping torque shall be applied to the nut only.

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SECTION 33 92 20 - DUCTILE IRON PIPE AND FITTINGS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide ductile iron pipe and appurtenant WORK, complete and in place, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

AWWA C104	Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C105	Polyethylene Encasement for Ductile-Iron Pipe Systems
AWWA C110	Ductile-Iron and Gray-Iron Fittings, 3 in through 48 in for Water
AWWA C111	Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115	Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C116	Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings for Water Supply Service.
AWWA C150	Thickness Design of Ductile-Iron Pipe
AWWA C151	Ductile-Iron Pipe, Centrifugally Cast for Water
AWWA C153	Ductile-Iron Compact Fittings. for Water Service
AWWA C600	Installation of Ductile Iron Water Mains and Their Appurtenances
AWWA C606	Grooved and Shouldered Joints
ASTM C 150	Portland Cement

1.3 CONTRACTOR SUBMITTALS

A. Furnish Submittals in accordance with Section 0133 00 - Contractor Submittals and the following supplemental requirements:

B. Shop Drawings

1. Certified dimensional drawings of valves, fittings, and appurtenances.

2. For pipe 24-inches diameter and larger, line layout and marking diagrams which indicate the specific number of each fitting and the location and the direction of each fitting in the completed line. In addition, the line layouts shall include: the pipe station and invert elevation at changes in grade or horizontal alignment; elements of curves and bends, both in horizontal and vertical alignment; and the limits of each reach of restrained joints, or of concrete encasement.

C. **Certifications:** Certified affidavit of compliance for pipe and other products or materials furnished under this Section and as specified in the referenced standards and the following supplemental requirements:

1. Physical and chemical properties.

2. Hydrostatic test reports.

D. The CONTRACTOR shall be responsible for performing and paying for sampling and testing as necessary for the certifications.

1.4 QUALITY CONTROL

A. **Tests:** Except as modified herein, materials used in the manufacture of the pipe shall be tested in accordance with the requirements of the referenced standards as applicable.

B. The CONTRACTOR shall perform said material tests as part of the WORK. The ENGINEER shall have the right to witness testing conducted by the CONTRACTOR; provided, that the CONTRACTOR's schedule is not delayed for the convenience of the ENGINEER.

C. In addition to those tests specifically required, the ENGINEER may request additional samples of any material including lining and coating samples for testing by the OWNER. The additional samples shall be furnished as a part of the WORK.

D. **Inspection:** Pipe shall be subject to inspection at the place of manufacture in accordance with the provisions of the referenced standards, as supplemented by the requirements herein. The CONTRACTOR shall notify the ENGINEER in writing of the manufacturing starting date not less than 14 Days prior to the start of any phase of the pipe manufacture.

E. During the manufacture of the pipe, the ENGINEER shall be given access to areas where manufacturing is in process and shall be permitted to make inspections necessary to confirm compliance with the Specifications.

PART 2 -- PRODUCTS

2.1 PIPE GENERAL

A. Mortar-lined ductile iron pipe shall conform to AWWA C151, and C104, subject to the supplemental requirements in this Section. The pipe shall be of the diameter and class indicated, shall be provided complete with rubber gaskets, specials, and fittings as required under the Contract Documents.

B. **Markings:** The CONTRACTOR shall legibly mark specials 24-inches diameter and larger in accordance with the laying schedule and marking diagram. Each fitting shall be marked at each end with top field centerline.

C. **Handling and Storage:** The pipe shall be handled as a minimum at the 1/3 points by use of wide slings, padded cradles, or other devices designed and constructed to prevent damage to the pipe coating/exterior. The use of chains, hooks, or other equipment that might injure the pipe coating/exterior will not be permitted. Stockpiled pipe shall be supported on padded skids, sand or earth berms free of rock exceeding 3-inches diameter, sand bags, or suitable means so that the coating will not be damaged. The pipe shall not be rolled and shall be secured to prevent accidental rolling

D. **Laying Lengths:** Nominal pipe laying lengths shall be 20-ft.

E. **Finish:** The pipe shall have smooth dense interior surfaces and shall be free from fractures, excessive interior surface crazing, and roughness.

F. **Closures and Correction Pieces:** Closures and correction pieces shall be provided as required so that closures may be made due to different headings in the pipe laying operation and so that correction may be made to adjust the pipe laying to conform to pipe stationing on the Drawings. The locations of correction pieces and closure assemblies are indicated. Any change in location or number of said items shall only be as accepted by the ENGINEER.

2.2 SPECIALS AND FITTINGS

A. Fittings for ductile iron pipe shall conform to the requirements of AWWA C153 or AWWA C110 and shall have a minimum pressure rating of 250 psi.

2.3 DESIGN OF PIPE

A. The pipe shall be designed, manufactured, tested, inspected, and marked according to AWWA C150 and C 151 except where modified by this Section.

B. **Pipe Dimensions:** The pipe shall be of the diameter and class indicated.

C. **Fitting Dimensions:** The fittings shall be of the diameter and class indicated.

D. **Joint Design:** Ductile iron pipe and fittings shall be furnished with mechanical joints, push-on joints, flanged joints, or restrained joints as required.

1. Mechanical and push-on joints shall conform to AWWA C111.

2. Flanged joints shall conform to AWWA C115. Where threaded flanges are provided, the pipe wall thickness under the cut threads shall not be less than the calculated net thickness required for the pressure class of the pipe.

3. Restrained joints shall be **Field Flex-Ring, Lok-Ring, Fast-Grip,** restrained joint by **American Ductile Iron Pipe**, **TR FLEX** restrained joint by **U.S. Pipe**, or equal.

4. Joint restraining devices that impart point loads and/or wedging action on the pipe wall as a means of joint restraint shall not be allowed unless there are no other options for joint restraint available. Under such circumstances, the CONTRACTOR may propose such devices provided the following conditions are met and the request is made as a substitution:

   a. A formal request for substitution is submitted stating the locations where the devices are intended to be used and a statement from the device manufacturer and the pipe manufacturer that the proposed device is appropriate for the intended installation and is rated at least for the class of the pipe being supplied.

   b. A statement from the pipe manufacturer is provided accepting the use of the retaining devices and indicating that the use of such devices will in no way affect the warranty of the pipe and/or the performance of the pipe.

   c. The manufacturer of the device and the pipe manufacturer jointly provide instruction on the proper installation of the device to the personnel installing the units and provide certification to the OWNER that the installers are adequately trained in the installation of the units and that warranties are in full affect for the project.

   d. The devices shall be **MegaLug Model 1100**as manufactured by **EBAA Iron** or equal.

E. For bell-and-spigot ends with rubber gaskets, the clearance between the bells and spigots shall be such that when combined with the gasket groove configuration and the gasket itself, will provide watertight joints under all operating conditions when properly installed. The CONTRACTOR shall require the pipe manufacturer to submit details complete with significant dimensions and tolerances and also to submit performance data indicating that the proposed joint has performed satisfactorily under similar conditions. In the absence of a history of field performance, the results of a test program shall be submitted.

F. Bolting systems shall be ductile iron conforming to AWWA C 111,11-7.5

2.4 CEMENT-MORTAR LINING

A. **Cement-Mortar Lining for Shop Application:** Except as otherwise provided herein, interior surfaces of ductile iron pipe, fittings, and specials shall be cleaned and lined in the shop with cement-mortar lining applied centrifugally in conformity with AWWA C104. During the lining operation and thereafter, the pipe shall be maintained in a round condition by suitable bracing or strutting. The lining machines shall be of a type that has been used successfully for similar work. Every precaution shall be taken to prevent damage to the lining. If lining is damaged or found defective at the Site, the damaged or unsatisfactory portions shall be replaced with lining conforming to these Specifications.

   1. Cement: Cement for mortar lining shall conform to the requirements of AWWA C104; provided, that cement for mortar lining shall be Type II or V. Cement shall not originate from kilns that burn metal-rich hazardous waste fuel, nor shall a fly ash or pozzolan be used as a cement replacement.

B. The minimum lining thickness shall be as follows:

Nominal Pipe Diameter, in	Minimum Lining Thickness, in
3 - 12	1/16
14 - 24	3/32
30 - 64	1/8

2.5 EXTERIOR PROTECTION OF PIPE

A. **Exterior Coating of Exposed Piping:** The exterior surfaces of pipe which will be exposed to the atmosphere inside structures or above ground shall be thoroughly cleaned and then given a shop coat of rust-inhibitive primer conforming to the requirements of Section 09800 - Protective Coating.

B. **Exterior Coating of Buried Piping:** The exterior coating shall be an asphaltic coating approximately 1-mil thick.

PART 3 -- EXECUTION

3.1 INSTALLATION OF PIPE

A. The CONTRACTOR shall inspect each pipe and fitting prior to installation to insure that there are no damaged portions of the pipe. Pipe damaged prior to Substantial Completion shall be repaired or replaced by the CONTRACTOR.

B. Before placement of pipe in the trench, each pipe or fitting shall be thoroughly cleaned of any foreign substance which may have collected thereon and shall be kept clean at all times thereafter. For this purpose, the openings of pipes and fittings in the trench shall be closed during any interruption to the WORK.

C. **Pipe Laying:** The pipe shall be installed in accordance with AWWA C600.

D. Pipe shall be laid directly on the bedding material. No blocking will be permitted, and the bedding shall be such that it forms a continuous, solid bearing for the full length of the pipe. Excavations shall be made as needed to facilitate removal of handling devices after the pipe is laid. Bell holes shall be formed at the ends of the pipe to prevent point loading at the bells or couplings. Excavation shall be made as needed outside the normal trench section at field joints to permit adequate access to the joints for field connection operations and for application of coating on field joints.

E. Each section of pipe 24-inches diameter and larger shall be laid in the order and position shown on the laying schedule. Each section shall be laid to the line and grade, within approximately one-inch plus or minus.

F. Where necessary to raise or lower the pipe due to unforeseen obstructions or other causes, the ENGINEER may change the alignment and/or the grades. Such change shall be made by the deflection of joints, by the use of bevel adapters, or by the use of additional fittings. However, in no case shall the deflection in the joint exceed 75 percent of the maximum deflection recommended by the pipe manufacturer. No joint shall be misfit any amount that will be detrimental to the strength and water tightness of the finished joint.

G. Except for short runs that may be permitted by the ENGINEER, pipes shall be laid uphill on grades exceeding 10 percent. Pipe that is laid on a downhill grade shall be blocked and held in place until sufficient support is furnished by the following pipe to prevent movement. Bends shall be properly installed as indicated.

H. **Cold Weather Protection:** No pipe shall be installed upon a foundation into which frost has penetrated or at any time that there is a danger of the formation of ice or penetration of frost at the bottom of the excavation before backfilling occurs.

I. **Pipe and Specials Protection:** The openings of pipe and specials shall be protected with suitable bulkheads to prevent unauthorized access by persons, animals, water, or any undesirable substance. At all times, means shall be provided to prevent the pipe from floating.

J. **Pipe Cleanup:** As pipe laying progresses, the CONTRACTOR shall keep the pipe interior free of debris. The CONTRACTOR shall completely clean the interior of the pipe of sand, dirt, mortar splatter, and any other debris following completion of pipe laying and shall perform any necessary interior repairs prior to testing and disinfecting the completed pipeline.

3.2 RUBBER GASKETED JOINTS

A. **Rubber Gasketed Joints:** Immediately before jointing pipe, the bell end of the pipe shall be thoroughly cleaned, and a clean rubber gasket shall be placed in the bell groove. The spigot end of the pipe and the inside surface of the gasket shall be carefully cleaned and lubricated. The lubricant shall be suitable for lubricating the parts of the joint for assembly and be a compound listed as in compliance with NSF Standard 61. The lubricant shall be nontoxic, shall not support the growth of bacteria, and shall have no deleterious effects on the gasket material. The lubricant shall not impart taste or odor to water in the pipe. The spigot end of the pipe section shall then be inserted into the bell of the previously laid joint and telescoped into its proper position. Tilting of the pipe to insert the spigot into the bell will not be permitted.

3.3 INSTALLATION OF PIPE APPURTENANCES

A. **Protection of Appurtenances:** Where the joining pipe is dielectric-coated, buried appurtenances shall be coated in kind. Where pipe is encased in polyethylene sleeves, buried appurtenances shall be encased in polyethylene.

B. **Installation of Valves:** Valves shall be handled in a manner to prevent any injury or damage to any part of the valve. Joints shall be thoroughly cleaned and prepared prior to installation. The CONTRACTOR shall adjust stem packing and operate each valve prior to installation to insure proper operation.

C. Valves shall be installed so that the valve stems are plumb and in the location indicated.

- END OF SECTION -

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SECTION 33 95 34 – HIGH DENSITY POLYETHYLENE PRESSURE PIPE (AWWA C906, MODIFIED)

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide high density polyethylene (HDPE) pressure pipe, complete and in place, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

AWWA C906	Polyethylene (PE) Pressure Pipe and Fittings, 4 In Through 63 In, for Water Distribution and Transmission
ASTM D 3350	Polyethylene Plastics Pipe and Fittings Materials

1.3 CONTRACTOR SUBMITTALS

A. Furnish Shop Drawings of pipe, fittings, and appurtenances in accordance with Section 01 33 00 - Contractor Submittals.

B. **Certifications:** Furnish a certified affidavit of compliance for pipe and other products or materials furnished under this Section:

1. Hydrostatic proof test reports.

2. Sustained pressure test reports.

3. Burst strength test reports.

C. Expenses incurred in making samples for certification of tests shall be borne by the CONTRACTOR as part of the WORK.

1.4 QUALITY CONTROL

A. Each manufacturer shall have an approved in-house QA/QC program for compliance to the testing specifications and requirements of AWWA C906 for both pipe and fittings.

B. **Inspection:** Pipe shall be subject to inspection at the place of manufacture in accordance with the provisions of the referenced standards as supplemented by the requirements herein. The CONTRACTOR shall notify the ENGINEER in writing of the manufacturing start date not less than 14 calendar days prior to the start of any phase of manufacture.

C. During manufacture of the pipe, the ENGINEER shall be given access to areas where manufacturing is in process confirm compliance with the Specifications.

D. **Tests:** Except as modified herein, materials used in the manufacture of the pipe shall be tested in accordance with the requirements of this Section and in the referenced standards, as applicable.

E. The CONTRACTOR shall perform said material tests in accordance with the requirements of the Contract Documents. The ENGINEER shall have the right to witness testing conducted by the CONTRACTOR, provided that the CONTRACTOR'S schedule will not be delayed for the convenience of the ENGINEER.

F. In addition to those tests specifically required, the ENGINEER may request additional samples of any material for testing by the OWNER. The additional samples shall be furnished as part of the WORK.

PART 2 -- PRODUCTS

2.1 GENERAL

A. **Scope:** The pipe shall be nominal, meeting the specifications and requirements of AWWA C 906. Shall be in iron pipe sizes (IPS).

B. **Materials:** Pipe and fittings shall be made from prime virgin resins exhibiting a cell classification of PE 345444C as defined in ASTM D 3350, with an established hydrostatic-design basis of 1600 psi for water at 73 degrees F. The resin shall be listed by the PPI (Plastic Pipe Institute) in its pipe-grade registry Technical Report (TR) 4, "Listing of Plastic Pipe Compounds.

C. **Pipe and Fittings:** The pressure rating shall be DR-26 Laying lengths shall be 40-ft standard. Both pipe and fittings shall be listed as compliant with NSF Standard 61 and shall bear the "NSF-pw" logo or mark.

D. **Joints:** Pipe sections shall be joined by heat fusion.

E. **Marking:** Pipe and fittings shall be marked as prescribed by AWWA C906 and NSF Pipe markings shall include nominal size, OD base (ie: 12-inch ductile iron pipe sizing, DIPS), dimension ratio, pressure class, AWWA C906, manufacturer's name, manufacturer's production code including day, month, and year extruded, manufacturer's plant and extrusion line, and NSF - pw logo.

2.2 PLASTIC MARKING TAPE

A. The pipeline shall be marked with a magnetically detectable blue marking tape labeled “Caution Sanitary Sewer Below.” The tape shall be placed along the trench centerline between 18 and 24 inches above the pipe.

PART 3 -- EXECUTION

3.1 GENERAL

A. Laying, jointing, and testing for defects and for leakage shall be performed in the presence of the ENGINEER and shall be subject to approval before acceptance. All material found to be defective will be rejected and the CONTRACTOR shall promptly remove such materials from the Site.

B. Installation shall conform to AWWA M23, instructions furnished by the pipe manufacturer, and to the supplementary requirements or modifications herein. Wherever the provisions of this Section and the aforementioned requirements are in conflict, the more stringent provision shall apply.

3.2 HANDLING AND STORAGE

A. **Handling:** Pipe, fittings, and accessories shall be carefully inspected before and after installation and those found defective will be rejected. Pipe and fittings shall be free from fins and burrs. Before placing in position, clean pipe, fittings, and accessories, and maintain them in a clean condition. Proper methods shall be used for lowering sections of pipe into trenches. Under no circumstances shall pipe, fittings, or any other material be dropped or dumped into trenches.

B. **Storage:** Pipe shall be stored, if possible, at the Site in unit packages provided by the manufacturer. Caution should be exercised to avoid compression damage or deformation to the pipe. Pipe shall be stored in such a way as to prevent sagging or bending, and it shall be protected from exposure to direct sunlight by covering with an opaque material that allows adequate air circulation above and around the pipe. Gaskets shall be stored in a cool, dark place out of the direct rays of the sun, preferably in original cartons.

3.3 TRENCHING AND BACKFILL

A. Trench excavation and backfill shall conform to Section 31 30 00 - Earthwork.

3.4 JOINING

A. Prior to installation of any pipe, the manufacturer shall provide training in the recommended butt fusion and saddle fusion procedures, testing procedures, and any other installation methods required by the WORK. Training shall include the CONTRACTOR'S installation personnel, an OWNER'S representative, the ENGINEER'S representative, and any other personnel chosen by the OWNER. The CONTRACTOR shall record the names of trained personnel.

B. On every day that butt fusion joints are to be made, the first fusion of the day shall be a test. The test fusion shall be allowed to cool completely, and then fusion test straps shall be cut out. Test strap length shall be 12-inches (min) or 30 times the wall thickness with the fused area in the center and width shall be 1-inch (min) or 1.5 times the wall thickness. The CONTRACTOR shall bend the test strap until the ends of the strap touch. If the test strap fails at the joint, the CONTRACTOR shall perform a new test to be cooled completely and bent as before. The CONTRACTOR shall not commence installation of pipe until a test fusion has passed the bent strap test.

3.5 INSTALLATION

A. Trench shall be graded in straight lines, taking care to avoid formation of any dips or low points. Pipe shall not be laid when the conditions of trench or weather are unsuitable. At the end of each day's work, open ends of pipe shall be closed temporarily with wood blocks or bulkheads.

B. Pipe shall be cut by means of saws, power driven abrasive wheels, pipe cutters, or other manufacturer recommended methods that will produce a clean, square cut.

C. Pipe shall be supported uniformly and firmly at its proper elevation. Wood support blocking will not be permitted. The full length of each section of pipe and fittings shall rest solidly on the soil, with recesses to accommodate joints and couplings. Anchors and supports shall be provided where necessary and where indicated for fastening WORK into place. Fittings shall be independently supported.

D. Short lengths of pipe shall be used in and out of each rigid joint or rigid structure. Piping that does not allow sufficient space for proper installation of jointing shall be replaced.

E. Joints shall be installed according to manufacturer's recommendations. Trenches shall be kept free of water until joints have been properly made. The maximum combined deflection at any coupling shall be in accordance with the manufacturer's recommendations.

3.6 FIELD TESTING AND DISINFECTION

A. Field testing and disinfection shall conform to the requirements.

- END OF SECTION –

SECTION 33 95 40 - PVC NONPRESSURE PIPE

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide PVC solid wall nonpressure pipe and appurtenant work, complete and in place, in accordance with the Contract Documents.

B. This Section covers pipe from 4 to 15-inches diameter nominal size.

C. **Pipe Material Group No. 27**. This piping system is referred to in the Pipe Schedule on Contract Sheet GM-1 as Piping Material Group No. 27.

1.2 CONTRACTOR SUBMITTALS

A. Submittals shall be in accordance with Section 01 33 00 - Contractor Submittals.

B. **Shop Drawings:** The CONTRACTOR shall submit Shop Drawings and laying diagrams of pipe, joints, bends, special fittings, and piping appurtenances.

C. **Certificates:** The CONTRACTOR shall submit manufacturer's certificate that pipe conforms to these specifications.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Pipe shall be continuously and permanently marked with the manufacturer's name, pipe size, and minimum pipe stiffness in psi.

B. The CONTRACTOR shall also require the manufacturer to mark the date of extrusion on the pipe. This dating shall be done in conjunction with records to be held by the manufacturer for 2 years, covering quality control tests, raw material batch number, and other information deemed necessary by the manufacturer.

2.2 PIPE

A. Pipe shall conform to the requirements of ASTM D 3034 - Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings, and shall be of **SDR 26** wall thickness. Material for PVC pipe shall conform to the requirements of ASTM D 1784 - Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds, for cell classification 12454-B or 12454-C as defined therein. The manufacturer shall test a sample from each batch according to ASTM D 2444 - Test Method for Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight).

B. Joints shall conform to ASTM D 3212 - Joints for Drain and Sewer Plastic Pipe Using Flexible Elastomeric Seals. Elastomeric seals for compression type joints shall conform to the requirements of ASTM F 477 - Elastomeric Seals (Gaskets) for Joining Plastic

Pipe or ASTM F 913 - Thermoplastic Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

2.3 FITTINGS

A. All fittings shall conform to the requirements of ASTM D 3034. The ring groove and gasket ring shall be compatible with PVC pipe ends. The flanged fittings shall be compatible with cast-iron or ductile iron pipe fittings.

B. The stiffness of the fittings shall be not less than the stiffness of adjoining pipe.

2.4 BEDDING MATERIAL

A. Unless otherwise indicated, material used for pipe bedding shall conform to Section 31 30 00 - Earthwork.

2.5 FLEXIBLE COUPLINGS

A. Flexible couplings shall be neoprene, full-circle, clamp-on type conforming to ASTM C 425 - Compression Joints for Vitrified Clay Pipe and Fittings and provided with two stainless steel band screw-clamps to secure the coupling tightly to entering and exiting pipes. All screw-clamp hardware shall be Type 304 or Type 316 stainless steel. Neoprene material shall be suitable for utility water / wash down service.

PART 3 -- EXECUTION

3.1 TRENCHING AND BACKFILL

A. Trench excavation and backfill shall conform to the requirements of Section 31 30 00 - Earthwork and the Contract Drawings.

3.2 LAYING PIPE

A. Pipe shall be installed in accordance with the requirements of ASTM D 2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications and as indicated. Pipe sections shall be closely jointed to form a smooth flow line. Immediately before placing each section of pipe in final position for jointings, the bedding for the pipe shall be checked for firmness and uniformity of slope.

B. Handling

1. Handling of the PVC pipe shall be done with implements, tools, and facilities as recommended by the pipe manufacturer to insure that the pipe is not damaged in any manner during storage, transit, loading, unloading, and installation.

2. Pipe shall be inspected both prior to and after installation in the ditch and all defective lengths shall be rejected and immediately removed from the working area.

3. Fittings shall be lowered into trench by means of rope, cable, chain, or other means without damage. Cable, rope, or other devices used for lowering fitting into trench,

shall be attached around exterior of fitting for handling. Under no circumstances shall the cable, rope, or other device be attached through the fitting interior for handling or shall pipe or fittings be dropped or dumped into the trench.

C. Cutting and machining of the pipe shall be accomplished in accordance with the pipe manufacturer's standard procedures. Pipe shall not be cut with a cold chisel, standard iron pipe cutter, or any other method that may fracture the pipe or will produce ragged, uneven edges.

D. All foreign matter or dirt shall be removed from the interior of the pipe before lowering into position in the trench. Pipe shall be kept clean during and after laying. All openings in the pipeline shall be closed with watertight expandable type sewer plugs or PVC test plugs at the end of each day's operation or whenever the pipe openings are left unattended. The use of burlap, wood, or other similar temporary plugs will not be permitted.

E. Adequate protection and maintenance of all underground and surface utility structures, drains, sewers, and other obstructions encountered in the progress of the WORK shall be the CONTRACTOR's responsibility.

F. Where the grade or alignment of the pipe is obstructed by existing utility structures such as conduits, ducts, pipes, branch connections to main sewers, or main drains, the obstruction shall be permanently supported, relocated, removed, or reconstructed by the CONTRACTOR in cooperation with owners of such utility structures. Unless otherwise indicated, protection of existing utility structures shall be the CONTRACTOR's responsibility.

3.3 FIELD JOINTING

A. Each pipe compression type joint shall be joined with a lock-in rubber ring and a ring groove that is designed to resist displacement during pipe insertion.

B. The ring and the ring seat inside the bell shall be wiped clean before the gasket is inserted. A thin film of lubricant shall be applied to the exposed surface of the ring and to the outside of the clean pipe end. Lubricant other than that furnished with the pipe shall not be used. The end of the pipe shall be then forced into the ring to complete the joint.

C. The pipe shall not be deflected either vertically or horizontally in excess of the printed recommendations of the manufacturer of the coupling.

D. Fittings shall be carefully connected to pipe, and joint shall be checked to insure a sound and proper joint.

E. When pipe lying is not in progress, the open ends of the pipe shall be closed to prevent trench water from entering pipe. Adequate backfill shall be deposited on pipe to prevent floating of pipe. Any pipe that has floated shall be removed from the trench, cleaned, and relaid in an acceptable manner. No pipe shall be laid when, in the opinion of the ENGINEER, the trench conditions or weather are unsuitable.

3.4 TESTING

A. Field testing of gravity sewer pipe shall conform to the requirements of Section 01 74 20 - Gravity Pipeline Testing.

- END OF SECTION -

SECTION 40 23 00 - PIPING, GENERAL

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide the piping systems indicated, complete and operable, in accordance with the Contract Documents.

B. The provisions of this Section shall apply to all piping sections.

C. The mechanical Drawings define the general layout, configuration, routing, method of support, pipe size, and pipe type. The mechanical Drawings are **not** pipe construction or fabrication drawings. Where pipe supports and spacing are indicated on the Drawings and are referenced to a Standard Detail, the CONTRACTOR shall use that Detail. Where pipe supports are not indicated on the Drawings, it is the CONTRACTOR'S responsibility to develop the details necessary to design and construct mechanical piping systems to accommodate the specific equipment provided, and to provide spacers, adapters, and connectors for a complete and functional system.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.

B. **Shop Drawings:** Shop Drawings shall contain the following information:

1. Drawings: Layout drawings including necessary dimensions, details, pipe joints, fittings, specials, bolts and nuts, gaskets, valves, appurtenances, anchors, guides, and material lists. Fabrication drawings shall indicate spacers, adapters, connectors, fittings, and pipe supports to accommodate the equipment and valves in a complete and functional system.

2. Thermoplastic Pipe Joints: Submit solvent cement manufacturer's catalog indicating that the recommended product is suitable for each fluid service application.

3. Gasket Material: Submit gasket manufacturer's catalog indicating that the recommended product is suitable for each fluid service application.

4. Modular Seals for Pipe: Manufacturer's catalog sheet showing materials and installation procedures.

C. **Samples:** Performing and paying for sampling and testing as necessary for certifications are the CONTRACTOR'S responsibility.

D. Certifications

1. Necessary certificates, test reports, and affidavits of compliance shall be obtained by the CONTRACTOR.

2. A certification from the pipe fabricator that each pipe will be manufactured subject to the fabricator's or a recognized Quality Control Program. An outline of the program shall be submitted to the ENGINEER for review prior to the manufacture of any pipe.

PART 2 -- PRODUCTS

2.1 GENERAL

A. **Extent of Work:** Pipes, fittings, and appurtenances shall be provided in accordance with the requirements of the applicable Sections and as indicated. Materials in contact with potable water shall be listed as compliant with NSF Standard 61.

B. **Pipe Supports:** Pipes shall be adequately supported, restrained, and anchored in accordance with Section 43 10 52 - Pipe Supports, and as indicated. Supports shall resist stresses created by specified maximum seismic load from Project General Conditions

C. **Lining:** Application, thickness, and curing of pipe lining shall be in accordance with the applicable Sections unless otherwise indicated.

D. **Coating:** Application, thickness, and curing of coating on buried pipe shall be in accordance with the applicable Sections unless otherwise indicated. Pipes above ground or in structures shall be coated in accordance with Section 09 96 00 - Protective Coatings.

E. **Pressure Rating:** Piping systems shall be designed for the maximum expected pressure as defined in Section 01656 - Pressure Pipe Testing and Disinfection, or as indicated on the Piping Schedule, whichever is greater.

F. **Inspection:** Pipe shall be subject to inspection at the place of manufacture. During the manufacture, the ENGINEER shall be given access to areas where manufacturing is in progress and shall be permitted to make inspections necessary to confirm compliance with requirements.

G. **Tests:** Except where otherwise indicated, materials used in the manufacture of the pipe shall be tested in accordance with the applicable specifications and standards. The CONTRACTOR shall be responsible for performing material tests.

H. **Welding Requirements:** Qualification of welding procedures used to fabricate pipe shall be in accordance with the provisions of AWS D1.1 - Structural Welding Code. Welding procedures shall be submitted for the ENGINEER's review.

I. **Welder Qualifications:** Welding shall be done by skilled welders and welding operators who have adequate experience in the methods and materials to be used. Welders shall be qualified under the provisions of AWS D1.1 or the ASME Boiler and Pressure Vessel Code, Section 9, by an independent local, approved testing agency not more than 6 months prior to commencing WORK on the piping. Machines and electrodes similar to those used in the WORK shall be used in qualification tests. Qualification testing of welders and materials used during testing is part of the WORK.

2.2 PIPE FLANGES

A. **General:** Flanges shall have flat faces and shall be attached with bolt holes straddling the vertical axis of the pipe unless otherwise indicated. Attachment of the flanges to the pipe shall conform to the applicable requirements of AWWA C207. Flange faces shall be perpendicular to the axis of the adjoining pipe. Flanges for miscellaneous small diameter pipes shall be in accordance with the standards indicated for these pipes.

B. Pressure Ratings

1. 150 psi or less: Flanges shall conform to either AWWA C207 - Steel Pipe Flanges for Waterworks Service--Sizes 4 In. Through 144 In., Class D, or ASME B16.5 - Pipe Flanges and Flanged Fittings, 150 lb class.

2. 150 psi to 275 psi: Flanges shall conform to either AWWA C207 Class E or Class F, or ASME B16.5 150 lb class.

3. 275 psi to 700 psi: Flanges shall conform to ASME B16.5, 300 lb class.

4. Selection based on test pressure: AWWA flanges shall not be exposed to test pressures greater than 125 percent of rated capacity. For higher test pressures, the next higher rated AWWA flange or an ANSI-rated flange shall be selected.

C. **Blind Flanges:** Blind flanges shall be in accordance with AWWA C207, or as indicated for miscellaneous small pipes. Blind flanges for pipe sizes 12-inches and greater shall be provided with lifting eyes in the form of welded or screwed eye bolts.

D. **Flange Coating:** Machined faces of metal blind flanges and pipe flanges shall be coated with a temporary rust-inhibitive coating to protect the metal until the installation is completed.

E. **Flange Bolts:** Bolts and nuts shall conform to Section 05 55 00 - Miscellaneous Metalwork. All-thread studs shall be used on valve flange connections where space restrictions preclude the use of regular bolts.

F. **Insulating Flanges:** Insulated flanges shall have bolt holes 1/4-inch diameter greater than the bolt diameter.

G. **Insulating Flange Sets:** Insulating flange sets shall be provided where indicated. Each insulating flange set shall consist of an insulating gasket, insulating sleeves and washers, and a steel washer. Insulating sleeves and washers shall be one piece when flange bolt diameter is 1-1/2 inch or smaller and shall be made of acetal resin. For bolt diameters larger than 1-1/2 inches, insulating sleeves and washers shall be 2 piece and shall be made of polyethylene or phenolic material. Steel washers shall be in accordance with ASTM A 325 - Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength. Insulating gaskets shall be full-face.

H. Insulating flange manufacturers, or equal

1. **JM Red Devil, Type E**

2. **Maloney Pipeline Products Co.**

3. **PSI Products, Inc.**

I. Flange Gaskets

1. Gaskets for flanged joints used in general water and wastewater service shall be full-faced type, with material and thickness in accordance with AWWA C207, suitable for temperatures to 700 deg F, a pH of one to 11, and pressures to 1000 psig. Blind flanges shall have gaskets covering the entire inside face of the blind flange and shall be cemented to the blind flange. Ring gaskets shall not be permitted unless otherwise indicated. Flange gaskets shall be as manufactured by **John Crane, Style 2160, Garlock, Style 3000,** or equal**.**

2. Gaskets for flanged joints used in water with chloramines shall be **Gylon, Style 3500** as manufactured by **Garlock,** or equal.

3. Gaskets for flanges for PVC and CPVC piping used in general water and wastewater service shall be full faced, 1/8-inch thick, made of ethylene propylene rubber (EPR) having a Type A durometer hardness of 50 to 70 when tested in accordance with ASTM D 2240. When the mating flange has a raised face, provide a flat ring gasket filler between the PVC flange and gasket and the adjacent flange.

4. Gaskets for flanged joints used in chemicals, air, solvents, hydrocarbons, steam, chlorine and other fluids shall be made of materials compatible with the service, pressure, and temperature.

2.3 THREADED INSULATING CONNECTIONS

A. **General:** Threaded insulating bushings, unions, or couplings, as appropriate, shall be used for joining threaded pipes of dissimilar metals and for piping systems where corrosion control and cathodic protection are involved.

B. **Materials:** Threaded insulating connections shall be of nylon, Teflon, polycarbonate, polyethylene, or other non-conductive materials, and shall have ratings and properties to suit the service and loading conditions.

2.4 MECHANICAL-TYPE COUPLINGS (GROOVED OR BANDED PIPE)

A. **General:** Cast mechanical-type couplings shall be provided where indicated. The couplings shall conform to the requirements of AWWA C606 - Grooved and Shouldered Joints. Bolts and nuts shall conform to the requirements of Section 05500. Gaskets for mechanical-type couplings shall be compatible with the piping service and fluid utilized, in accordance with the coupling manufacturer's recommendations. The wall thickness of grooved piping shall conform to the coupling manufacturer's recommendations to suit the highest expected pressure. To avoid excessive load on equipment caused by pipe movement due to steady state or transient pressure conditions, equipment connections with mechanical-type couplings shall have rigid grooved couplings or flexible type coupling with harness in sizes where rigid type couplings are not available, unless thrust restraint is provided by other means. Mechanical type couplings shall be bonded. The CONTRACTOR shall have the coupling manufacturer's service representative verify the correct choice and application of couplings and gaskets, and the workmanship, to assure a correct installation. To assure uniform and compatible piping components, grooved fittings, couplings, and valves shall be furnished by the same manufacturer as the coupling. Grooving tools shall be from the same manufacturer as the grooved components.

B. Manufacturers of couplings for steel pipe, or equal

1. **Gustin-Bacon (Aeroquip Corp.)** (banded or grooved)
2. **Victaulic Style 41 or 44** (banded, flexible)
3. **Victaulic Style 77** (grooved, flexible or rigid)
4. **Victaulic Style 07 or HP-70** (grooved, rigid)

C. Manufacturers of ductile iron pipe couplings, or equal

1. **Gustin-Bacon, (Aeroquip Corp.)**
2. **Victaulic Style 31** (flexible or rigid grooving)

Note: Ductile iron pipe couplings shall be furnished with flush seal gaskets.

D. Manufacturers of couplings for PVC pipe, or equal

1. **Gustin-Bacon, (Aeroquip Corp)**
2. **Victaulic Style 775**

Note: Couplings for PVC pipe shall be furnished with radius cut or standard roll grooved pipe ends.

2.5 SLEEVE–SPLIT TYPE COUPLINGS (**Depend-O-Lok**)

A. **General:** Where indicated sleeve-split type couplings shall be furnished.

B. **Construction:** Couplings shall be split-type, consisting of one or 2 piece housing, gasket assembly, bolts and nuts, and end rings. The double arch cross section that closes around the pipe ends shall be smooth to allow for expansion or contraction requirements. The pipe ends with steel end rings affixed shall provide restraint requirements. As the coupling closes, it shall confine the elastomeric gasket beneath the arches of the sleeve to create a radial seal. The axial seal shall squeeze the closure plates as the bolts pull the coupling snug around the pipe. The coupling shall permit angular pipe deflection, flexibility, contraction and expansion as designed by the manufacturer. The coupling housing shall be designed for internal pressure and external loads as determined by the design procedures of AWWA M-11. The coupling shell thickness of the steel coupling shall be calculated using the formula:

$T=PwDy/2Fs$ Where:

T = steel coupling thickness, in.

Dy = pipe outside diameter, in.

Pw = Design working pressure, psi

Fs = 50 percent of minimum yield point of steel, psi

1. Coupling design calculations shall be stamped and signed by a registered engineer and shall be included in the Shop Drawing submittal for couplings.

2. The sealing members shall comprise of two “O”-ring gaskets and an elastomer sealing pad bonded to sealing plate. Internal pressure shall not be required to make the seal.

C. Materials

1. Unless otherwise indicated, coupling housing material shall be the same material as the piping. Carbon steel couplings shall be fabricated from ASTM A 36. Stainless steel couplings shall be fabricated from ASTM A 240, T-304, 304L, 316, or 316L.

2. Carbon steel end rings shall conform to ASTM A 108 Grade 1018. Stainless steel end rings shall conform to ASTM A 276 T-316L.

3. Bolts and nuts shall be in conformance with Section 05500.

4. Gaskets shall be EPDM conforming to ASTM D 2000 for air service up to 240 degrees F. Gaskets for general water or sewerage service within the temperature range of –20 to 180 degrees F shall be isoprene or EPDM conforming to ASTM D 2000.

5. Carbon steel couplings shall be fusion bond epoxy coated inside and outside of the coupling in accordance with Section 09800. Couplings installed underground shall be provided with **Depend-O-Wrap** tape or equal. Application of wrapping material shall be in conformance with AWWA C209.

D. Pipe Preparation

1. Ends of pipes shall be prepared for the flexible split sleeve type couplings inspected and approved by the coupling manufacturer. The pipe outside diameter and roundness tolerances shall comply with tolerances listed in AWWA C219.

2. Plain ends for use with couplings shall be smooth and round for a distance of 12-inches from end of the pipe.

3. End rings shall be furnished with couplings when restraint is required. Carbon steel end rings shall be ASTM A 108 Grade 1018. Stainless steel end rings shall conform to ASTM A 276 T-316L.

4. Where the split-type coupling is used to take up thermal expansion or contraction (**Depend-O-Lok F X E**) at the pipe joint, one end ring shall be fixed to one end of the pipe to keep the coupling in the proper location.

5. Where the split-type coupling is used for a fully restrained pipe joint (**Depend-O-Lok F X F**) at the pipe joint, one end ring shall be welded to each of the pipe ends to fit beneath the coupling and shall be protected by the coating. Welding design and specification shall be in conformance with the coupling manufacturer’s recommendation.

E. Manufacturer

1. **Depend-O-Lok**

2.6 SLEEVE-TYPE COUPLINGS

A. **General:** Sleeve-type couplings shall be provided where indicated. The CONTRACTOR will not be allowed to substitute a sleeve-split coupling, or any other type in lieu of sleeve coupling unless approved by the ENGINEER.

B. **Construction:** Sleeve couplings shall be in accordance with AWWA C219 - Standard for Bolted Sleeve-Type Couplings for Plain-End Pipe. Couplings shall be steel with steel bolts, without pipe stop. Couplings shall be of sizes to fit the pipe and fittings indicated. The middle ring shall be not less than 1/4-inch thick or at least the same wall thickness as the pipe to which the coupling is connected. If the strength of the middle ring material is less than the strength of the pipe material, the thickness of the middle ring shall be increased to have the same strength as the pipe. The coupling shall be either 5- or 7-inches long for sizes up to and including 30-inches and 10-inches long for sizes greater than 30-inches, for standard steel couplings, and 16-inches long for long-sleeve couplings. The followers shall be single-piece contoured mill sections welded and cold-expanded as required for the middle rings, and of sufficient strength to accommodate the number of bolts necessary to obtain adequate gasket pressures without excessive rolling. The shape of the follower shall be of such design as to provide positive confinement of the gasket. Bolts and nuts shall conform to the requirements of Section 05500. Buried sleeve-type couplings shall be epoxy-coated at the factory as indicated.

C. **Pipe Preparation:** Where indicated, the ends of the pipe shall be prepared for flexible steel couplings. Plain ends for use with couplings shall be smooth and round for a distance of 12-inches from the ends of the pipe, with outside diameter not more than 1/64-inch smaller than the nominal outside diameter of the pipe. The middle ring shall be tested by cold-expanding a minimum of one percent beyond the yield point, to proof-test the weld to the strength of the parent metal. The weld of the middle ring shall be subjected to air test for porosity.

D. Gaskets

1. Gaskets for sleeve-type couplings shall be rubber-compound material that will not deteriorate from age or exposure to air under normal storage or use conditions. Gaskets for wastewater and sewerage applications shall be Buna "N," Grade 60, or equivalent suitable elastomer. The rubber in the gasket shall meet the following specifications:

    a. Color - Jet Black

    b. Surface - Non-blooming

    c. Durometer Hardness - 74 plus and minus 5

    d. Tensile Strength - 1000 psi minimum

    e. Elongation - 175 percent minimum

2. The gaskets shall be immune to attack by impurities normally found in water or wastewater. Gaskets shall meet the requirements of ASTM D 2000 - Classification System for Rubber Products in Automotive Applications, AA709Z, meeting Suffix B13 Grade 3, except as noted above. Where sleeve couplings are used in water containing chloramine or other fluids which attack rubber materials, gasket material shall be compatible with the piping service and fluid utilized.

3. Gasket materials used in water with chloramines shall be **Gylon Style 3500** by **Garlock** or equal.

E. **Piping Connection to Equipment:** Where piping connects to mechanical equipment such as pumps, compressors, and blowers, the piping shall be brought to the equipment connection aligned and perpendicular to the axis of the flange or fitting for which the piping is to be connected. The piping shall not impose excessive stress to the equipment connection to cause misalignment of the equipment. The CONTRACTOR shall assign the responsibility to the equipment manufacturer to review the piping connection to the equipment and submit any modifications to the ENGINEER for review.

F. **Insulating Sleeve Couplings:** Where insulating couplings are required, both ends of the coupling shall have a wedge-shaped gasket which assembles over a sleeve of an insulating compound material compatible with the fluid service in order to obtain insulation of coupling metal parts from the pipe.

G. **Restrained Joints:** Sleeve-type couplings on pressure lines shall be harnessed unless thrust restraint is provided by other means. Harnesses shall be designed by the pipe manufacturer in accordance with AWWA Manual M11, or as indicated. Harness sets shall be designed for the maximum test pressure of the pipe in which they are installed. Where harness sets are installed near the suction and discharge of the pump, harness bolts shall have zero elongation to prevent misalignment of the pump imparted by the thrust within the piping system.

H. Manufacturers, or equal

1. **Dresser, Style 38**

2. **Ford Meter Box Co., Inc., Style FC1 or FC3**

3. **Smith-Blair, Style 411**

2.7 FLANGE COUPLING ADAPTERS

A. Flange coupling adapters shall be provided where indicated. The CONTRACTOR will not be allowed to substitute any other type in lieu of flange coupling adapter unless approved by the ENGINEER. The coupling shall be rated as indicated.

B. **Construction**: Flange coupling adapter body shall be fabricated from steel ASTM A 512 - Cold-Drawn Buttweld Carbon Steel Mechanical Tubing or A 513 - Electric-Resistance Welded Carbon and Alloy Steel Mechanical Tubing with steel bolts, without pipe stop. Flange shall be in accordance with AWWA C207. Couplings shall be of sizes to fit the pipe and fittings indicated. The body shall be not less than 1/4-inch thick or at least the same wall thickness as the pipe to which the coupling is connected. If the strength of the body material is less than the strength of the pipe material, the thickness of the middle ring shall be increased to have the same strength as the pipe. The follower flange shall be fabricated from steel, ASTM A 576 - Steel Bars, Carbon, Hot Wrought, Special Quality or AISI C1012. The shape of the follower shall be of such design as to provide positive confinement of the gasket. Flange coupling adapters installed in piping system rated for positive pressure, the coupling shall be restrained with harness bolts or tie rods. Other means of restraining the coupling such as set screws will not be acceptable. Bolts and nuts shall conform to the requirements of Section 05500. Buried couplings shall be epoxy-coated at the factory as indicated.

C. **Gaskets:** Gaskets for flange coupling adapters shall be rubber-compound material that will not deteriorate from age or exposure to air under normal storage or use conditions. Gaskets for wastewater and sewerage applications shall be Buna "N," Grade 60 NSF approved, or equivalent suitable elastomer.

1. The rubber in the gasket shall meet the following specifications:

    a. Color - Jet Black

    b. Surface - Non-blooming

    c. Durometer Hardness - 74 plus and minus 5

    d. Tensile Strength - 1000 psi Minimum

    e. Elongation - 175 percent Minimum

2. The gaskets shall be immune to attack by impurities normally found in water or wastewater. Gaskets shall meet the requirements of ASTM D 2000 - Classification System for Rubber Products in Automotive Applications, AA709Z, meeting Suffix B13 Grade 3, except as noted above. Where flange coupling adapters are used in water containing chloramine or other fluids which attack rubber materials, gasket material shall be compatible with the piping service and fluid utilized.

3. Gasket materials used in water with chloramines shall be **Gylon Style 3500** by **Garlock** or equal.

D. **Piping Connection to Equipment:** Where piping connects to mechanical equipment such as pumps, compressors, and blowers, the piping shall be brought to the equipment connection aligned and perpendicular to the axis of the flange or fitting for which the piping is to be connected. The piping shall not impose excessive stress to the equipment connection to cause misalignment of the equipment. The CONTRACTOR shall assign the responsibility to the equipment manufacturer to review the piping connection to the equipment and submit any modifications to the ENGINEER for review.

E. **Restrained Joints:** Flange coupling adapters on pressure lines shall be harnessed unless thrust restraint is provided by other means. Harnesses shall be designed by the pipe manufacturer in accordance with AWWA Manual M11, or as indicated. Harness sets shall be designed for the maximum test pressure of the pipe in which they are installed. Where harness sets are installed near the suction and discharge of the pump, harness bolts shall have zero elongation to prevent misalignment of the pump imparted by the thrust within the piping system.

F. Manufacturers, or Equal

1. **Smith-Blair, Model 975**

2. **JCM, Model 309**

2.8 FLEXIBLE CONNECTORS

A. **Low Temperatures**: Flexible connectors shall be installed in piping connections to engines, blowers, compressors, and other vibrating equipment, and where indicated. Flexible connectors for service temperatures up to 180 deg F shall be flanged reinforced neoprene or butyl spools, rated for a working pressure of 40 to 150 psi, or reinforced flanged duck and rubber, as best suited for the application. Flexible connectors for service temperatures above 180 deg F shall be flanged, braided stainless steel spools with inner, annular, corrugated stainless steel hose, rated for minimum 150 psi working pressure, unless otherwise indicated. The connectors shall be a minimum of 9-inches long, face-to-face flanges, unless otherwise indicated. The final material selection shall be approved by the manufacturer. The CONTRACTOR shall submit Shop Drawings and calculations.

B. **High Temperature:** Flexible connectors shall be installed in engine exhaust piping and where indicated. Connectors shall be sufficient to compensate for thermal expansion and contraction and also to isolate vibration between the engine and the exhaust piping system. Connectors shall be stainless steel bellows type, flanged, and rated for minimum 150 psi, 2000 deg F.

2.9 EXPANSION JOINTS

A. Piping subject to expansion and contraction shall be provided with sufficient means to compensate for such movement without exertion of undue forces to equipment or structures. This may be accomplished with expansion loops, bellow-type expansion joints, or sliding-type expansion joints. Expansion joints shall be flanged end, stainless steel, Monel, rubber, or other materials best suited for each individual service. The CONTRACTOR shall submit detailed calculations and manufacturer's Shop Drawings of proposed expansion joints, piping layouts, and anchors and guides, including information on materials, temperature, and pressure ratings.

2.10 PIPE THREADS

A. Pipe threads shall be in accordance with ASME B1.20.1 - Pipe Threads, General Purpose (inch), and be made up with Teflon tape unless otherwise indicated.

2.11 PIPE INSULATION

A. Hot and cold liquid piping, flues, and engine exhaust piping shall be insulated as indicated, in accordance with the requirements of Section 15145 - Pipe and Equipment Insulation. No unprotected hot piping shall be within reach of operating personnel or other persons.

2.12 MODULAR MECHANICAL SEALS FOR PIPING PENETRATIONS

A. Where indicated and where required to prevent flow of water or air, the passages of piping through wall sleeves and cored openings shall be sealed with modular interlocking link mechanical closures. Individual links shall be constructed of EPDM rubber, be suitable for temperatures between minus 40 and plus 250 deg F, and be shaped to fill the annular space between the outside of the pipe and the inside of the wall sleeve or cored opening. Links shall be assembled with type 316 stainless steel bolts and nuts to form a continuous rubber belt around the pipe. Pressure plates under each bolt and nut shall be fabricated of a corrosion-resistant composite material. After the seal assembly is positioned in the sleeve, tighten the bolts against the pressure plates to expand the rubber links and form the watertight seal. Sizing and installation of sleeves and assemblies shall be in accordance with the manufacturer's recommendations.

B. Manufacturers, or equal

1. **Thunderline Corporation, Link-Seal**

2.13 HEAT TRACING

A. Pipes subject to freezing shall be protected by heat tracing

2.14 AIR AND GAS TRAPS

A. Air and gas pipes shall slope to low points and be provided with drip legs, shut-off valves, strainers, and traps. The traps shall be piped to the nearest drain. Air and gas traps shall be not less than 150 lb iron body float type with copper or stainless steel float. Bracket, lever, and pins shall be of stainless steel. Drain traps shall have threaded connections.

B. Manufacturers, or equal

1. **Armstrong International, Inc.**

2. **Spirax Sarco, Inc.**

PART 3 -- EXECUTION

3.1 MATERIAL DELIVERY, STORAGE, AND PROTECTION

A. Piping materials, fittings, valves, and accessories shall be delivered in a clean and undamaged condition and stored off the ground for protection against oxidation caused by ground contact. Defective or damaged materials shall be replaced with new materials.

3.2 GENERAL

A. Piping, fittings, and appurtenances shall be installed in accordance with the requirements of applicable Sections of Division 2 and Division 15. Proprietary manufactured couplings shall be installed in accordance with the coupling manufacturer's recommendation.

B. Care shall be taken to insure that piping flanges, mechanical-type couplings, sleeve-type couplings, flexible connectors, and expansion joints are properly installed as follows:

1. Gasket surfaces shall be carefully cleaned and inspected prior to making up the connection. Each gasket shall be centered properly on the contact surfaces.

2. Connections shall be installed to prevent inducing stress to the piping system or the equipment to which the piping is connected. Contact surfaces for flanges, couplings, and piping ends shall be aligned parallel, concentric, and square to each axis at the piping connections.

3. Bolts shall be initially hand-tightened with the piping connections properly aligned. Bolts shall be tightened with a torque wrench in a staggered sequence to the AISC recommended torque for the bolt material.

4. Groove ends shall be clean and free from indentations, projections, and roll marks in the area from the pipe end to the groove.

5. After installation, joints shall meet the indicated leakage rate. Flanges shall not be deformed nor cracked.

C. **Lined Piping Systems:** The lining manufacturer shall take full responsibility for the complete, final product and its application. Pipe ends and joints of lined pipes at screwed flanges shall be epoxy-coated to assure continuous protection.

D. **Core Drilling:** Where core drilling is required for pipes passing through existing concrete, core drilling locations shall be determined by radiograph of concrete construction to avoid damage to embedded raceways and reinforcing bars.

E. **Cleanup:** After completion of the WORK, cuttings, joining and wrapping materials, and other scattered debris shall be removed from the Site. The entire piping system shall be handed over in a clean and functional condition.

END OF SECTION

SECTION 40 23 01 - PIPING IDENTIFICATION

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide identification for exposed piping and valves, complete and in place, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

ANSI A13.1	Scheme for the Identification of Piping Systems

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.

B. **Shop Drawings**: A list of suggested wording for each valve tag, prior to fabrication.

C. Samples

1. One sample of each type of identification device.

2. Sample of each proposed color required by the pipe color schedule.

PART 2 -- PRODUCTS

2.1 IDENTIFICATION OF PIPING

A. Except as indicated below for very short pipe lengths, identify exposed piping larger than 2-inches nominal size for the pipe contents and direction of flow.

1. Marker Type

   a. Adhesive: Vinyl or polyester sheet with UV- resistant ink, shaped similar to pipe curvature and coated with pressure sensitive adhesive.

2. Marker Area: Sized per pipe size according to ANSI A13.1; color from the table below.

3. Lettering: Sized per pipe size according to ANSI A13.1; color from the table below.

4. Arrows: at least 2 arrows at each marker area, showing direction of flow.

B. Pipe 2-inches and smaller shall be identified by plastic plates made from laminated 3 layer plastic with engraved black letters on white background.

C. Pipe identification shall be as manufactured by **Brady, Seton,** or equal.

2.2 EXISTING IDENTIFICATION SYSTEMS

A. In installations where existing piping identification systems have been established, the CONTRACTOR shall follow the existing system. Where existing identification systems are incomplete, utilize the existing system as far as practical and supplement with the indicated system.

2.3 IDENTIFICATION OF VALVES AND SHORT PIPE LENGTHS

A. Identifying devices for valves and the sections of pipe that are too short to be identified with markers and arrows shall be identified with metal or plastic tags.

B. Metal tags shall be stainless steel with embossed lettering. Plastic tags shall be solid black plastic laminate with white embossed letters. Tags shall be designed to be firmly attached to the valves or short pipes or to the structure immediately adjacent to such valves or short pipes.

C. Wording on the valve tags shall describe the exact function of each valve, e.g., "HWR-BALANCING," "CLS THROTTLING", "RAS-PUMP SHUT-OFF," etc.

PART 3 -- EXECUTION

3.1 GENERAL

A. Markers and identification tags shall be installed in accordance with the manufacturer's printed instructions, and shall be neat and uniform in appearance. Tags and markers shall be readily visible from all normal working locations.

3.2 VALVE TAGS

A. Valve tags shall be permanently attached to the valve or structure by means of 2 stainless steel bolts or screws.

3.3 MARKER LOCATIONS

A. Each pipe shall be marked at:

1. Intervals of 20-feet in straight runs.

2. At least once in every room.

3. Within 2-feet of turns, elbows, and valves.

4. On the upstream side of tees, branches, and other distribution points.

5. On both sides of walls and floors through which the piping passes.

3.4 IDENTIFICATION COLORS

A. Conform to the following color codes.

Color Schedule				
Pipe Contents		Pipe Color	Marker Color	Letter Color
Abbreviation	**Identification**			
CWS	Domestic Cold Water Supply		green	white
HWS	Domestic hot water supply		yellow	black
IW	Irrigation Water		blue	white
OF	Overflow		green	white
DR	Plant drain		green	white
TW	Treated water		yellow	black
FW	Filtered water		blue	white
PW	Potable water		green	white
RW	Raw water		green	white
SDR	Storm drain		green	white
SS	Sanitary sewer		yellow	black
UW	Utility water (non-potable water)		yellow	black
VT	Vent		blue	white

- END OF SECTION -

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SECTION 40 23 02 - PIPE SUPPORTS

PART 1 -- GENERAL

1.1 SUMMARY

A. Provide pipe supports, hangers, guides, and anchors, complete and in place, as indicated in accordance with the Contract Documents.

B. Where pipe support systems are not indicated on the Drawings, the CONTRACTOR shall design and provide the supports in accordance with this Section.

C. Seismic and Wind Forces

1. Pipe support details indicated in the Contract Drawings are not designed to resist seismic and wind forces.

2. The CONTRACTOR shall arrange for the services of a registered professional engineer experienced in pipe support design to design such pipe supports.

3. The CONTRACTOR shall provide additional supports as needed to resist such forces.

1.2 CONTRACTOR SUBMITTALS

D. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.

E. Shop Drawings

1. Submit Shop Drawings which shall include the following information:

a. Drawings of pipe supports, hangers, anchors, and guides

b. Calculations for special supports and anchors, stamped and signed by a registered professional engineer.

PART 2 -- PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Code Compliance

1. Piping systems and pipe connections to equipment shall be properly anchored and supported in order to prevent undue deflection, vibration, and dislocation due to seismic events, line pressures, pipe weight, fluid weight, liquid movement, thermal changes, vibration, probable forces applied during construction, and stresses on piping, equipment, and structures.

2. Supports and parts thereof shall conform to the requirements of ASME B31.1 - Power Piping, except as supplemented or modified in this Section.

3. Supports for plumbing piping shall be in accordance with the latest edition of the applicable plumbing code or local administration requirements.

B. Structural Members

1. Wherever possible, pipes shall be supported from structural members.

2. Where it is necessary to frame structural members between existing members, such supplementary members shall be provided by the CONTRACTOR.

3. Supplementary members shall be in accordance with the requirements of the Building Code and the American Institute of Steel Construction, and shall be as acceptable to the ENGINEER.

C. Pipe Hangers

1. Pipe hangers shall be capable of supporting the pipe in operation, allowing free expansion and contraction of the piping and preventing excessive stress on equipment.

2. Hangers shall have a means of vertical adjustment after erection.

3. Hangers shall be designed to prevent becoming disengaged by any movement of the supported pipe.

4. Hangers subject to shock, seismic disturbances, or thrust imposed by the actuation of safety valves shall include hydraulic shock suppressors.

5. Hanger rods shall be subjected to vertical loading only.

D. Hangers Subject to Horizontal Movements

1. At hanger locations where lateral or axial movement is anticipated, suitable linkage shall be provided to permit such movement.

2. Where horizontal pipe movement is greater than 1/2 inch, or where the hanger rod deflection from the vertical is greater than 4 degrees from the cold-to-hot position of the pipe, the hanger rod and structural attachment shall be offset in such a manner that the rod is vertical in the hot position.

E. Spring-Type Hangers

1. Spring-type pipe hangers shall be provided for piping subject to vibration or vertical expansion and contraction, such as engine exhausts and similar piping.

2. Spring-type hangers shall be sized to the manufacturer's printed recommendations and the loading conditions encountered.

3. Variable spring supports shall be provided with means to limit misalignment, buckling, eccentric loading, or to prevent overstressing of the spring, and with means to indicate the compression of the spring.

4. Supports shall be capable of accommodating at least 4 times the maximum travel due to thermal expansion.

F. Thermal Expansion

1. Wherever expansion and contraction of piping is expected, a sufficient number of expansion loops or expansion joints shall be provided, together with the necessary rolling or sliding supports, anchors, guides, pivots, and restraints permitting the piping to expand and contract freely away from the anchored points.

2. Components shall be structurally suitable to withstand the imposed loads.

G. Heat Transmission

1. Supports, hangers, anchors, and guides shall be designed and insulated such that excessive heat will not be transmitted to the structure or to other equipment.

H. Riser Supports

1. Where practical, risers shall be supported on each floor with riser clamps and lugs, independent of the connected horizontal piping.

I. Freestanding Piping

1. Freestanding pipe connections to equipment such as chemical feeders and pumps shall be firmly attached to steel frames fabricated from angles, channels, or I-beams anchored to the structure.

2. Exterior, freestanding overhead piping shall be supported on fabricated pipe stands consisting of pipe columns anchored to concrete footings, or with horizontal, welded steel angles, and U-bolts or clamps securing the pipes.

J. Materials of Construction

1. Pipe support assemblies, including framing, hardware, and anchors, shall be of steel construction, galvanized after fabrication, unless otherwise indicated.

2. Submerged supports, as well as piping, conduits, and equipment in hydraulic structures within 24 inches of the water level, shall be supported with support assemblies, including framing, hardware, and anchors constructed of Type 316 stainless steel, unless otherwise indicated.

3. Piping in chemical and corrosive areas shall be supported with support assemblies, including framing, hardware, and anchors constructed of Type 316 stainless steel or FRP, unless otherwise indicated.

K. Point Loads

1. Meters, valves, heavy equipment, and other point loads on PVC, FRP, or other plastic pipes, shall be supported on both sides, according to manufacturer's recommendations, in order to avoid undue pipe stresses and failures.

2. In order to avoid point loads, the supports on PVC, FRP, or other plastic piping shall be equipped with extra wide pipe saddles or galvanized steel shields.

L. Concrete Anchors

1. Unless otherwise indicated, concrete anchors for pipe supports shall be according to the following table; consult the ENGINEER for any anchor applications not appearing on the table.

2. Anchor embedment shall be in accordance with the requirements of Section 05 50 00 – Metal Fabrications & Miscellaneous Metals.

Pipe Support Application	Type of Concrete Anchor
New Concrete	Use embedded concrete insert anchors on a grid pattern. Use **Grinnell (Anvil International), Tolco**, or equal.
Existing Concrete	Use non-shrink grouted anchors, metallic type expansion anchors, or epoxy anchors. Exceptions: Metallic type expansion anchors and epoxy anchors are not permitted for pipe supports subject to vibrating loads. Epoxy anchors are not permitted where the concrete temperature is in excess of 100 deg F or higher than the limiting temperature recommended by the manufacturer. Epoxy anchors are not accepted where anchors are subject to vibration or fire.
Vibratory Loads and High-Temperature Conditions	Use non-shrink grouted anchors

M. Noise Reduction

1. In order to reduce the transmission of noise in piping systems, copper tubes in buildings and structures shall be wrapped with a 2-inch wide strip of rubber fabric or similar suitable material at each pipe support, bracket, clip, or hanger.

2.2 SUPPORT SPACING

A. Supports for piping with the longitudinal axis in approximately a horizontal position shall be spaced to prevent excessive sag, bending, and shear stresses in the piping, with special consideration given where components such as flanges and valves impose concentrated loads.

B. Pipe support spacing shall not exceed the maximum indicated spans.

C. For temperatures other than ambient temperatures or those listed, and for other piping materials or wall thicknesses, the pipe support spacings shall be modified in accordance with the pipe manufacturer's recommendations.

D. Vertical supports shall be provided to prevent the pipe from being overstressed from the combination of loading effects.

E. Steel Pipe

1. Install supports for steel pipe in accordance with the requirements of AWWA: Manual of Practice MOP-11.

2. For steel pipe sizes not indicated, the support spacing shall be designed such that the stress on the pipe does not exceed 5,000 psi.

3. Where support spacing is not indicated on the Drawings, the CONTRACTOR shall use the spacing indicated in the following schedule, for the indicated support condition:

PRACTICAL SPANS FOR SIMPLY SUPPORTED PIPE IN 120-DEGREE CONTACT SADDLES, FEET[1]

Nominal Pipe Diameter, inches	Pipe Wall Thickness, inches									
	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1
6	36	40	44							
8	38	42	45							
10	39	43	46							
12	40	44	47							
14	40	44	47							
16	41	45	48							
18	41	46	49	52						
20	42	46	50	53						
22	42	46	51	54						
24	42	48	52	55	58	60				
26	43	48	52	56	59	61				
28	43	48	53	56	59	62				
30	43	49	53	57	60	63				
32	44	49	54	57	61	64				

34	44	49	54	58	61	64				
36	44	50	54	58	62	65	70			
38	44	50	55	59	62	65	70			
40	44	50	55	59	63	66	71			
42	44	50	55	59	63	66	72			
45		51	55	60	63	67	72			
48		51	56	60	64	67	73	78		
51		51	56	60	64	68	74	79		
54		51	56	61	65	68	74	79		
57		51	57	61	65	69	75	80		
60		51	57	61	65	69	75	80		
63		52	57	62	66	69	76	81		
66		52	57	62	66	70	76	81	86	90
72		52	58	62	66	70	77	82	87	92
78			58	62	67	71	77	83	88	93
84			58	63	67	71	78	84	89	94
90			58	63	67	71	78	84	90	94
96			58	63	68	72	79	85	90	95

[1] Reference: AWWA MOP 11, Table 7-1

F. Ductile Iron Pipe

1. Install supports for ductile iron pipe in accordance with the recommendations of the Ductile Iron Pipe Research Association (DIPRA) Design of Ductile Iron Pipe on Supports.

2. As a minimum, where support spacing is not indicated on the Drawings, the CONTRACTOR shall use the spacing indicated in the following schedule:

Nominal Pipe Diameter, inches	Support Configuration
ALL DIAMETERS	two supports per pipe length, with one of the two supports located at a joint

G. Copper Tube

1. Install supports for copper tube in accordance with the recommendations of ANSI/MSS SP-69 Pipe Hangers and Supports - Selection and Application, as indicated in the following schedule:

Nominal Tube Size, inches	Support Spacing, feet[1]	
	Water Service	Vapor Service
1/4	5	5
3/8	5	6
1/2	5	6
3/4	5	7
1	6	8
1-1/4	7	9
1-1/2	8	10
2	8	11
2-1/2	9	13
3	10	14
3-1/2	11	15
4	12	16
5	13	18
6	14	20
8	16	23
10	18	25
12	19	28

[1] Reference: ANSI/MSS SP-69, Table 3

H. Schedule 80 PVC Pipe

1. Install supports for Schedule 80 PVC pipe as indicated in the following schedule:

Support Spacing for Schedule 40 PVC Pipe[1]			
Nominal Pipe Size, inches	Maximum Support Spacing, feet, at Various Temperatures		
	60 deg F	100 deg F	140 deg F
1	5	4	NA
1-1/2	5.75	5.25	NA
2	6.5	5.75	NA
3	8	7	NA
4	9	8.5	NA
6	10	10	NA
8	13	11.75	NA
10	15	13	NA
12	13	14.5	NA
14	15	15	NA

[1] Reference: USACE based on Harvel Plastics Product Bulletin 112/401 (rev, 10/1/95), p. 63; spacing values based on test data developed by the manufacturer for the specific product and continuous spans; the piping is insulated and full of liquid with a specific gravity of 1.0

2.3 MANUFACTURED SUPPORTS

I. Stock Parts

1. Where not specifically indicated, designs that are generally accepted as exemplifying good engineering practice and using stock or production parts shall be utilized wherever possible.

2. Such parts shall be locally available, new, of best commercial quality, and designed and rated for the intended purpose.

J. Manufacturers, or Equal

1. **Basic Engineers Inc**.

2. **Bergen-Paterson Pipesupport Corp**.

3. **Grinnell Corp. (Anvil International)**

4. **NPS Products, Inc**.

5. **Power Piping Company**

6. **Tolco Incorporated**

2.4 COATING

K. Galvanizing

L. Other Coatings

1. Other than stainless steel or non-ferrous supports, supports shall receive protective coatings in accordance with the requirements of Section 09 96 00 – Protective Coating.

PART 3 -- EXECUTION

3.1 INSTALLATION

M. General

1. Pipe supports, hangers, brackets, anchors, guides, and inserts shall be fabricated and installed in accordance with the manufacturer's printed instructions and ASME B31.1 - Power Piping.

2. Concrete inserts for pipe hangers and supports shall be coordinated with the formwork.

N. Appearance

1. Pipe supports and hangers shall be positioned in order to produce an orderly, neat piping system.

2. Hanger rods shall be vertical, without offsets.

3. Hangers shall be adjusted to line up groups of pipes at the proper grade for drainage and venting, as close to ceilings or roofs as possible, and without interference with other WORK.

3.2 FABRICATION

O. Quality Control

1. Pipe hangers and supports shall be fabricated and installed by experienced welders and fitters, using the best welding procedures available.

2. Fabricated supports shall be neat in appearance without sharp corners, burrs, or edges.

- END OF SECTION -

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SECTION 40 23 15 - STEEL PIPE (ASTM A53 / A106, MODIFIED)

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide steel pipe and appurtenances, complete and in place, in accordance with the Contract Documents.

B. The requirements of Section 40 23 00 - Piping, General apply to the WORK of this Section.

C. **Pipe Material Group No. 1**. The piping system defined in this section is referred to in the Pipe Schedule on Contract Sheet G008 as Piping Material Group No. 1.

PART 2 -- PRODUCTS

2.1 PIPE MATERIAL

A. **Water, Air, Fuel Gas:** Unless otherwise indicated, galvanized and black steel pipe shall conform to ASTM A 53 - Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless or ASTM A 106 - Seamless Carbon Steel Pipe for High Temperature Service, Grade B, and shall be Schedule 40 or 80, as indicated in the Piping Schedule. Galvanized steel pipe shall not be cement mortar lined unless so indicated.

2.2 PIPE JOINTS

A. Black steel pipe for general service shall have screwed ends with NPT threads, welded joints, or flanged joints. Screwed joints shall be made up with Teflon tape and welded joints may have butt-weld fittings, socket-weld fittings, or flanges. Where indicated, black steel pipe shall have grooved ends for shouldered couplings or plain ends for sleeve-type couplings.

B. Black steel pipe for chlorine or sulfur dioxide pressure service shall be socket-welded except where required to match mating fittings of vacuum regulator-check units, gas filters, valves, diaphragm units, gauges, and switches.

C. Galvanized steel pipe shall have screwed ends with NPT threads made up with Teflon tape. Where indicated, galvanized steel pipe shall have grooved ends for shouldered couplings or plain ends for sleeve-type couplings.

D. Where pressure conditions permit, black and galvanized steel pipe may have push-on joints for compression type fittings. For high pressure service these joints shall be harnessed.

2.3 FITTINGS

A. **Common Use:** The following fittings shall be provided for galvanized or black steel pipe, as indicated in the Piping Schedule:

1. Threaded malleable iron fittings conforming to ASME B 16.3 - Malleable-Iron Threaded Fittings, Classes 150 and 300.

2. Threaded cast iron fittings conforming to ASME B 16.4 - Cast Iron Threaded Fittings, Class 125 and 250.

3. Forged steel socket welded fittings conforming to ASME B 16.11 - Forged Fittings, Socket - Welding and Threaded.

4. Butt welding fittings conforming to ASME B 16.9 - Factory-Made Wrought Steel Butt Welding Fittings, Schedule 40 or 80, as indicated.

5. Threaded cast iron drainage fittings conforming to ASME 16.12 - Cast Iron Threaded Drainage Fittings.

6. Flanged cast iron fittings conforming to ASME B 16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250 and 800.

7. Flanged steel fittings conforming to ASME B 16.5 - Pipe Flanges and Flanged Fittings, Steel Nickel Alloy and Other Special Alloys.

8. Grooved ductile iron fittings with grooving dimensions conforming to AWWA C 606 - Joints, Grooved and Shouldered Type.

9. Compression-type steel fittings with armored Buna S gaskets for plain end pipe.

B. Special Applications

1. Fittings for chlorine and sulfur dioxide under pressure shall be 3,000 lb. forged steel socket welded fittings conforming to ASTM A 105, Grade 2 - Forgings, Carbon Steel, for Piping Components, and 300 lb. forged steel fittings conforming to ASME B 16.11, as indicated in the Piping Schedule.

2. Flanges for chlorine and sulfur dioxide pressure service shall conform to ASTM A 105, ASME B 16.5, Class 300, with 1/16-inch raised face, with 1/16-inch high temperature, compressed, self-centering ring type gaskets to ASME B 16.21 - Nonmetallic Flat Gaskets for Pipe Flanges. Unions shall be 4 bolt tongue and groove, ammonia type, suitable for chlorine and sulfur dioxide service, with female threads and lead gaskets.

3. High tensile alloy steel corrosion-resistant bolts and nuts shall be used with each set of flanged unions. Unions shall be rated for 500 lb. CWP service pressure, reducing-type, straight-type or blind-type, as required for the installation. Blind unions shall be provided as cleanouts where indicated, and straight unions shall be provided adjacent to each threaded valve or piece of equipment. Unions shall be as manufactured by **Henry Valve Company, Vogt Valve Co.,** or equal.

PART 3 -- EXECUTION

3.1 INSTALLATION

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

B. **Supports and Anchors:** Piping shall be firmly supported with fabricated or commercial hangers or supports in accordance with Section 40 23 02 - Pipe Supports. Where necessary to avoid stress on equipment or structural members, the pipes shall be anchored or harnessed. Expansion joints and guides shall compensate for pipe expansion due to temperature differences.

C. **Valves and Unions:** Water, steam, condensate, gas, vacuum, and air supply piping to fixtures, groups of fixtures, and equipment shall be provided with a shutoff valve and union, unless the valve has flanged ends. Low points in water systems and driplegs in steam, gas, and air systems shall have drainage valves. Unions shall be provided at threaded valves, equipment, and other devices requiring occasional removal or disconnection.

D. **Branch Connections:** Branch connections in horizontal runs of air and gas piping shall be made from the top of the pipe, to avoid drainage of condensate into the equipment.

3.2 PIPE PREPARATION

A. Prior to installation, each pipe length shall be carefully inspected, be flushed clean of any debris or dust, and be straightened if not true. Ends of threaded pipes shall be reamed and filed smooth. Fittings shall be equally cleaned before assemblage.

3.3 PIPE JOINTS

A. **Threaded Joints:** Pipe threads shall conform to ASME B 1.20.1 - Pipe Threads, General Purpose (inch), and shall be full and cleanly cut with sharp dies. Not more than 3 threads shall remain exposed after installation.

B. **Welded Joints:** Welded joints shall conform to the specifications and recommendations of ASME B 31.1 - Power Piping. Welding shall be done by skilled and qualified welders per Section 40 23 00 - Piping, General.

C. **Grooved Joints:** Grooves for grooved couplings and fittings shall be made with specially designed grooving tools to the manufacturer's recommendations and conform to AWWA C 606. Grooves shall be clean and sharp without flaws, and the pipe ends shall be accurately cut at 90 degrees to the pipe axis.

D. **Push On Joints:** Push on joints and gasket installation shall be in accordance with the manufacturer's recommendations and lubricants. Pipe ends shall be beveled to facilitate assembly. Lubricants shall be suitable for potable water service and shall be kept clean in closed containers.

3.4 INSPECTION AND FIELD TESTING

A. **Inspection:** Finished installations shall be carefully inspected for proper supports, anchoring, interferences, and damage to pipe, fittings, and coating. Any damage shall be repaired.

B. **Field Testing:** Prior to enclosure or burying, piping systems shall be pressure tested as required in the Piping Schedule for a period of not less than one hour without exceeding the tolerances listed in the Piping Schedule. Where no pressures are indicated, the pipes shall be subject to 1-1/2 times the maximum working pressure. The CONTRACTOR shall furnish test equipment, labor, materials, and devices as part of the WORK.

1. Leakage may be determined by loss of pressure, soap solution, chemical indicator, or other positive and accurate method. Fixtures, devices, or other accessories which are to be connected to the lines and which would be damaged if subjected to the test pressure shall be disconnected and ends of the branch lines plugged or capped as required during the testing procedures.

2. After completion of the pressure tests, chlorine gas piping shall be tested for leakage using chlorine gas under operating pressures. Piping shall be thoroughly clean and dry before admitting chlorine gas into the system. Chlorine shall be slowly admitted to the piping system. Leakage shall be checked with a swab soaked in aqua ammonia solution and waved in the vicinity of each fitting. Ammonia solution shall not be applied to the fittings. Formation of white fumes will be evidence of leaks. Chlorine gas shall be purged from the line before leaks are repaired.

3. Leaks shall be repaired, and the system shall be re-tested until no leaks are found.

- END OF SECTION -

SECTION 40 23 17 - COPPER WATER TUBE
(ASTM B88, MODIFIED)

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide copper tubing or pipe, as called for in the Contract Documents for water, gas, and vacuum service, complete and in place, in accordance with the Contract Documents.

B. **Pipe Material Group No. 24**. This piping system is referred to in the Pipe Schedule on Contract Sheet G008 as Piping Material Group No. 24.

C. The requirements of Section 40 23 00 - Piping, General apply to the WORK of this Section.

1.2 CONTRACTOR SUBMITTALS

A. Submittals shall be in accordance with Section 01 33 00 - Contractor Submittals.

PART 2 -- PRODUCTS

2.1 PIPE MATERIAL

A. Copper water tube shall conform to the requirements of ASTM B 88 - Seamless Copper Water Tube, and shall be soft temper tube in rolls for buried locations, and hard drawn pipe, minimum of 20-ft long pipe sticks, for above-grade applications. Copper water tubing and pipe shall be of **Type K** wall thickness.

B. Copper piping used for oxygen service shall be marked by the manufacturer "Cleaned for Oxygen Service"

2.2 JOINTS

A. Copper water tube shall have either soldered joints, flared ends and fittings, or compression type joints. Soldered joints shall be made with 95 - 5 percent tin-antimony solder or with silver solder. Buried piping shall have flared or compression type joints. No soft-soldered joints will be allowed on buried piping. No solders containing more than 0.2 percent of lead shall be used.

2.3 FITTINGS

A. **Soldered Fittings:** Soldered fittings shall conform to ANSI B 16.18 - Cast Copper Alloy Solder Joint Pressure Fittings, or to ASME B 16.22 - Wrought Copper and Copper Alloy Solder - Joint Pressure Fittings. The soldering flux shall be the manufacturer's approved type for the fitting and solder used.

B. **Flared Fittings:** Flared fittings shall conform to ASME B 16.26 - Cast Copper Alloy Fittings for Flared Copper Tubes.

C. **Compression Fittings**: Compression type fittings shall be brass fittings as manufactured by **Crawford Company - SWAGELOK, Parker-Hannifin - CPI**, or equal.

D. **Flanged Fittings:** Cast copper alloy flanges and flanged fittings shall be in accordance with ASME B 16.24 - Cast Copper Alloy Pipe Flanges and Flanged Fittings, and ASTM B 62 - Composition Bronze or Ounce Metal Castings, with 150 lb. ratings, or as indicated.

E. Copper fittings used for oxygen service shall be marked by the manufacturer "Cleaned for Oxygen Service"

PART 3 -- EXECUTION

3.1 INSTALLATION

A. **General:** Copper tubes shall be installed in a neat and workmanlike manner, properly aligned, and cut from measurements taken at the Site to avoid interferences with structural members, architectural features, openings, and equipment. Exposed tubing shall afford maximum headroom and access to equipment, and where necessary, tubing shall be installed with sufficient slopes for venting or drainage of liquids and condensate to low points. Installations shall be without defects.

B. **Supports and Anchors:** Tubing shall be firmly supported with fabricated or commercial hangers, brackets, or supports in accordance with Section 43 10 52 - Pipe Supports. Where necessary to avoid stress on equipment or structural members, the tubes shall be anchored or harnessed. Expansion joints and guides shall compensate for expansion due to temperature differences.

C. **Valves and Unions:** Unless otherwise indicated, tubing to fixtures, groups of fixtures, and equipment shall be provided with a shutoff valve and union, unless the valve has flanged ends. Low points in water systems and driplegs in steam, gas, and air systems shall have drainage valves. Unions shall be provided at threaded valves, equipment, and other devices requiring occasional removal or disconnection.

D. **Branch Connections:** Branch connections in horizontal runs of air and gas tubing shall be made from the top of the main to avoid drainage of condensate into the equipment.

3.2 PREPARATION

A. Prior to installation, each tube length shall be carefully inspected, flushed clean of any debris or dust, and be straightened, if not true. Ends of tubes shall be reamed and filed smooth. Fittings shall be equally cleaned before assembly.

3.3 JOINTS

A. **Brazed and Soldered Joints:** Brazed and soldered joints shall conform to the manufacturer's recommendations and to the specifications and recommendations of ASME B 31.1 - Power Piping. Brazing shall be done by skilled and qualified welders per Section 43 10 50 - Piping, General. Prior to the application of flux, the ends of tubes shall be thoroughly dried and cleaned.

3.4 INSPECTION AND FIELD TESTING

A. **Inspection:** Finished installations shall be carefully inspected for proper joints and supports, anchoring, interferences, and damage to tubing, fittings, and coating. Defective WORK shall be repaired.

B. **Field Testing:** Prior to enclosure or burying, tubing systems shall be pressure tested as required in the Piping Schedule, for a period of not less than one hour without exceeding the tolerances listed in the Piping Schedule. Where no pressures are indicated, the tubes shall be subject to 1.5 times the maximum working pressure. The CONTRACTOR shall furnish test equipment, labor, materials, and devices as part of the WORK.

1. Leakage may be determined by loss of pressure, soap solution, chemical indicator, or other positive and accurate method. Fixtures, devices, or other accessories which are to be connected to the lines and which would be damaged if subjected to the test pressure shall be disconnected and ends of the branch lines be plugged or capped as required during the testing procedures.

2. Leaks shall be repaired, and the piping shall be re-tested until no leaks are found.

- END OF SECTION -

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SECTION 40 23 22 - PVC PRESSURE PIPE

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide polyvinyl chloride (PVC) pressure pipe, complete and in place, in accordance with the Contract Documents.

B. **Pipe Material Group No. 16 and 17**. This piping system is referred to in the Pipe Schedule as Piping Material Group No. 16 and 17.

C. The requirements of Section 40 23 00 - Piping, General, apply to the WORK of this Section.

D. This Section includes PVC pressure pipe with solvent-welded, flanged, or screwed joints.

1.2 CONTRACTOR SUBMITTALS

A. Submittals shall be in accordance with Section 01 33 00 - Contractor Submittals.

B. **Shop Drawings:** The CONTRACTOR shall submit Shop Drawings of pipe, joints, bends, special fittings, and piping appurtenances.

PART 2 -- PRODUCTS

2.1 PIPE MATERIAL

A. PVC pipe shall be made from new rigid unplasticized polyvinyl chloride and shall be normal impact Type 1, Grade 1, class 12454, listed as compliant with NSF Standard 61, unless otherwise indicated, in accordance with ASTM D 1785-Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.

2.2 PIPE JOINTS

A. Pipe joints shall be solvent-welded type with solvent cement and primer as recommended by the pipe manufacturer for the chemical in the pipe.

B. Screwed joints that are necessary to match up to threaded valves or fittings shall be made up with appropriate thread sealant, either paste or tape.

C. Flanged joints shall be made with solvent-welded PVC flanges, drilled to ASME B16.5 - Pipe Flanges and Flanged Fittings, Class 150, unless otherwise indicated. Gaskets shall be ANSI 150 lb. full face, 1/8-inch thick Neoprene for water service. Gasket material for chemicals shall be suitable for the chemical service.

2.3 FITTINGS

A. **Solvent Welded and Threaded Fittings:** Solvent-welded and threaded fittings shall be compact type, Schedule to match pipe PVC fittings in accordance with ASTM D 2466 or ASTM D 2467 - Socket-Type Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, to match pipe schedule.

B. **Flanged Fittings:** Flanged fittings shall be Schedule to match fabricated PVC fittings with 150 lb. flanges to ASME B 16.5.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. **General:** PVC pipe shall be installed in a neat and workmanlike manner, properly aligned, and cut from measurements taken at the Site to avoid interferences with structural members, architectural features, openings, and equipment. Exposed pipe shall afford maximum headroom and access to equipment, and where necessary, piping shall be installed with sufficient slopes for venting or drainage of liquids and condensate to low points. It is recommended that the CONTRACTOR obtain the assistance of the pipe manufacturer's field representative to instruct the pipefitters in the correct installation and support of PVC piping.

B. **Supports and Anchors:** Piping shall be firmly supported with fabricated or commercial hangers or supports in accordance with Section 43 23 02 - Pipe Supports. Where necessary to avoid stress on equipment or structural members, the pipe shall be anchored or harnessed. Expansion joints and guides shall compensate for pipe expansion due to temperature changes.

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

3.2 PIPE PREPARATION

A. Prior to installation, each pipe length shall be carefully inspected, flushed clean of any debris or dust, and be straightened, if not true. Ends of threaded pipes shall be reamed and filed smooth. Pipe fittings shall be equally cleaned before assembly.

3.3 PIPE JOINTS

A. **Solvent-Welded Joints:** Solvent-welded joints shall be made with fresh primer and solvent cement on clean, dry pipe ends. The primer and cement cans shall be kept closed at all times and the joints shall be made up at the recommended ambient temperatures, to the pipe or cement manufacturer's written recommendations. Pipe ends shall be inserted to the full depth of the socket.

B. **Flange Joints:** Flanged joints shall be made with gaskets and galvanized steel bolts and nuts. Care shall be taken not to over-torque the bolts, in accordance with the manufacturer's written recommendations.

3.4 INSPECTION AND FIELD TESTING

A. **Inspection:** Finished installations shall be carefully inspected for proper joints and sufficient supports, anchoring, interferences, and damage to pipe, fittings, and coating. Defective WORK shall be repaired.

B. **Field Testing:** The CONTRACTOR shall allow adequate time for the solvent cement joints to cure. Curing time shall be per the solvent cement manufacturer's recommendation. Prior to enclosure or burying, piping systems shall be pressure tested as required in the Piping Schedule, for a period of not less than one hour, without exceeding the tolerances listed in the Piping Schedule. Caution - Do not use air or gas for testing PVC pipe. Where no pressures are indicated, the pipes shall be subject to 1.5 times the maximum working pressure. The CONTRACTOR shall furnish test equipment, labor, materials, and devices.

C. Leakage shall be determined by loss of pressure. Fixtures, devices, or other accessories that would be damaged if subjected to the test pressure shall be disconnected and ends of the branch lines shall be plugged or capped as appropriate during the testing procedures.

D. Leaks shall be repaired, and the piping shall be re-tested until no leaks are found.

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SECTION 40 42 00 – PIPE AND EQUIPMENT INSULATION

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide pipe and equipment insulation, complete and in place, as indicated in accordance with the Contract Documents.

B. In addition to the insulation indicated, the CONTRACTOR shall insulate cold or hot piping and exhausts that could be hazardous to personnel upon contact.

1.2 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Federal Specifications

HH-1-558B	Insulation Blocks, Boards, Blankets, Felts, Sleeving (Pipe and Tube Covering), and Pipe Fitting Covering, Thermal (Mineral Fiber, Industrial Type)

B. Commercial Standards

ASTM C 547	Mineral Fiber Pipe Insulation
TM E 84	Test Method for Surface Burning Characteristics of Building Materials

1.3 CONTRACTOR SUBMITTALS

A. Submit complete Shop Drawings of thermal insulation, with manufacturer's data on materials, covering, jackets, and finish, in accordance with the requirements of Section 01 33 00 – Contractor Submittals.

B. Furnish the following certifications:

1. Certification from the heating system manufacturer that the insulation has been installed in accordance with the manufacturer's recommendations.

2. Certification from the acoustic insulation/duct lining manufacturer that the lining has the indicated sound absorption coefficients.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Components of the insulation, including covering, mastics, and adhesives, shall have a flame-spread rating of not greater than 25 and a smoke development rating of not greater than 50.

B. Ratings shall be as established by tests in accordance with ASTM E 84, and the above federal and commercial specification standards.

Insulation shall be applied in strict accordance with the manufacturer's instructions.

2.2 BASIC MATERIALS

A. Unless otherwise indicated, the insulation thickness shall be as follows:

Pipe		Minimum Thickness of Insulation (inches)
Hot and cold potable water	6-inch and smaller	1
	8-inch and larger	1-1/2
Hot and chilled process water	6-inch and smaller	1-1/2
	8-inch and larger	2
Low-pressure steam (50 psig and less)	4-inch and smaller	1
	5-inch and larger	1-1/2
High-pressure steam (51 psig and greater)	all sizes	3
Condensate, boiler blowdown, and boiler feed	8-inch and smaller	1-1/2
	10-inch and larger	2
Heated sludge and process piping	6-inch and smaller	1
	8-inch and larger	1-1/2
Compressed air piping and liquid refrigerant piping exposed to the weather	all sizes	2
Heat-traced piping	3-inch and smaller	1
	4-inch and larger	1-1/2

Equipment and Tanks	Minimum Thickness of Insulation (inches)
Boilers, heaters, and manufactured equipment	as recommended by manufacturer
Heat exchangers, tanks, and vessels	3

2.3 PIPING INSULATION

A. Except as indicated otherwise, piping shall be insulated with heavy density, unfaced, fiberglass pipe insulation.

B. Pipe insulation shall have an average density of 4 pounds per cubic foot or greater, and its conductivity (k) shall not exceed 0.23 BTU-inch per (hour) (square foot) (degree F) at a mean temperature of 75 degrees F.

C. Supporting Hangers

1. For 3-inch piping and larger, the insulation shall be protected at supporting hangers by the suitable hollow steel protection saddles, filled with loose glass fiber insulation as indicated.

2. For piping smaller than 3-inch, place 1/16-inch thick sheet metal shims between the insulation and the supporting hanger; the shim shall be at least 6 inches long.

3. The insulation shall be oversized for installation over electric heating cable.

4. The insulation shall have a factory-applied white fire-retardant vapor-barrier jacket of kraft paper and aluminum foil laminated together and reinforced with fiberglass yarn.

5. Fittings and valves shall be covered with the same material as the pipe, cut in segments to fit snugly without open spaces, held in place with copper wire or cement, and then covered with the same jacketing material as the pipe.

6. Insulated fittings adjacent to vapor-barrier insulation shall be sealed with an acceptable vapor-barrier cement before installation of the finish jacket.

7. The pipe insulation and vapor-barrier shall be continuous through hangers and supports.

8. Where insulation is indicated for the top-half segment of pipe, insulation at support locations shall be of the same density.

9. The bottom-half insulation segments provided between the pipe and the insulation protection shields shall have a density of not less than 6 lb/cu ft.

D. Jacketing

1. A final covering of the insulation for piping shall be of 0.030-inch thick PVC or equivalent strength smooth aluminum, preformed jacketing with a factory-attached moisture barrier.

2. Valves, flanges, fittings, and ends of insulation shall be covered with a pre-molded, precision-formed, high-low temperature PVC fitting cover or end cap, or equivalent preformed unit to match the piping insulation jacket.

3. The pre-molded covers shall be sized to receive the same thickness of insulation as used on the adjacent piping, and shall be sized to cover and protect the insulated fitting.

4. Joints shall be sealed with silicone mastic or solvent welding to provide a continuous air- and weather-tight joint.

5. Strapping shall be 1/2-inch wide, Type 3003 aluminum or stainless steel.

6. Pre-molded fittings shall be **Zeston 2000 PVC**, or equal.

E. Standard Temperature Insulation

1. Standard temperature insulation shall be used for process, cold and hot water, steam, and condensate piping and equipment with surface temperatures up to 850 degrees F.

2. Pipe insulation and jacketing shall be applied to piping where indicated, including associated fittings, flanges, and valves.

3. Pipe insulation shall consist of a molded-type pipe covering, constructed of fibrous glass with a minimum k-factor of 0.23 at 75 degrees F mean temperature.

F. High Temperature Insulation

1. High temperature insulation shall be employed for engine exhaust pipes, flues, and similar pipes and equipment with surface temperatures up to 1200 degrees F.

2. High temperature insulation shall consist of 4-inch thick calcium silicate or similar pre-molded blocks, constructed in 2 layers of 2-inch thickness each with staggered joints, and applied over a 3/4-inch-high metal rib lath.

3. The inner layer shall be suitable for 1200 degrees F, and the outer layer for 1000 degrees F.

4. Bends, voids, joints, fittings, and other parts of the piping system shall be filled with insulating cement.

5. Aluminum lagging with preformed aluminum fittings shall be banded to the insulation in a similar fashion as required for standard insulation.

6. Allowance shall be made for thermal expansion.

G. Manufacturers, or Equal

1. **Armstrong Contracting and Supply Corp.**

2. **Certain-Teed Corporation**

3. **Johns Manville**

4. **Owens-Corning**

5. **P.P.G. Industries, Inc.**

2.4 AERATION PIPING INSULATION

A. Provide acoustical-thermal insulation on blower inlet, discharge and blowoff piping, including fittings, flanges, valves, couplings, meters, silencers, and appurtenances.

B. Acoustical Insulation

1. Acoustical insulation shall consist of 1/2-inch thick fiberglass laminated to a lead barrier having a density of 16 ounces per square foot.

2. The fiberglass/lead barrier shall have a temperature rating to 350 degrees F, and shall be **Hushcloth** as manufactured by **American Acoustical Products**, **Alpha Associates, Inc.**, or equal.

3. The acoustical insulation shall overlap at least 2 inches in both the transverse and longitudinal directions and shall be installed to avoid sagging or gapping.

4. Scrim

a. The acoustical insulation shall be held in place by the use of scrim fabric at least 6 inches wide.

b. Provide at least 2 wraps of scrim per length of acoustical insulation.

c. The scrim shall be 5 x 5-thread-count fiberglass mesh, with a thread thickness of 0.03 inch, and weighing 5.8 ounces per square yard.

d. Scrim shall be **Alpha Associates Luben 8405**, or equal.

C. Thermal Insulation

1. The acoustical insulation shall be covered by a fiberglass thermal insulation and fiberglass lagging fabric.

2. The thermal insulation shall have an average density of 4 pounds per cubic foot or greater, and its conductivity (k) shall not exceed 0.23 BTU-inch per (hour) (square foot) (degree F) at a mean temperature of 75 degrees F.

3. The thermal insulation shall be as manufactured by **Manville, Owens-Corning**, or equal.

D. Lagging Fabric

1. The final covering shall be a 100 percent fiberglass lagging fabric, with a thickness of 0.034 inch, and weighing 19 ounces per sq yd.

2. The lagging fabric shall be **Alpha Associates (Style 2025)**, **J.P. Stevens Co.**, or equal.

E. Compression Couplings and Expansion Joints

1. Compression couplings and expansion joints on piping shall be covered as indicated, using rigid insulation block.

2. The insulation block shall be composed of hydrous calcium silicate, and segmented to wrap around the piping.

3. Manufacturers, or Equal

   a. **Manville, Thermo 12**

   b. **Owens-Corning, Kaylo 10**

F. Valves and flanges shall be covered in a similar manner to the adjacent piping.

2.5 STANDBY GENERATOR PIPING INSULATION

A. The exhaust piping, fittings, and silencers shall be insulated with a rigid calcium silicate material, capable of withstanding pipe temperatures of 1200 degrees F, and shall be of **Kaylo 10 Asbestos Free** type pipe insulating material, or equal.

B. The silencer insulation shall be 6 inches thick, and the exhaust piping and fittings insulation shall be 4 inches thick.

C. The insulation shall be pre-molded blocks in 2 layers with staggered joints, applied on a 3/4-inch high metal rib lath, and covered with a glass cloth vapor barrier jacket secured by adhesive.

D. Manufacturers, or Equal

1. **Armstrong Contracting and Supply Corporation**

2. **Certain-Teed Corporation**

3. **Johns Manville**

4. **Owens-Corning**

5. **P.P.G. Industries, Inc.**

2.6 ANTI-CONDENSATION PIPING INSULATION

A. In general, piping 5 inches and larger in diameter for raw water, settled water, filtered water, service water, water tanks, and as indicated, shall be insulated.

B. The insulation shall be a flexible closed-cell elastomeric thermal insulation, black in color and provided with a smooth skin on one side to form the outer exposed insulation surface.

C. The insulation shall be supplied in sheets and rolls, as follows:

Thickness	1/8-inch to 2-inch
Thermal conductivity	0.27 BTU-inch per (hour) (square foot) (degree F) at a mean temperature of 75 degrees F
Water vapor permeability	0.10 perm-inch
Water absorption	6 percent maximum
Upper use limit	180 degrees F
Lower use limit	-40 degrees F
Flame-spread rating	25 or less
Smoke-developed rating (thickness to 3/4-inch)	50 or less
Smoke-developed rating (thickness 1-inch or greater)	100 or less

D. Manufacturer, or Equal

1. **Armstrong, AP Armaflex Sheet and Roll**

2.7 BURIED HEATING PIPING SYSTEM INSULATION

A. Insulate piping with one-inch thick, hard preformed fiberglass.

B. Manufacturer, or Equal

1. **Ric-Wil-Galva-Guard**

2.8 BOILER BREECHING PIPING INSULATION

A. The flue piping, fittings, and breeching shall be insulated with a rigid calcium silicate material capable of withstanding pipe temperatures of 1200 degrees F.

B. The insulation shall be 4 inches thick.

C. The insulation shall be covered with a glass cloth vapor barrier jacket secured by adhesive.

D. Manufacturer, or Equal

1. **Owens-Corning, Kaylo 10 - Asbestos Free**

2. **Johns Manville**

2.9 DUCTWORK INSULATION

A. Supply ductwork and outside air ductwork shall be insulated as indicated under this Section.

B. Insulation shall be provided for air duct systems operating at internal air temperatures up to 250 degrees F.

C. The finished duct system shall meet the requirements of NFPA 90A and 90B.

D. Duct wrap insulation shall meet the requirements of ASTM C 1290, Type III, to a maximum service temperature of 250 degrees F.

E. Facing material shall meet the requirements of ASTM C 1136, Type II, when surface burning characteristics are determined in accordance with ASTM E 84 with the foil surface of the material exposed to the flame.

F. Density and Thickness

1. Density: 1.5 lbs per cu ft

2. Thickness: 1-1/2 inches or 2 inches, as indicated

G. The duct wrap insulation shall consist of a blanket of glass fibers factory-laminated to a reinforced foil/ kraft (FRK) vapor retarder facing, with a 2-inch-wide (minimum) stapling and taping flange on one edge.

H. The duct wrap insulation shall provide installed R-values as indicated in the following table:

Density, lbs/cu ft	Nominal Thickness, inches	R-value[1,2], (hour) (sq ft) (degree F) per BTU
1.50	1-1/2	6.0
1.50	2	8.0

[1] *at 75 degrees F mean temperature*

[2] *assumes 25 percent compression of insulation*

I. Exposed Ductwork

1. Ductwork with exterior insulation which is exposed to the weather shall be protected with an aluminum-magnesium alloy jacket having a minimum thickness of 0.016 inch.

2. The jacketing shall include built-in isolation felt.

3. The jacket shall be lapped at least 3 inches at joints, and secured with stainless steel bands on 6-inch centers.

J. Duct Lining

1. The fiberglass ductwork lining shall be one-inch thick, and shall have a density 1-1/2-lbs/cu ft.

2. The liner shall have a flame spread rating of 25 or less, a smoke development rating of 50 or less, an average thermal conductivity not to exceed 0.23 BTU-inch per (hour) (square foot) (degree F) at a mean temperature of 75 degrees F, and shall be suitable for duct velocities up to 5,000 FPM.

3. The liner shall have sound absorption coefficients as follows:

Frequency, Hertz	125	250	500	1000	2000	4000	NRC
Sound absorption coefficient	0.15	0.55	0.71	0.94	1.03	1.05	0.80

4. The indicated duct sizes are the airway dimensions of the duct system which does not include provisions for the duct liner; therefore, the CONTRACTOR shall add the duct liner thickness to the indicated duct sizes.

5. Manufacturers, or Equal

   a. **Manville Products Corporation, Linacoustic-HP**

   b. **Owens-Corning**

2.10 EQUIPMENT AND TANK INSULATION

A. Low Temperature Insulation

1. For equipment and tank insulation up to 250 degrees F, use pipe insulation as described above.

2. The installation shall be in strict accordance with the manufacturer's recommendations.

3. An aluminum or PVC jacket shall be installed over the insulation for protection.

B. High-Temperature Insulation

1. High temperature insulation shall be utilized for equipment and tanks with surface temperatures up to 1200 degrees F.

2. The high temperature insulation shall consist of 4-inch thick calcium silicate or similar pre-molded blocks, constructed in 2 layers of 2-inch thickness each, with staggered joints, and applied over a 3/4-inch high metal rib lath.

3. The inner layer shall be suitable for use up to 1200 degrees F, and the second layer shall be suitable for use up to 1000 degrees F.

4. Bends, voids, joints, fittings and other parts shall be filled with insulating cement.

5. Aluminum laggings shall be banded to the insulation in a similar fashion as indicated for standard insulation, and allowances shall be made for thermal expansion.

C. The insulation thickness shall be as recommended by the manufacturer of the equipment or tank.

D. Ductwork Insulation Manufacturer, or Equal

1. **Owens Corning, Fiberglas All-Service Duct Wrap**

2. **Johns Manville, Type 150**

PART 3 -- EXECUTION

3.1 GENERAL

A. Insulation and liners shall be installed by a qualified insulation contractor in strict accordance with the manufacturer's recommendations.

3.2 PIPING INSULATION

A. Piping, fittings, and valves to be insulated shall be clean and dry prior to installation of insulation.

B. Piping indicated to be insulated shall be completely insulated inside structures, except where indicated otherwise.

3.3 INSULATION OF STRAIGHT DUCT AND FITTINGS

A. Before applying the duct wrap, air ducts shall be clean, dry and tightly sealed at joints and seams.

B. Portions of the duct designated to receive duct wrap shall be completely covered with duct wrap.

C. Remove a 2-inch piece of insulation from the facing at the end of the piece of duct wrap to form an overlapping stapling and taping flap.

D. Install duct wrap insulation with facing outside such that the tape flap overlaps the insulation and facing at the other end of the piece of duct wrap.

E. Adjacent sections of the duct wrap insulation shall be tightly butted and overlapped with the 2-inch stapling and taping flap.

F. If the duct is rectangular or square, install insulation such that it is not excessively compressed at corners.

G. Seams shall be stapled approximately 6 inches on center, using 1/2-inch steel outward clinching staples.

H. Seams and joints shall be sealed with pressure-sensitive tape matching the insulation facing (either plain foil or FRK backing stock) or glass fabric and mastic.

I. Cloth duct tape of color or finish using reclaimed rubber adhesives will not be accepted for use on duct wrap insulation.

J. Where rectangular ducts are 24 inches or greater in width, the duct wrap insulation shall be additionally secured to the bottom of the duct with mechanical fasteners such as pins and speed clip washers, spaced on 18-inch centers (maximum) to prevent the insulation from sagging.

K. Where a vapor retarder is indicated, seal tears, punctures and other penetrations of the duct wrap facing using one of the above methods to provide a vapor-tight system.

L. Damaged Insulation

1. The CONTRACTOR shall replace insulation that has been damaged or removed by modifications to the existing ductwork.

2. The replacement insulation shall be new and joints between new and existing insulation shall be made water-tight.

3.4 DUCTWORK INSPECTION

A. After completing the installation of the duct wrap and before operations are to commence, visually inspect the system and verify that it has been installed correctly.

B. Open system dampers and turn on fans to blow scraps and other loose pieces of material out of the duct system; allow for a means of removal of such material.

C. Check the duct system to ensure that there are no air leaks through joints.

3.5 FIBERGLASS INSULATION

A. Fiberglass insulation shall be securely held in place before the final covering is applied.

B. A scrim fabric, similar to a 20 x 10 thread count mesh and 100 percent fiberglass, shall be pasted in place to hold the pipe insulation securely to the pipe.

C. The scrim fabric shall be at least 4-inches wide, with at least 2 applications per length of pipe insulation, and one at each joint.

3.6 JACKETING

A. Joints shall be neatly finished with no ragged ends.

B. When finished, the covering shall show no exposed staples or other binding used during installation.

C. Staples, if used, shall be stainless steel.

3.7 LAGGING FABRIC

A. The final lagging fabric shall be neatly pasted in place with a 3-inch longitudinal overlap using a **Luben No. 9 adhesive**, or equal.

B. Each transverse joint shall have a 3-inch butt strip of the same fiberglass fabric.

C. Final joints shall be neatly finished with no ragged ends and the covering shall present a neat, uniform surface when finished.

D. The fabric shall show no exposed staples or other binding used during construction; staples, if used, shall be stainless steel.

3.8 COMPRESSION COUPLINGS AND EXPANSION JOINTS

A. The rigid insulation blocks shall be held in place with stainless steel bands, approximately 1/2 inch wide by 0.015 inch thick.

B. After banding, the blocks shall be finished with a trowel coat of insulating cement to filling voids, and troweled to a smooth, neat finish.

C. The installation shall then be covered with an acoustical insulation consisting of a fiberglass fabric weighing 24.6 oz. per sq yd, and coated with a loaded vinyl weighing 83.4 oz. per sq yd.

D. The acoustical insulation shall be **Alpha-Sonic Style No. 75**, or equal.

E. The acoustical insulation shall be covered with a 100-percent fiberglass lagging fabric as indicated.

- END OF SECTION -

SECTION 40 90 10 - PRESSURE AND LEVEL MEASURING SYSTEMS

PART 1 -- GENERAL

1.1 SUMMARY

A. **General:** The CONTRACTOR shall provide pressure measuring systems, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 40 90 00 - Process Control and Instrumentation Systems General apply to the WORK of this Section.

1.2 CONTRACTOR SUBMITTALS

A. The Shop Drawings and Technical Manual, shall be submitted in conformance with Section 40 90 00 and Section 01 33 00 - Contractor Submittals.

PART 2 -- PRODUCTS

2.1 PRESSURE GAUGES

A. Pressure gauges shall be 4-1/2 inches in diameter, Liquid-filled bottom connected, with white laminated dials and black graduations. Windows shall be shatterproof glass acrylic. Gauges shall have a blowout disc and be encased in phenolic, steel, or cast iron. Measuring element shall be a stainless steel bourdon tube with welded, stress-relieved joints. Socket shall have wrench flats. Movement shall be rotary geared stainless steel material. Pressure gauges shall be provided with a pulsation snubber constructed of 316 stainless steel and an isolation valve. Gauges shall be calibrated to read in 0-30 psi range for pressure gages and 30” Hg - 30 psi for compound gages. Accuracy shall be plus and minus 1/2 percent range to 150 percent of the working pressure or vacuum of the pipe or vessel to which they are connected. The pressure gauge shall be **Ashcroft 1279, Ametek Solfrunt Series 1900,** or equal.

2.2 DIAPHRAGM SEALS FOR PRESSURE MEASURING SYSTEMS

A. **Components:** Diaphragm seals shall consist of bottom housing, lower ring, diaphragm capsule, fill screw, flushing connection, and a top housing.

B. **Operating Principles:** The diaphragm seal shall attach to the inlet connection of a pressure instrument to isolate its measuring element from the process fluid. The space between the diaphragm and the pressure element shall be completely filled with a suitable liquid. Displacement of the liquid fill in the pressure element through the movement of the diaphragm shall transmit process pressure changes directly to a gauge, transmitter, switch, or other pressure instrument. The diaphragm seal shall have a removable bottom housing to permit servicing. The diaphragm seal shall be factory assembled to the corresponding pressure instrument and be factory-filled. The assembly shall be shipped with a tag reading "Do not disassemble for installation." All exposed surfaces housings shall be constructed of Type 316 stainless steel for pressure service over 15 psi.

C. Materials of Diaphragm Construction

For water, sewage, sludge, liquids containing solids, pulsating flow	Seals of Type 316 stainless steel with stainless steel diaphragm for pressures over 15 psi and elastomer dipahragm for pressures of 15 psi and below. Type 316 stainless steel nuts and bolts, fill connection and valved flush port size 1/4-inch NPT, capable of disassembly without loss of filler fluid. **Ashcroft model 101** **U.S. Gauge (Ametek) SG** **Marshalltown Series 225-01**

2.3 SUBMERSIBLE TRANSDUCER TYPE LEVEL MEASUREMENT

A. The level measurement system shall consist of a submersible transducer, electronic transmitter, support cable, and interconnecting cable with cable shield and vent tube for atmospheric reference. The vent tube shall be provided with a replaceable moisture barrier. The submersible transducer shall be the strain gauge type suitable for sensing pressure equivalent to the liquid level range of 1 to 20 psi. The transducer shall have titanium process wetted parts and shall be provided with a waterproof interconnecting cable. The transducer shall be suspended by a corrosion resistant Kevlar cable. The installation shall be encased in conduit to allow easy removal of the transducer and cable assembly for maintenance purposes. The electronic level transmitter shall be remote mounted and shall produce a 4 - 20 mA DC signal linearly proportional to the level range indicated. The interconnecting cable shall have a pull strength of 200 pounds, be factory attached to the transducer, and shall be terminated in a weather proof enclosure furnished with the unit. The weatherproof enclosure shall house the vent tube moisture barrier, provisions for zero and span adjustments. The measurement system shall be suitable for the area classification and operation over a temperature range of 32 to 122 degrees Fahrenheit with an accuracy of plus or minus 0.5 percent of span.

B. Submersible level transducers/transmitters shall be **Druck Model PTX 1830, Pressure Systems, by GE Sensing** or equal.

2.4 TIPPING FLOAT LEVEL SWITCHES

A. Tipping float level switches shall consist of a switch, a moving float, and a connecting cable that is anchored at the midpoint of a differential band. As the level rises and falls the float rights itself or inverts causing switching actions. The cable anchoring point shall be protected by strain relief. The hermetically sealed switches shall be SPDT with a minimum rating of 10 Amps at 120 VAC.

B. Manufacturer shall be **MAGNETROL T10, FLYGT ENM-10, KARI**, or equal.

2.5 ELECTRONIC GAUGE PRESSURE TRANSMITTERS

A. **Components:** Electronic gauge transmitters shall consist of a capsule assembly, bottom works, vent plug, drain plug, cover flange, process connector and connection, amplifier unit, integral indicator, terminal box with cover, block and bleed valves, and conduit connections.

B. **Operating Principles:** Pressure applied to the unit shall be transmitted by a sealed fill fluid to both sides of a sensing diaphragm. The sensing diaphragm and the sensor body shall function as the moving and fixed electrodes, respectively, of a differential capacitor. As the applied pressure causes the diaphragm to move, the capacitance of the cell shall change.

C. **Performance Requirements**: The amplifier unit shall convert the change in capacitance to a 4 to 20 mA DC signal, 2 wire type, with an allowable loop load of no less than 600 ohms. Static pressure rating shall be a minimum of 500 psig. The maximum overrange pressure limit shall be a minimum of 150 percent of the range. Span shall be adjustable over a minimum of 5:1 range. External adjustments shall include zero and span. Output signal damping shall be provided as an internal adjustment. Equipment shall be suitable for an ambient operating range of minus 40 degree F to plus 212 degrees F. The integral indicator shall be calibrated in process units. Power supply shall be 24 VDC. Accuracy, including linearity and repeatability, shall be a plus or minus 0.2 percent of span. Gauge pressure transmitters used for flow service shall include square root extraction to produce an output signal linearly proportional to flow. Wetted parts, including block and bleed valve parts, shall be constructed of 316 stainless steel. Manufacturers shall be **Foxboro Series 821, Rosemount 1151GP,** or equal.

D. The following electronic gauge pressure transmitters shall be provided:

Tag No.	**Range**	**Body/Bolt Material**	**Fill Fluid**	**Process Connection**	**NEMA Rating**
PIT-1	0-30 psi	316 SS	Silicone	1/2 in. NPT	4

PART 3 -- EXECUTION

3.1 GENERAL

A. Pressure measuring systems shall be handled, installed, calibrated, loop-tested, pre-commissioned, and performance tested according to Section 40 90 01. The manufacturer shall furnish the manufacturer's service, supervision, and training indicated by Section 40 90 00.

- END OF SECTION -

SECTION 40 90 11 – TEMPERATURE MEASURING

PART 1 -- GENERAL

1.1 SUMMARY

A. **General:** The CONTRACTOR shall provide temperature-measuring systems, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 40 90 00 - Process Instrumentation and Controls, General apply to this Section.

PART 2 -- PRODUCTS

2.1 TEMPERATURE MEASURING SYSTEMS

A. Insertion type RTDs shall be 100 ohms nominal at 0 degree C, tip-sensitive, 3 wire platinum in 1/4-inch Type 316 stainless steel sheath with watertight potting. Time constant in agitated water shall not exceed 6.0 seconds. RTD shall comply with International Practical Temperature Scale (IPTS) 68 standards. Accuracy shall be plus or minus 0.1 degree C. Temperature transmitters shall be 2 wire devices with continuously adjustable span and zero adjustments, integral direct reading indicator, solid state circuitry, and a 4 - 20 mA DC digital output linearly proportional to the indicated temperature span. RTDs shall be provided with 316 stainless steel thermowell, spring-loading device, extensions, union coupler, and explosion-proof aluminum connection head. Union shall extend out beyond the pipe lagging. Surface type RTDs shall be a 100 ohm nominal at 0 degree C, 3 wire platinum element in a flexible watertight case for strapping to a pipe surface.

B. Resistance temperature detector assemblies shall be **Rosemount Series 214C, Foxboro PR14U**, or equal.

C. Sensor shall be **Leeds & Northrup Series RTS-60L, Minco S32PB11Y36B**, or equal. Output shall be 4 - 20 mA DC linear to within 0.2 percent with temperature for 100 ohm platinum sensors. Lead resistance compensation shall be provided for 3 wire RTDs. Common mode noise rejection shall be greater than 120 db at 60 hertz. Time constant shall be 100 milliseconds or less. Input/output isolation shall be provided. Large LCD temperature display. Transmitter shall be **Rosemount Model 3144P,** or equal.

2.2 TEMPERATURE GAUGE

A. Bi-metallic thermometers shall have a 5-inch dial with a single direct-reading scale and scale as indicated. Each shall be rust and corrosion-resistant with a leak-proof, hermetically sealed 316 stainless steel housing. The sensing element shall be silicone dampened for vibration resistance. Stem length shall be the maximum standard size compatible with the piping or vessel but shall not exceed 9-inches. Dial shall be adjustable 360 degrees around the stem axis and tiltable to 90 degrees from vertical to obtain the best viewing angle. Accuracy shall be plus or minus 1 percent of range. Each thermometer shall be provided with a thermowell.

B. **Thermowells**: Thermowells shall have a minimum wall thickness between bore and outside of well of 3/16-inch. Wells shall have one-inch male NPT process connections except where line classification indicates some other type. Element connections shall be 1/2-inch female NPT. Material shall be Type 304 or 316 stainless steel unless the process requires otherwise. Flanged thermowells, where required, shall meet material and size requirements of the line classification. Insertion length shall be specific to the application, not exceeding the manufacturer's published recommendations for the allowable length and for the line velocity.

C. Manufacturers, or Equal

Omega Model J

Weksler Type AU

Trend Instruments Model 52

PART 3 -- EXECUTION

3.1 GENERAL

A. Temperature measuring systems shall be executed according to Section 40 90 00.

- END OF SECTION -

SECTION 40 90 50 - METERS, GENERAL

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide meters and flow measurement devices, complete and operable, in accordance with the Contract Documents.

B. Unless indicated otherwise, the requirements of this Section apply to all meters in Division 40 of the Specifications.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

ISA - S 5.1	Instrumentation Symbols and Identification
ANSI - B16.1	Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800
ANSI/AWWA C207	Steel Pipe Flanges for Waterworks Service - Sizes 4 In through 144 In.
ANSI/AWWA C701	Cold-Water Meters - Turbine Type for Customer Service
ANSI/AWWA C702	Cold-Water Meters - Compound Type
AWWA C704	Cold-Water Meters - Propeller Type for Main Line Applications
ASME REPORT	Fluid Meters, Sixth Edition, 1971

1.3 CONTRACTOR SUBMITTALS

A. **General:** Furnish submittals in accordance with Section 01 33 00 -Contractor Submittals.

B. **Shop Drawings:** Each meter shall be identified with its equipment number, as indicated.

C. **Manufacturer's Data:** With the Shop Drawings, furnish certified curves indicating flow versus differential pressure and any other information called for in the individual meter specifications.

D. **OWNER'S Manual:** Furnish 5 identical copies of complete operation and maintenance instructions of all the metering systems including instrumentation and controls, in accordance with the paragraph “Operational Procedures” in Section 01 33 00.

E. **Spare Parts List:** The CONTRACTOR shall furnish a list of manufacturer's recommended spare parts.

F. **Special Tools:** A list of special tools shall be submitted to the OWNER.

G. **Documentation:** After completion the CONTRACTOR shall furnish to the OWNER the manufacturer's written guarantees, that the metering systems will operate within the published accuracies and flow ranges and meet these Specifications. The CONTRACTOR shall also furnish the manufacturer's warranties as published in its literature and as specified.

1.4 QUALITY ASSURANCE

A. **Accuracy Requirements:** Unless otherwise indicated, flow meters shall be guaranteed to register flow to an accuracy of plus and minus 2 percent of actual flow throughout the range indicated. Density measuring equipment shall have a degree of accuracy within plus and minus 2 percent of actual solids content over the range indicated.

PART 2 -- PRODUCTS

2.1 SPARE PARTS AND SPECIAL TOOLS

A. Furnish the spare parts listed in the individual meter sections. Spare parts shall be suitably packaged and labeled by part name and associated equipment number.

B. The CONTRACTOR shall furnish special tools suitably wrapped and identified for application.

PART 3 -- EXECUTION

3.1 SERVICES OF MANUFACTURER

A. After installation, the CONTRACTOR shall obtain the services of an experienced factory service representative to inspect the installation and test all meters for proper performance.

B. **Instruction of OWNER's Personnel:** After completion of the installation and during startup of the plant, the CONTRACTOR shall instruct the OWNER's personnel in the proper operation, maintenance and repair of all metering equipment. For this purpose, the CONTRACTOR shall obtain the services of an experienced factory service representative, who shall spend sufficient time on the Site to fully instruct the OWNER's operating personnel on all phases of the metering equipment.

3.2 INSTALLATION

A. The CONTRACTOR shall assemble and install equipment in strict accordance with the manufacturer's published instructions, under the supervision of the manufacturer's representative. Installation shall be accomplished by competent craftsmen in a workmanlike manner.

B. Meters shall be installed, as shown in the Contract Drawings, in easily accessible locations for ease of reading and maintenance, and, where shown, for balancing of flow in several lines, in conjunction with throttling and shut-off valves. Wherever possible, all meters shall be installed in such a way to provide the manufacturer's recommended straight approach and straight piping downstream. When the recommended straight pipe runs on the influent or effluent of a given meter cannot be accomplished in the field installation, the CONTRACTOR shall notify the OWNER immediately via an RFI for direction on final meter location.

C. Meters and shut-off and balancing valves shall be firmly supported from the structure or from the floor with approved supports. In-line meters shall be installed to provide full-line flow and not less than the manufacturers recommended head at all times.

3.3 TESTING

A. Equipment shall be prepared for operational use in accordance with manufacturer's instructions, including bench test and calibration, where required.

B. Each item shall be subjected to an operating test over the total range of capability of the equipment. Where applicable, tests shall be conducted in accordance with the Test Code of the Standards of the Hydraulic Institute. The CONTRACTOR shall obtain copies of factory test certifications and shall notify the OWNER one week in advance of all tests to be conducted on Site.

- END OF SECTION -

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SECTION 40 91 23 – ELECTROMAGNETIC FLOWMETERS

PART 1 -- GENERAL

1.1 SCOPE

A. This section describes the requirements for an electromagnetic flow meters and microprocessor-based signal converters. Under this item, the CONTRACTOR shall furnish and install the full port flow sensor and accessories as indicated by the OWNER and as herein specified.

1.2 SUBMITTALS

A. The following information shall be included in the submittal for this section:

1. Data sheets and catalog literature for the Meter and the microprocessor-based signal converter.
2. Connection diagrams for equipment wiring.
3. List of spare parts and optional equipment.

PART 2 -- PRODUCTS

2.1 ELECTROMAGNETIC FLOWMETER (INSERTION MAGMETER)

A. The electromagnetic flow meters shall consist of a full port flow sensor based on Faraday's Law of Electromagnetic Induction and microprocessor-based signal converter.

B. A total of (16) nine full port flow sensors shall be provided as shown on the Drawings.

C. Flow Meter Requirements:

1. Operating principle: Utilizing Faraday's Law of Electromagnetic Induction, the flow of a conductive liquid around the sensor induces an electrical voltage that is proportional to the velocity of the flow.
2. Construction: The full port flow sensor material shall be constructed of carbon steel lined and with corrosion resistant resin coating and polyurethane lining, Type 316L stainless steel electrodes.
3. Ambient and Operating Fluid Temp: -4 to 140° F
4. Quantity and Size: (1) for 10" RU pipe, (4) for 6" GW pipe, (4) for 8" RU pipe.
5. Installation hardware shall be compatible for mounting between standard ANSI B16.5 pipe flanges.
6. Submergence: The sensor shall be IP-68 and NEMA 6P submersible type and allows for accidental submergence up to 15m for 48 hours.

7. Converter enclosure: IP-67 enclosure or NEMA 4X watertight.

8. Display: Full dot-matrix 128 x 128 dot LCD back-lit display.

9. Power supply: 100 to 240Vac, 50/60Hz or 24Vdc.

10. Operating temperature: -4 to +212 degrees F.

11. Outputs: 4-20 mA (load resistance 0 to 750 Ω).

12. Two separate digital outputs: Transistor open collector and solid-state relay output. Alarm outputs are also available.

13. Sensor and signal converter performance:

    a. Flow Range: 1.0 fps to 32.8 fps for accuracies stated below.

    b. Accuracy: For 1/2” to 18” diameter, ± 0.2% of rate.

    Totalizer control starts and stops at the built-in totalizer.

14. The electromagnetic flow meters shall be Toshiba GF630/LF620 Premium Value Series Flowmeter or equal, except for surface water pumps station flow meter FM-200 which shall be mount anywhere style, Toshiba LF654 requiring no straight piping runs for meter accuracy.

2.2 SPARE PARTS

A. Spare parts for the equipment shall include the following, unless otherwise noted:

1. 1. One set of manufacturer’s recommended spare parts for each meter.

2.3 OPERATOR FUNCTIONS

A. Calibration

1. Each flow sensor shall be N.I.S.T wet calibrated and all of the calibration information and factory settings matching the sensor shall be stored integrally within the converter’s non – volatile memory. At initial commissioning, the flow meter commences measurement without any initial programming. Should the signal converter need to be replaced, the new signal converter will upload all previous settings and resume measurement without any need for reprogramming or rewiring.

2. An N.I.S.T traceable certificate of calibration shall accompany each flow sensor.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Follow manufacturer’s written recommendations.

3.2 MANUFACTURER'S ASSISTANCE

A. Warranty

1. The manufacturer of the electromagnetic flow meter shall guarantee for two years of operation that the equipment shall be free from defects in design, workmanship, or materials.

2. In the event a component fails to perform as specified, or is proven defective in service during the guarantee period, the manufacturer shall promptly repair or replace the defective part at no cost to the owner.

- END OF SECTION -

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SECTION 40 91 28 - ROTAMETERS

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide rotameters and appurtenant WORK, complete and operable, in accordance with the Contract Documents.

PART 2 -- PRODUCTS

2.1 GENERAL

A. The meters shall be suitable for the service and chemicals conveyed at process temperatures.

B. **Basic Design:** Unless otherwise indicated, rotameters in chemical solution lines and where indicated shall have vertical bottom inlets and top outlets with ANSI 150-lb flanged ends, for vertical mounting. Meters in gas, air, and pump seal flushing lines shall be of the modified rotameter design with screwed ends, spring-loaded pistons, and union bodies for mounting in any position. Rotameters shall be rated for a minimum working pressure of 150 psi.

C. **Schedule:** Provide the following rotameters:

I.D.No.	Service	Pipe Size, Inches	Flow Range, gpm or cfm	Line Pressure, psi	Flanged or Screwed
RM-01	Formalin - Incubation	1”	0-1	25	NPT
RM-02	Formalin – Adult Holding	1”	0-1	25	NPT

2.2 BASIC MATERIALS

A. **Screwed Meters for Water, Air, and Fuel Gas:** Rotameters with NPT screwed ends for water, air, and fuel gas service shall be calibrated in gallons per minute or cubic feet per minute. The bodies shall have union ends for ease of maintenance, polysulphone tubes, aluminum or brass end fittings, Type 316 stainless steel internal parts, and scales suitable for the capacity range in the schedule above. The meters shall have an accuracy of plus and minus 5 percent over the capacity range.

B. Manufacturers, or Equal

1. Chlorine Service - **Emerson (Brooks) No. 1180**, or **US Filter/Wallace and Tiernan "Varea-Meter"**

2. Activated Carbon - **Emerson (Brooks) No. 3611**, or **US Filter/Wallace and Tiernan "Varea-Meter"**

3. Other Chemicals - **Emerson (Brooks) No. 1144**, or **US Filter/Wallace and Tiernan "Varea-Meter"**

4. Water, Air and Gas Meters - **Headland "In-Line Meters**", or **Universal Flow Monitors, Inc. "INSITE" meters.**

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Rotameters shall be installed in chemical solution lines, in dilution water lines, in pump seal flushing lines, in gas and air lines, and where indicated.

B. Rotameters shall be installed in strict accordance with the manufacturer's printed instructions.

- END OF SECTION -

SECTION 40 95 00 – PROCESS WATER CHILLER SYSTEM PACKAGE

PART 1 -- GENERAL

1.1 SUMMARY

A. The Chiller System Supplier (CSS) shall provide a skid-mounted, water-cooled chiller system package with all associated equipment and appurtenances including, booster pumps, heat-exchangers, basket strainer, piping, valves, local control panel with PLC, operator interface, temperature transmitter, and appurtenances, complete and operable, skid-mounted as indicated.

B. **Contract Drawing PF104** provides a schematic representation of what major water-based components and piping are to be provided on the common skid by the CSS and what piping, pumps, meters, and miscellaneous instruments are to be provided by the CONTRACTOR.

C. **Contract Drawing RF104** provides a schematic representation of the system controls and instrumentation. These drawings represent the minimum amount of instrumentation required by the CSS.

D. **Contract Drawing GM001** provides chiller schedule.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of, Section 01 33 00 - Contractor Submittals and with the requirements of Section 44 05 00 - Equipment General Provisions.

B. The submittals shall include operation, maintenance, inspection data, and service center location and telephone number.

1.3 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

1. American Society for Testing and Materials (ASTM).
2. American National Standards Institute (ANSI).
3. American Society of Mechanical Engineers (ASME).
4. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE).
5. American Welding Society (AWS).
6. National Fire Protection Association (NFPA).
7. National Electrical Manufacturers Association (NEMA).

1.4 EXPERIENCE QUALIFICATIONS

A. The CSS shall be experienced in the design and manufacture of water-cooled, skid-mounted chiller systems with redundant compressor / condenser refrigerant systems and with complete stand-alone control panel design (including a PLC with all Inputs / Outputs (I/O), HMI, and all software, and programming for a complete and operable system). At the request of the ENGINEER, the CSS via the CONTRACTOR shall submit a list of at least five (5) project references of their chiller system installations in North America which have been in successful operation chilling water for at least five (5) years. Each reference shall have the following minimum capacities / characteristics:

1. Individual compressor and condenser unit water-chilling tonnage capacity of at least 40 tons;

2. Experience with systems utilizing direct chilling (i.e. without relying on intermediate glycol / water heat-exchange loops);

3. Experience with shell and tube heat exchanger design in direct-chilling applications.

1.5 OWNER'S MANUALS

A. The CSS shall furnish complete Owner's Operations and Maintenance (O&M) Manuals on the complete chiller system and appurtenances in accordance with the requirements of Section 44 35 00 and Section 01 33 00 - Submittals.

1.6 WARRANTY

A. The CSS shall warrant the entire chiller system and all components against defects in the workmanship, materials, or any operational issues for a minimum period of two (2) years starting at the time in which the CONTRACTOR is granted Substantial Completion from the OWNER or the first day in which water is delivered to the hatchery head tank box, whichever comes first. Warranty documents shall be issued by the CSS and submitted by the CONTRACTOR prior to final acceptance of the project.

B. If at any time during the startup, testing or 1-year warranty period, any component of the chiller skid system, including heat exchanger, basket strainer, local control panel and all appurtenances, require full or partial removal from the hatchery site for servicing or replacement of parts, then:

1. The CSS shall be required to perform such removal of the equipment and reinstallation of the equipment after servicing, at no added cost to the CONTRACTOR or OWNER.

2. The cost of any additional engineering, parts, materials, and other equipment needed to fix a defective or damaged chiller system component, including labor costs of field and factory pump technicians for work performed on the pump, motor, and power / instrument cable assemblies, shall be paid entirely by the CSS.

PART 2 -- PRODUCTS

2.1 GENERAL DESIGN REQUIREMENTS

A. The chiller system specified is a twin independent circuit water cooled chiller providing cooling of up to a maximum flow of 200 gpm for egg incubation and early rearing chilled water for the Melvin R Sampson Coho Hatchery. Two (2) redundant water cooled chiller units will be selected, each providing 2/3rds of the total system chilling capacity.

B. Source Two (2) supply water booster pumps of either vertical in-line or end suction centrifugal style to booster supply pressures adequately to pass through the package skid and into the respective head tank for distribution. Booster pumps shall be designed such that one (1) pump can meet normal demands of 80 to 200 gpm. The standby pump will be for emergency chiller condenser supply, or if the primary pump is out of operation.

C. Source One (1) heat exchanger shall be a type 316 stainless steel plate and frame style heat exchanger. Heat exchanger design shall allow for disassembly and cleaning during annual maintenance.

D. Source One (1) source water duplex basket strainer shall be of PVC construction with a maximum screen size of 1/16-inch shall be provided on the chiller skid.

E. Chiller circuits shall be of identical size and manufacture, of high-performance design, and shall include the specified compressors, type 316 stainless steel shell and tube heat exchangers, and associated components.

F. The entire unit shall have one (1) common local control panel, operator interface (OI) and set of temperature and flow sensing instruments, controls, and programming required for a complete and operable system.

2.2 TECHNICAL DATA

A. Identification

Equipment Name	Process Water Chiller System Package
Equipment Number	CH-100
Quantity	-2 (duty, standby) booster pumps -2 (Independent compressor / condenser circuits both mounted on one common skid, with one common LCP) -1 Heat Exchanger and Duplex Basket Strainer
Location	Indoors

B. Operating Conditions

Parameter	**Value**
Chiller Operating Season	June - March

Chiller Non-Operating Season	April - May
Indoor Air Temps (deg F)	Ranges from 55 to 75
Process Water / Fluid Service	Freshwater from Headtank
Process Water Approach Temp (degrees F)	46-61
Process Water pH	6.5 to 7.5
Process Water Specific Gravity	1.0
Refrigerant	R-410A
Is a Glycol solution secondary pumped loop allowed for use in the Chiller System?	**No**
Altitude (feet above mean sea level)	~1,600 (compressor motors shall be derated by 7% for elevation).

C. Performance Requirements

Parameter	**Value**
Process Water Supply	Pressurized supply from Wells
Process Water Flow Rate (gpm)	Varies 72 to 100
Pre-Chill Heat Exch Inlet Water Temp (deg F)	~60 +/- 1F
Pre-Chill Heat Exchanger Outlet Water Temp (deg F)	~50 +/- 1F
Chiller Inlet Water Temp (deg F)	~50
Chiller Outlet Water Temp Req. (deg F)	~41
Chiller Capacity (full system total tons)	40
Total Suspended Solids Loading (mg/l)	< 30
Source Water Heat Exchanger Inlet Temp (deg F)	~42+/- 1F
Source Water Heat Exchanger Outlet Temp (deg F)	~50+/- 1F
Source Water Chiller Inlet Temp (deg F)	~48+/- 1F
Source Water Chiller Outlet Temp (deg F)	~55

2.3 CHILLER SYSTEM SKID FRAME

A. Skid Construction. The system skid unit shall be 8 feet maximum width, assembled on minimum of 2-inch square or rectangular tubing, steel frame. The frame and all steel components shall be factory primed and coated with an approved liquid epoxy system.

Manufacturer to supply CONTRACTOR with at least one-liter of primer and liquid epoxy system, along with manufacturer's instructions, for field touch-up preparation and coating work. CONTRACTOR shall apply all field touch-up coatings due to defects created by the shipping, handling, and installation procedures. As an alternative to a liquid epoxy steel frame, Chiller Manufacturer may supply a 304 stainless steel frame which shall not require a coating system.

B. The unit shall have removable panels allowing access to all major components, including internal instruments, and electrical power supply and controls.

C. CSS shall verify final Chiller Room dimensions and ensure that chiller skid will fit through the roll up door and provide 3-feet minimum on all sides for operator access.

2.4 PROCESS WATER BOOSTER PUMPS

A. (2) constant speed, vertical in-line or end suction centrifugal, close coupled pumps shall be required for reclaiming headloss lost within the chilled water system.

B. The pumps shall be operated in a primary and backup configuration with the primary pump status to be rotated on a fixed schedule, or upon in the event of the current duty pump failure.

C. Pumps shall be provided within check valves, and manual isolation valves.

D. Inlet and outlet connections of pumps shall be ANSI Class 125.

E. Pump Materials:

1. Casing: ASTM A48 Cast Iron
2. Impeller: Cast Iron or Stainless Steel
3. Shaft: Stainless Steel AISI 416
4. Wear Ring: Bronze ASTM B584
5. Mechanical Seal: Ceramic or EPT

F. Pump Characteristics:

1. Pumping Fluid: Fresh water
2. Flow Rate: 100 gpm
3. Head: approximately 50 feet with a minimum of 20-ft of external head leaving the skid shall be provided. CSS shall verify package headloss and adjust pumping head as required to ensure 20-ft of available head after flows leaves the package skid.
4. Motor Size: 2 hp
5. Motor RPM: 1750 rpm

6. Electrical Connection: 460V, 3 phase, 60 hz.

G. Manufacturers:

1. Armstrong;

2. Taco; or approved equal

2.5 COMPRESSORS

A. Type. Each chiller circuit shall have its own digital scroll-type compressor unit with its own internal controls and safety switches. Scroll type compressors shall provide inherently low vibration and a completely enclosed compression chamber with no leakage paths. Compressors shall be suction gas cooled, direct drive, 3600 RPM full-hermetically sealed, inverter duty rated motors, with a minimum service factor of 1.15. Compressors shall be by Trane, Copeland, or approved equal. Compressors shall include a centrifugal oil pump to provide positive lubrication to all moving parts.

B. Compressor shall have voltage utilization range of plus or minus 10 percent of nameplate voltage. Crankcase heater, internal temperature and current–sensitive motor overloads shall be included for maximum protection.

C. Gas Pressure Safety Switches. Internal refrigerant gas pressure cutout switches (one for high pressure on discharge side of each compressor and one for low pressure on the inlet side to each compressor) shall be provided to safeguard the compressor from operation under abnormal conditions.

2.6 SHELL AND TUBE HEAT EXCHANGERS

A. Type. The heat exchangers shall be type 316 stainless steel in shell and U-tube design with an insulated, shell and internal U-tubes. Shell with helical coil or plate and frame style heat exchangers are not acceptable substitutes to the specified shell and tube style heat exchangers.

B. Orientation. Heat Exchangers shall be piped independent to one another, and shall be oriented in the horizontal position. Heat exchangers shall have the necessary isolation valves to allow one heat exchanger to be removed or worked on without shutting down the system. In the submittals, Chiller System Manufacturer shall indicate the required clear space on ends of heat exchanger for removal of shell for cleaning purposes.

C. Normal Operation. Heat exchangers shall be designed and operated to pass water through them at all times, regardless of whether the respective compressor unit is required to operate or not. This operation strategy should help prevent freeze up of stagnant water in the heat exchanger body, and keep water stream fresh (aerobic).

D. Characteristics of the heat exchangers shall include.

1. The minimum surface area of the U-tubes within this customized chiller shall be at least 25% greater than the surface area of the U tubes within the manufacturer’s standard 32.5 ton air-cooled chiller system.

2. Heat exchanger's internal refrigerant tubing shall be of type 316 stainless steel welded tubing with a minimum wall thickness of no less than 0.063-inches (1/16-inch). Diameter and length of tubing shall be as required by Chiller Manufacturers heat exchanger design. Tubing shall be welded to a stainless steel flange plate for positive leak proof joints.

3. Shell shall be removable from the interior U-tube bundle without disconnecting refrigeration lines for simple access and cleaning as necessary.

4. Heat exchanger shall be mounted on a 304 stainless steel rack with the heat exchangers mounted in the horizontal position on the rack.

5. The stainless steel shell shall be of minimum wall thickness equivalent to schedule 10 pipe and insulated according to the requirements below.

6. Interior of the heat exchanger shell shall be equipped with ABS or other approved plastic transverse baffles. Transverse baffles shall direct flow through the shell for maximum heat transfer efficiency.

E. Inlet & Outlet Water Connections. Water connections to the chiller heat exchanger shall be a minimum diameter of 4-inch and shall be of PVC flange construction. (CONTRACTOR shall provide connection PVC Van-Stone style flanges and all 316 SS bolts, nuts and connecting hardware.)

1. Inlet and outlet flanges shall be located to allow for simple disconnect of the water piping inlet and outlets to allow for removal of the PVC shell system and cleaning of the internal U-tubes of the heat exchanger.

2.7 REFRIGERANT PIPING AND INSULATION

A. Piping and Insulation. All refrigerant piping, except for the piping / tubing within the shell and tube heat exchangers, shall be of type K copper (refrigerant grade and cleaned for refrigerant service) and shall be of soft-tempered tubing for diameters of 7/8-inch or less, and shall be of hard-tempered piping for diameters of 1-inch or larger. All refrigerant piping downstream of the expansion valve to the evaporator / heat exchanger and back to the inlet (suction) to the Compressor unit shall be insulated with a minimum 3/4-inch thick heavy-density, unfaced, fiberglass or Nitrolite foam pipe insulation, or approved equal. Where insulation is outside of chiller cabinet enclosure, insulation shall be covered with a PVC jacket, or approved equal, to resist weather, rain, and UV radiation.

2.8 DUPLEX BASKET STRAINERS (ME-200)

A. Equipment Requirements: The pipeline strainers for screening solids shall be a double (duplex) basket type strainer with manual switch-over valves suited for a maximum flow of 200 gpm.

B. Construction: The strainer shall have a CPVC body with non-bolted, manual spin-off removable covers. Features of the basket strainer shall include:

1. Handles for the spin-off covers shall be heavy duty PVC construction and at least 4-inches long each for easy manual turning of the housing cover.

2. O-ring seals shall be either EPDM or FPM materials.

3. Top cover shall have a venting port (female NPT) for air release. A drain port (female NPT) shall also be provided near the bottom of the unit. CONTRACTOR shall provide a sch 80 PVC nipple and PVC ball valve on each port for easy manual operation of the port.

4. The strainer shall have full-faced flanged ends (NPT and true-union ends are not acceptable) of 4-inch diameter. Unit shall be designed for in-line piping installation (with inlet on one side of basket strainer and outlet on opposite side of basket strainer.)

5. Unit shall have a drain plug, a plastic basket with 1/16-inch perforations and minimum ratio of 6:1 of open area to pipe cross-section. Provide one (1) additional spare PVC basket with 1/32-inch perforations and minimum ratio of 6:1 of open area to pipe cross-section. Simplex strainers shall have a non-shock pressure rating of at least 125 psi at 70 degrees F.

C. Manufacturers, or Equal

1. Hayward Industrial Products, Inc.

2.9 PLATE AND FRAME HEAT EXCHANGER (ME-210)

A. For prechilling of the process water, the CSS shall supply one (1) single-wall bolted heat exchanger with frame shall be provided of adequate size and capacity shall be provided to meet the system requirements below.

B. Heat exchanger construction:

1. Plates shall be constructed from Type 316L stainless steel.

2. All gaskets shall be NBR HT.

3. All connections shall be ANSI B16.5 flanges, rubber lined with NBR.

4. Heat exchanger frame shall be carbon steel, epoxy coated.

C. Manual isolations valves and test ports shall be provided on all inlets and outlets of the heat exchanger.

D. A bypass leg with isolation butterfly valve shall be provided on both process water streams thru the heat exchanger.

E. Heat Exchanger Design Criteria / Performance:

1. Process Water at 80 gpm flow rate:

a. Entering Water Temp: 60 deg F

b. Leaving Water Temp: 49 deg F

c. Maximum allowable Pressure Drop at 200 gpm: 5 psi,

d. Flow range: 50 to 80 gpm

e. Minimum plate wall thickness: 0.40 mm

f. Minimum Inlet and Outlet Port Size: 3-inch, 316 SS Flange

2. Source Water at 80 gpm flow rate:

a. Entering Water Temp: 42 deg F

b. Leaving Water Temp: 48 deg F

c. Maximum allowable Pressure Drop at 200 gpm: 5 psi

d. Flow Range: 50 to 80 gpm

e. Minimum plate wall thickness: 0.40 mm

f. Minimum Inlet and Outlet Port Size: 3-inch, 316 SS Flange

2.10 MAGNETIC FLOW METERS

A. General

1. Magnetic flowmeter systems shall be of the low frequency electromagnetic induction type and produce a DC pulsed signal directly proportional to and linear with the liquid flow rate. Complete zero stability shall be an inherent characteristic of the flowmeter system. Each magnetic flow metering system shall include a metering tube, signal cable, transmitter and flowmeter grounding rings.

2. Magnetic flow meters and electronics shall be manufactured at facilities certified to the quality standards of ISO Standard 9001 - Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation, and Servicing.

B. **Metering Tube:** The metering tube shall have the following:

1. Housing constructed of epoxy coated steel with ANSI 150# flanged connections.

2. Liner: Dual Durometer rubber.

3. Minimum of 2 type 316 stainless steel electrodes.

4. Meter housing rated for NEMA 4X

C. **Transmitter:** The microprocessor-based signal converter/transmitter shall have the following:

1. Utilize DC pulse technique to drive flux-producing coils

2. Convert DC pulse signal from the tube to a standard 4 - 20 mA signal into a minimum of 700 ohms.

3. A 8-digit LCD display for totalizer in gpm x1000 and 5 digit for gpm flow rate

4. An operator interface consisting of keypads which respond to English text entry

5. Integral zero return to provide a consistent zero output signal in response to an external dry contact closure

6. Integral low flow cut-off and zero return

7. Automatic range change

8. Capable of measuring flow in both directions

9. Programmable parameters including meter size, full scale Q, magnetic field frequency, primarily constant, time constant

10. Data retention for a minimum of 5 years without auxiliary main or battery power

11. Self diagnostics and automatic data checking

12. Protected terminals and fuses in a separate compartment which isolates field connection from electronics

13. Can tolerate ambient temperature operating limits of -20 to 140 degrees F (-29 to 60 degrees C).

D. Performance Requirements

1. Time Constant: 0.5 to 1000 seconds

2. Accuracy: plus or minus 1% of flow rate from 10 to 100 percent of full scale for velocities over 3-ft/sec.

3. Repeatability: 0.25 percent of full scale

4. Isolation: either galvanic or optic

5. Power consumption: 30 watts max

2.11 PVC PIPE FOR WATER CONVEYANCE

A. Material

1. PVC pipe shall be made from new rigid unplasticized polyvinyl chloride and shall be normal impact Type 1, Grade 1, class 12454, Schedule 80, listed as compliant with NSF Standard 61, unless otherwise indicated, in accordance with ASTM D 1785-PVC Plastic Pipe, Schedule 80.

B. Pipe Joints

1. Pipe joints shall be solvent-welded type with solvent cement and primer as recommended by the pipe manufacturer for the chemical in the pipe.

2. Screwed joints that are necessary to match up to threaded valves or fittings shall be made up with appropriate thread sealant, either paste or tape.

3. Flanged joints shall be made with solvent-welded PVC flanges (Van-Stone style), drilled to ASME B 16.5 - Pipe Flanges and Flanged Fittings, Class 150, unless otherwise indicated. Gaskets shall be ANSI 150 lb. full face, 1/8-inch thick Neoprene for water or wastewater service. Gasket material for chemicals shall be suitable for the chemical service.

C. Fittings

1. Solvent Welded and Threaded Fittings: Solvent-welded and threaded fittings shall be Schedule 80 PVC fittings in accordance with ASTM D 2467 - Socket-Type Poly PVC Plastic Pipe Fittings, Schedule 80.

2. Flanged Fittings: Flanged fittings shall be Schedule 80 fabricated PVC fittings with 150 lb. flanges to ASME B 16.5.

2.12 PVC BUTTERFLY ISOLATION VALVES (2-inch thru 4-inch Diameter)

A. General: On the inlet and outlet of each chiller heat exchanger, and where else shown on the water piping for the Chiller System Manufacturer's skid, Chiller System Manufacturer shall provide PVC Butterfly Isolation Valves. The valves shall be of PVC construction suitable for steady-state water working pressures and steady-state differential pressures up to 150 psi and for water having a pH range from 6 to 9 and temperature range from 33 to 60 degrees F.

B. Body: Butterfly valves shall be all solid thermoplastic Polyvinyl Chloride (PVC) butterfly valves of the lined body design and shall be suitable for bubble tight shut-off service as well as throttling service. The liner and disc shall be the only wetted parts. All non-plastic exterior valve components, including stem and miscellaneous hardware, shall be Type 316 stainless steel.

C. Disc: The disc shall be made of Ethylene-Propylene-Dene Monomer (EPDM) or Polypropylene (PP) material. The chord length of the valve disc shall be less than the internal diameter of the pipe or flange to which it is to be installed.

D. Seat: Seat shall be of EPDM material to provide bubble-tight seating. The seat shall totally encapsulate the body with no need for flange gaskets for installation. The seat shall be field-replaceable without special tools.

E. Stem: Stems shall be made of Type 316 stainless steel. If connecting pins or screws are required for a particular manufacturer's design, then the disc as well as the connecting hardware shall be Type 316 stainless steel.

F. Stem Bushing: The stem busing shall be a non-corrosive, heavy-duty acetal bushing.

G. Stem Seal: The stem seal shall be a double "U" cup seal or O-ring design which is self adjusting and provides positive sealing in both directions, and is suitable for the service conditions.

H. Body Style: All PVC butterfly valves 6-inch and smaller shall be wafer type, unless otherwise specified.

I. Actuators: Unless otherwise specified, all PVC butterfly valves 6-inch and smaller shall have manual lever operators. Manual lever type actuators shall allow for positive throttling and have at minimum 10 stop positions from open to closed position for positive locking of the valve.

J. Manufacturers, no "or-Equals"

1. Asahi America, type 57 Wafer Style Butterfly valves

2. Hayward

2.13 PVC SWING OR WYE CHECK VALVES

A. **General:** Plastic swing or wye-check valves for corrosive fluids, in sizes up to 8-inches or as available, may be used for horizontal or vertical up-flow conditions.

B. **Construction:** The valve bodies and discs or piston shall be of PVC, PP, or PVDF construction as best suited for each individual service condition. They shall have flanged ends conforming to ASME B16.5 Class 150, and flanged top access covers and shall shut positively at no-flow conditions. The seats and seals shall be of EPDM, Teflon, or Viton.

C. Manufacturers, or Equal

1. **ASAHI-AMERICA**

2. **George Fischer, Inc.**

3. **Hayward**

2.14 LOCAL CONTROL PANEL AND TEMPERATURE & FLOW INSTRUMENTS

A. Located on the chiller skid itself, the CSS shall provide one (1) local control panel (LCP), factory designed to include a PLC and human-machine interface (HMI) touch screen for programming and entering of all Operator setpoints. The LCP shall be wired, and programmed all within a NEMA 4 enclosure. LCP shall be mounted on the same skid as the chiller package itself. Features of the LCP, shall include but not be limited to:

1. One "Auto-Off" Mode Selector Switch for each of the two Compressor / Condenser / Heat Exchanger Units. These selector switches shall be hard-wired switches to the front panel of the LCP. Chillers shall only be allowed to operate if their Mode Selector Switch is on the "Auto" position.

2. The LCP shall be equipped with a programmable logic controller (PLC) (model ____________________ or equal), and programmed to provide all control functions for the 2-stage chilling system. The controller shall feature an HMI touch screen

(model _____________ or equal)for set-up and Operator adjustment with LCD display showing critical process water temperatures on the outlet of each individual shell and tube heat exchanger and refrigerant liquid temperatures approaching heat exchanger and other control functions

3. The HMI shall provide a software display screen for each of the two (2) compressor / condenser unit refrigeration loops, and shall provide a green light / red light status of each compressor's run status.

4. The PLC shall provide an adjustable anti short-cycle timer to prevent rapid on/off cycling of each compressor / condenser unit.

5. Provide one (1) flashing red light, software icon alarm signal on the HMI screen for each of the two chiller circuits, to provide a visual indication of an alarm /shutdown condition for the respective chiller circuit.

6. Inside the LCP panel, provide remote alarm and control I/O output cards - for reporting alarm / shutdown status to the plants main SCADA / PLC system. A minimum of one (1) digital output card and one (1) analog output card, each capable of transmitting upto four (4) individual outputs shall be provided with the PLC. At a minimum, the following outputs shall be programmed by the CSS for output to the main plant PLC:

   a. Run / Off status of system

   b. General system alarm

7. Any switches, alarm lights, or other control features and hardware on the front panel of the LCP shall be rated for NEMA 4 or more stringent service.

8. Power for all instruments located on the chiller skid unit, including all transmitters, alarms and other sensors, shall be provided from either a 24 Volt DC or a 120 VAC power source, as required, from within the LCP provided by the CSS.

B. **Chiller Outlet Water Temperature Controls**. On the common outlet water PVC tee – downstream of the individual chiller heat exchanger outlets, provide one (1) common digital temperature sensing device to transmit the actual outlet water temperature (after chilling) to the LCP's PLC. The temperature sensing device shall be a 4-20 mA output approved temperature indicating transmitter (Rosemount, or equal). The temperature transmitter shall provide an analog signal to the controller within the LCP for the following control strategy. The following control strategies assume that the respective chiller circuit Mode Selector Switches are in the “Auto” position.

1. **Chiller Call for Operation**. When the outlet water temperature is above the deadband on the Operator desired temperature setpoint (normally in the range of 40F to 45F, adjustable thru the HMI and clamped between 40F to 50F), controller shall call for start of the Lead compressor unit. If the water temperature rises to above 2-deg F above the setpoint, the PLC shall call for operation of the Lag compressor unit also.

2. During startup and testing, the CSS shall determine and program the appropriate ramp-up and ramp-down rates for any variable speed compressor units, to appropriately match the project conditions.

C. **Other Unit Temperature Controls, Flow Controls & Accessories**. Provide the unit with the following additional temperature, water flow and ancillary controls:

1. **Temp Switch Low Water Outlet**. For each of the chiller circuits provided with the package, provide one (1) low temperature switch on the water leaving the respective process water heat exchanger to shut down the respective compressor and condenser unit upon sensing low water outlet temperature. The switch shall be field adjustable and factory set at 36º F.

2. **Inlet Water Pressure High.** For each of the system inlets downstream of pumps, both on the heat exchanger inlet and recycle water inlet, provide (1) high pressure switch. In a high pressure condition, an alarm shall be generated. The switches shall be field adjustable and factory set to 35 psi.

3. **Low Flow Alarms.** The system PLC shall monitor the skid flow meters in order to alarm a low flow scenario. If the flow should drop below an Operator adjustable setpoint a system alarm shall be generated. The condenser flow meter, M-230, low flow alarm shall be factory set at the minimum flow through the condenser coils. The pre-chilled water flow meter, M-220, shall be factory set at 25 gpm.

D. **Other Instrumentation** (by CONTRACTOR). The CONTRACTOR shall provide the following instruments:

1. **Temperature Gauges in System** Temperature gauges shall be supplied with the unit at the indicated locations, at a minimum, as shown on the contract drawings. The CONTRACTOR shall provide 316 SS, 3-inch dial, temperature gauges (32º F to 60º F range) to indicate the approach water temperature. Gauges shall be provided with a PVC snubber and mounted between 4 ft and 6 ft above finish grade for easy viewing.

2. **Pressure Gauges in System**. Pressure gauges shall be supplied with the unit at the indicated locations, at a minimum, as shown on the contract drawings. The CONTRACTOR shall provide 316SS, 3-inch dial, pressure gauges with range appropriate to the location of measure. Gauge shall be provided with a PVC snubber and mounted between 4 ft and 6 ft above finish grade for easy viewing.

E. The controls and alarms as presented in this specification are the minimum required. The CSS shall be responsible to verify the control systems and provide a complete and operable system that operates in the manner indicated on the contract drawings and within this specification. The system shall be capable of monitoring and alarming critical components and functions necessary to safeguard the system.

2.15 ELECTRICAL ACCESS PANEL & POWER DISTRIBUTION

A. The CSS's chiller skid shall have one main electrical power supply access panel to receive the incoming 480 VAC, 3-phase, 60-hertz power supply, provided to the skid by the CONTRACTOR. This main power supply panel by the CSS shall include a local disconnect switch for the main 480 VAC, 3-phase power feed, to allow for maintenance and servicing of the chiller equipment. The CSS shall provide appropriate 480 VAC, 3-phase power distribution hardware to all equipment on the skid unit. Unit shall be completely factory wired with necessary controls, contact pressure lugs, and terminal block for power wiring and distribution to all internal equipment.

B. Electrical access panel shall be clearly labeled with appropriate "Warning" labels for voltage service.

C. All control power needs (120 VAC, 1-phase or 24 VDC) within the chiller LCP and unit shall be derived from an appropriate step down transformer provided by the CSS within their unit.

D. Within the electrical access panel, provide an oversized magnetic contactor for each compressor and any other equipment requiring magnetic contactors or starters in the chiller unit.

E. Within this electrical access panel, the CONTRACTOR shall provide one service disconnect switch for the entire chiller system, according to Electrical code requirements and those of Division 26 specifications.

2.16 MISCELLANEOUS HARDWARE

A. All flange bolts, nuts, washers, skid anchors and miscellaneous hardware on the chiller skid unit shall be 316 stainless steel w/ anti-seize compound.

1. Unless otherwise indicated, stainless steel bolts, anchor bolts, nuts, and washers shall be fabricated from Type 316 stainless steel, Class 2, conforming to ASTM A 193 for bolts and to ASTM A 194 for nuts.

2. Anti-seize lubricant shall be "PURE WHITE" by Anti-Seize Technology, Franklin Park, IL, 60131, AS-470 by Dixon Ticonderoga Company, Lakehurst, NJ, 08733, or equal.)

2.17 CHILLER SYSTEM MANUFACTURERS, or Equal

A. Innovative Air (208) 331 3303

B. Johnson Thermal Systems (208) 453 1000

PART 3 -- EXECUTION

3.1 FACTORY HYDROSTATIC TESTING

A. Shop testing shall include non-destructive testing, welded attachment inspection, and hydrostatic testing in accordance with indicated codes and industry standards.

B. Hydrostatic testing shall conform to the following requirements:

1. A hydrostatic freshwater test pressure of no less than 50 psig shall be applied to each shell and tube heat exchanger assembly.

2. The hydrostatic test pressure shall be held for a sufficient time to permit a thorough inspection and detection of small leaks, and for no less than 1 hour.

3. After the completion of the test, the heat exchanger shall be completely drained.

4. Any leaks detected in the hydrostatic testing shall be reported to the OWNER, and each leak shall be fixed, and the entire heat exchanger assembly shall be retested according to the above steps.

3.2 INSTALLATION

A. CONTRACTOR shall install the entire chiller system exchangers in accordance with the recommendations and instructions of the CSS.

3.3 FIELD TESTING & STARTUP

A. After installation of chiller system is completed by CONTRACTOR, the CSS shell send a fully trained and minimum 5-yr experienced Factory Technician to the site for an on-site duration of no less than three (3) days, to assist the CONTRACTOR with system start-up and testing procedures. Equipment shall be field tested after installation to demonstrate satisfactory operation without excessive noise, vibration, or overheating of compressor bearings or motor.

B. The following field testing shall be conducted:

1. Start equipment, check, and operate the equipment over its entire operating range for a time period of at least 48-hours. Vibration level shall be within the amplitude limits as indicated or as recommended by the reference applicable standards.

2. Obtain concurrent readings of refrigerant temperature at all critical stages in the system along with water inlet and outlet temperatures to check for proper operation. Check compressor voltage and amperage levels along with bearing temperatures, as required.

3. Over the time period of the test, confirm that the chiller is providing the minimum required chilling tonnage requirements, and submit field calculations to COTR for approval.

C. The OWNER shall have the option to be present and witness field-testing. The CONTRACTOR shall notify the OWNER of the test schedule at least 7-Days in advance.

D. In the event that any equipment fails to meet the test requirements, the equipment shall be modified and retested until it satisfies the requirement.

- END OF SECTION -

SECTION 43 10 22 – PROCESS WATER TREATMENT SYSTEMS

PART 1 -- GENERAL

1.1 SUMMARY

A. Provide process water treatment systems complete and operable, including microstrainers, ultraviolet disinfection units, end suction centrifugal pumps, gas stabilization units, oxygen dosing and control units, control panels and accessories in accordance with the Contract Documents.

B. The requirements of Section 01 33 00 – Submittals, Section 01 60 60 – Facility Start-Up and 44 05 00 - Equipment General Provisions and 44 35 00 - Pumps General apply to the WORK of this Section.

PART 2 -- PRODUCTS

2.1 MICROSTRAINERS

A. SYSTEM DESCRIPTION

1. Influent Flow: Influent flow shall be gravity fed to the microscreen drum filter(s). Influent piping to the filter shall allow for equal distribution of the flow to each filter. Upon entering the drum, the flow disperses radially as it moves through the woven polyester screen panels mounted to the periphery of the drum frame.

2. Operating Liquid Levels: The influent hydrostatic head shall be sufficient to overcome headloss within the microscreen filter and ensure gravity flow through the microscreen filter. Influent flow shall enter the inside of the drum where the water level shall vary between the minimum allowable water level and a maximum water level as set by an internal bypass weir. The fluctuating water level inside the drum is caused by the increased headloss as particles to be filtered collect on the screen panels. A constant water level shall be maintained around the filter drum using an internal weir prior to flowing to the filter enclosure. The microscreen filter shall be operated at minimum submergence of 40 percent of its filtering surface area.

3. Backwash Cycle: Cycle: When the differential water level between the inside of the drum and the filter enclosure reaches a pre-set limit, a level switch shall initiate the backwash cycle. After the switch is activated, the drum drive shall rotate the drum 2 to 2½ rotations, which is controlled by a timer in the control panel. As the drum rotates, the backwash pump shall operate to convey high-pressure filtered process water to the spray bar and spray nozzles located above the drum screens. To withdraw filtered process water, the inlet of the backwash pump shall draw from the filter enclosure. As backwash water passes through the screens, it is collected in a solids trough located directly under the spray bar inside the drum. The collected solids water is conveyed out of the drum by the inclined trough to discharge by gravity.

B. **Operating Conditions:** conform to the following operating conditions:

Module	Juvenile 2 tank (RMS-300, RMS 400)	Juvenile 3 tank (RMS-100, RMS-200)	SW Influent (MS-200)	Hatchery Effluent (MS-700)
Quantity	Two (2)	Two (2)	One (1)	One (1)
Model Type	FRP Tank	FRP Tank	Frame	Frame
Design flow rate (USGPM)	1080	1620	1350	1600
Design Influent TSS (mg/L)	20	20	15	25
Screen Pore Size	37 micron	37 micron	37 micron	54 micron
Filter surface area (per unit)	40.5 ft2	60.7 ft2	60.7 ft2	60.7 ft2
Minimum Drum Submergence	40% of filtering surface area	40% of filtering surface area	40% of filtering surface area	40% of filtering surface area
Maximum screen hydraulic loss	12 in	12 in	12 in	12 in

C. **Equipment Requirements:**

1. Enclosure (for Reuse System Modules, RMS-100, RMS-200, RMS-300, RMS-400):

    a. Each reuse system microscreen drum filter shall have a watertight, fiberglass reinforced plastic (FRP) enclosure complete with removable lid. The enclosure shall be self-supporting when operated continuously at the design maximum water level.

    b. The inner surface of the enclosure shall be a smooth, glossy molded surface, fully sealed with a food-grade, pigmented polyester gel coat that is a minimum of 15 mils thick. The exterior of each tank is to be fully sealed with a pigmented polyester gel coat that is a minimum of 10 mils thick. All internal surfaces must be free of ripples, dimples and any surface imperfections. All perforations and exposed laminate surfaces must be sealed with resin and gel coat.

    c. The filter enclosure shall incorporate an integral, longitudinal weir for control of the water level downstream of the microscreen filter panels. The weir height shall be factory set to maintain the minimum drum submergence at the minimum flow rate.

    d. Bypass: The rotary microscreen drum filter enclosure must be equipped with an internal bypass such that if the input flow exceeds the filter capacity, excess water will overflow from the inlet side of the filter to the outlet side of the filter, bypassing the filter panels, without overflowing the outer tank.

2. Support Frame (for Frame models MS-200 and MS-700):

   a. Each microscreen drum filter shall have a structural welded 304 stainless steel frame that provides support for the rotating drum assembly and all mechanical components.

   b. The support frame shall include an integral sump for control of the filter water level downstream of the micro-screen panels.

   c. Bypass: The rotary microscreen drum filter frame must be equipped with a bypass such that if the input flow exceeds the filter capacity, excess water will overflow from the inlet side of the filter to the outlet side of the filter, bypassing the filter panels.

   d. Include support frame leg extensions as needed to provide for water surface operating levels shown on the Drawings.

3. Filter Cover

   a. The filter shall be furnished with a cover constructed of fiberglass (FRP) with a hinged access panel for access to the spraybar. The cover must also be removable to facilitate maintenance.

4. Drive Train Assembly:

   a. The drive axle shall be constructed of 316 stainless steel and shall have a keyed shaft. The axle shall be coupled to an FRP plate forming the closed end of the drum assembly. The FRP plate shall be capable of absorbing flexure due to normal wear of drum support wheels.

   b. Ensure that there is no risk of lubricants or grease directly contacting the process water or dripping into the process water.

   c. FRP Tank models shall have a sealed mechanical gear reducer mounted directly on the FRP enclosure. The drive shaft shall be connected directly to the gear.

   d. Frame Models shall have a sealed mechanical gear reducer mounted to a drive tower. The drive shaft shall be driven by a lubricated chain and supported by self-aligning pillow block bearings.

   e. The mechanical gear reducer shall be coupled to a high efficiency, TEFC electric motor.

5. Screen Media:

   a. Screen media is to be woven polyester fabric with a nominal screen contained within and supported by a molded injected polypropylene grid. Screen media shall be furnished in complete pre-formed panels that can be individually installed, repaired or replaced. Individual cells of the media panel grid must be designed to allow the use of patching plug(s), as furnished by the manufacturer, for repair of minor damage to filter plates.

b. Screen panels, when mounted on the drum filter, shall be capable of withstanding a maximum continuous headloss of twelve (12) inches of water.

c. Each screen panel shall be sealed continuously on all edges with a silicon sponge gasket, attached to the drum frame with 304 stainless steel anchoring assemblies.

d. Replacement of the filter media must be possible from outside the filter tank. Individual panel removal shall be achievable without removal or disengagement of more than one additional panel.

6. Rotating Drum:

a. The rotating drum shall be fabricated from structural welded, 304 stainless steel and shall be open at one end to allow the influent to enter. The drum assembly shall be sealed sufficiently to prevent bypassing of influent flow into the filtered water tank except in a bypass condition.

7. Drum Seal:

a. The drum seal is to consist of a synthetic elastomer seal wear ring integrally assembled to the front face of the drum filter enclosure or support frame. The seal shall be formed to maintain continuous contact with the surface of the open end of the rotating drum assembly.

8. Backwash System:

a. Each filter shall be supplied with a backwash system comprised of a backwash spray bar assembly, a backwash collection trough, and a backwash pump. The backwash system must operate automatically based on high differential water level between the inside of the drum and the outside of the drum.

b. The backwash collection trough must be located to allow the rotating drum to achieve a bypass condition without influent overflowing into the waste trough. The trough shall discharge by gravity.

c. Backwash spray bar assembly is to consist of a stationary spray header, oriented along the length of the drum assembly, on which are mounted a series of spray nozzles. The spray nozzles shall be sufficient in quantity and shall be spaced appropriately to ensure full spray coverage of the drum length. Spray nozzles shall be of quick-disconnect design to allow for cleaning without turning the spray bar off. The spray nozzle shall consist of a nozzle tip made of 303 SS stainless steel, mounting cap for quick removal, nozzle body and seals. The replacement or cleaning of nozzles must be possible from outside of the filter enclosure.

d. The backwash pump shall be of the horizontal multi-stage design with the motor mounted directly to the pump. The pump shall be capable of supplying the required backwash flow, as specified by the Manufacturer, at a pressure of 100 psi. The motor shall be Totally Enclosed Fan Cooled (TEFC). The pump and backwash piping system for MS-700 shall be configured for year-round outdoor service in conjunction with heat trace and insulation as needed to prevent freezing.

e. Filtered effluent shall be used as the backwash water source. The filter enclosure shall be provided with an integral port downstream of the screen media for supply of backwash water to the backwash pump. A valve and pressure gauge assembly shall be installed on the backwash spray header piping downstream of the pump in order to regulate to the desired nozzle pressure. The backwash system shall be plumbed with PVC or stainless steel piping supplied and installed by the Contractor.

9. Control Panel:

a. Each microscreen filter shall have a local control panel which shall house the automatic level control circuit and motor controls. The panel will have a lockable NEMA-4X enclosure. The circuit shall be UL approved. The circuit shall be capable of closing and opening the motor contacts for the drive motor, and the backwash pump motor. The circuitry for the level switch shall be operated at low voltage.

b. The control panel shall activate the motors for operation when the backwash cycle is initiated. Each of the motors shall have a hand-off-auto (HOA) selector switch and run indication pilot lights on the panel door.

1) “Hand” Operation – When the HOA selector switch is in “hand” or “manual” mode, the drum drive and backwash pump shall operate continuously without any interlocking logic.

2) “Auto” Operation – When the HOA selector switch is in “auto” or “automatic” mode, the level switch shall control the operation of the drum drive and backwash pump.

c. The control panel shall include a VFD or soft start circuitry to ensure the smooth, controlled starting of the filter motor on initiation of the backwash cycle, preventing damaging the filter or electrical components due to high initial torque and current draw.

d. In addition to the Backwash cycle level switch, a High level alarm switch is also included with the filter. When triggered, the High level switch will be able to activate a visual or audible alarm. Level switch is a single-point magnetic reed switch constructed from 316 SS.

D. **Equipment Construction:** Construction shall be as follows:

Filter enclosure (FRP Tank models)	Fiber-reinforced fiberglass

Filter support frame (Frame models)	304 Stainless Steel
Filter Drum, Screen Clamps, Drive Structure	304 Stainless Steel
Filter Element	Polyester fabric on polypropylene grid with silicone sponge gasket
Drum Seal	EPDM
Drive Motor	TEFC , 480 V 3PH 60 Hz
Drive Shaft	316 Stainless Steel
Backwash Pump	TEFC , 480 V 3PH 60 Hz
Control Panel	NEMA 4X, UL
Lubrication	Food safe mineral oil and grease

E. Manufacturers, or Equal

1. Pentair Aquatic Eco-Systems

2.2 REUSE PUMP SKID – END SUCTION CLOSE COUPLED CENTRIFUGAL TYPE

A. Reuse module pumps shall be provided on a pre-assembled powder coated steel skid, complete with 3 pumps per skid, VFD's, inlet and outlet piping, inlet and outlet isolation butterfly valves, inlet compound and outlet pressure gauges, outlet check valves, and pipe supports for discharge header as shown on the Drawings. Piping shall be schedule 40 PVC per Section 40 23 22. Butterfly valves shall conform to Section 43 25 02, Butterfly Valves. Check valves shall conform to Section 43 25 03, Check Valves. Gages shall conform to Section 40 90 10, Pressure and Level Measuring Systems.

B. **Operating Conditions:** conform to the following operating conditions:

Module	Juvenile 2 tank (Reuse Modules 300 and 400)	Juvenile 3 tank (Reuse Modules 100 and 200)
Quantity of Pumps	Six (6)	Six (6)
Design flow rate (USGPM)	513	770
Design TDH	36ft TDH	36ft TDH

C. **Equipment Requirements:**

1. CASING

    a. The casing will be of the end suction design with tangential discharge outlet.

    b. For suction piping diameters of 2" or less and discharge piping diameters of 1.5" or less, the suction and discharge connections shall be NPT threaded. For suction piping diameters of 2" or greater, the suction inlet and the discharge outlet shall be a bolt through flange connection. Flange connections shall be ANSI 125# rated.

    c. The casing bore shall be large enough to allow "back pullout" of the impeller without disturbing the casing or suction and discharge piping.

    d. The casing shall be supported by the driving unit.

2. IMPELLER

    a. The impeller shall be of the enclosed type, and investment cast. It shall be finished all over, the exterior being turned and the interior being finished smooth and cleaned of all burrs, trimmings, and irregularities.

    b. The impeller shall be dynamically balanced. The impeller will be keyed to the shaft, and fastened with a washer, gasket and cap screw.

3. MECHANICAL SEAL

    a. Shaft sealing shall be accomplished by means of a mechanical seal with a Ceramic seat, carbon washer, Buna-N elastomers, and stainless steel metal parts.

4. SHAFT

    a. The impeller shall be direct-coupled to the motor shaft. The motor shaft shall be machined to provide a keyway, and drilled and tapped to accept the impeller fastener. Stub shafts are not acceptable.

5. SHAFT SLEEVE

    a. The pump shaft shall be fitted with a shaft sleeve to minimize shaft wear. The sleeve shall be sealed to the impeller hub by an O-ring, and shall be positively driven by a pin to the keyway. The use of adhesive compounds to fasten the sleeve to the shaft shall not be accepted.

6. Driver:

    a. The driver shall be an electric motor in accordance with the latest NEMA Standards, and shall have the following characteristics:

Enclosure	TEFC
Voltages	460 Volt
Number of Phases	Three
Frequency	60 Hz
Speed	1200 RPM
Efficiency	Premium
Duty	Inverter Duty

b. Each motor shall have a sufficient horsepower rating to operate the pump at any point on the pump's head-capacity curve without overloading the nameplate horsepower rating of the motor, regardless of service factor and shall be inverter rated for VFD control. VFD’s shall be as specified in Section 26 29 23 Variable Frequency Drives.

c. The motor shall have a service factor of at least 1.15. The service factor is reserved for variations in voltage and frequency.

D. **Equipment Construction:** Construction shall be as follows:

Casing	Cast Iron (ASTM A48)
Impellor	Stainless Steel (ASTM 316)
Motor Bracket	Cast Iron (ASTM A48)
Shaft	Steel (AISI C1045)
Shaft Sleeve	Stainless Steel (ASTM 316)

E. Manufacturers, or Equal

1. Pentair Aquatic Eco-Systems – Aurora Pump

2.3 DEGASSERS AND REUSE GAS CONTROL TOWERS

A. **Operating Conditions:** conform to the following operating conditions:

Equipment No.	GW Influent (DG-101)	Chilled GW (DG-102)	Adult Holding (DG-201)	RGT-300, RGT-400	RGT-100, RGT-200
Quantity of Gas Control Towers	1	1	1	Two (2)	Two (2)
Design flow rate (USGPM)	865	80	1350	1080	1620
Water temperature (°F)	45-60	41-50	33-55	55	55
Water pH	6.5	6.5	7.0	6.9-7.2	6.9-7.2
Elevation (ft MSL)	1607	1607	1600	1607	1607
Oxygen source	NA	NA	NA	LOX tank 50 psi, 99% purity (+/-1%)	LOX tank 50 psi, 99% purity (+/-1%)
Inflow dissolved oxygen concentration (%sat)	2	8	8	85	85
Inflow dissolved carbon dioxide concentration (mg/L)	35	20	0	15	15
Outflow dissolved oxygen concentration (%sat)	80%	80%	80%	130	130
Outflow dissolved carbon dioxide concentration (mg/L)	15	15	15	9	9

B. **Equipment Requirements:**

1. General:

   a. The reuse system Gas Control Towers shall include a forced-air Carbon Dioxide Stripper (CO2 Stripper), a Low Head Oxygenator (LHO) as described in U.S. Patent #4880445, and a Sump Tank (LHO Sump). The three components are to be integrated as a single unit when assembled with the CO2 Stripper mounted directly above the LHO which is to be mounted within the LHO Sump.

   b. Each Gas Control Tower must conform to the criteria as specified in this Section and in the Drawings.

   c. The Gas Control Tower shall be engineered by the Manufacturer to account for fluid service and loading conditions described in this Section and in the Drawings.

d. The Gas Control Towers shall be manufactured according to the specification for FRP vessels ‘11 94 01 - Fiberglass Tanks’.

2. Reuse Module CO_2 Strippers:

a. General:

1) The CO_2 Stripper shall be mounted on the LHO, as indicated in the drawing set.

2) Assembly of the Plastic Media, the Distribution Plate, and the Blowers onto the CO_2 Stripper during installation.

3) The CO_2 Stripper shall operate with air flow countercurrent to the water flow. As a minimum, the fall height of water within the gas transfer chamber shall be 48 in.

b. Inlet Box:

1) The Inlet Box shall be located at the top of the CO_2 Stripper. Reuse process water shall be delivered to a fitting on the bottom of the box and shall up-well into the box before flowing laterally onto the Distribution Plates.

2) The Inlet Box must attach directly to the CO_2 Stripper. Inlet pipe and inlet box must be supported during installation to prevent deflection of the CO_2 Stripper when flooded.

c. Distribution Plates:

1) Distribution Plates are to provide even distribution of water into the CO_2 Stripper.

2) Each plate shall be removable, shall have a series of evenly distributed orifices, and a low pressure nozzle installed in each orifice.

d. Plastic Media:

1) After passing through the CO_2 Stripper Distribution Plates, process reuse water flows down through the Plastic Media that is contained within the vessel.

2) The Plastic Media shall be polypropylene or PVC structured plastic packing with a minimum depth of 36 inches.

e. Water Deflector Plate:

1) Process reuse water flows directly out of the bottom of the CO_2 Stripper and over the FRP Water Deflector Plate which shall provide quiescent flow into the LHO unit.

f. Blowers:

1) The CO_2 Stripper shall be furnished with inline plastic fans that will draw air from the room, through the CO_2 Stripper (counter-current to the cascading water). Each fan shall continuously provide the specified airflow under the operating conditions of the CO_2 Stripper.

2) The blower motor(s) to be fully enclosed, and to include all guards and covers required for safe operation.

3. LHO's for Reuse Gas Towers (RGT-100,200,300 and 400)

a. General:

1) The LHO shall be supported on the LHO Sump with the FRP lugs that are integrated into the sides of the LHO.

2) The Contractor shall be responsible for assembly of the Off Gas Fittings and the Orifice Plates onto the LHO during installation.

b. Header Box and Orifice Plates:

1) Under normal operation, the process water falls over the deflector plate under the CO_2 Stripper and is distributed around the perimeter of the LHO as it enters the LHO Header Box. The Orifice Plates shall seat into and be contained by the Header Box.

2) Orifice Plates shall provide even distribution of water into the LHO and must be designed such that a water seal is maintained when operated at the design flow rate.

3) The Orifice Plate shall be constructed from FRP with ozone resistant vinyl ester resin. The Orifice Plate shall have a minimum thickness of ¼ inch, and shall be one piece with two handles attached on the top of each plate section for easy removal from the LHO.

c. LHO Vessel:

1) The oxygen/(ozone) gas is transferred to the process water as it falls through the LHO unit. Oxygenated water flows out of the bottom of the LHO and into the LHO Sump. The outlet of the LHO shall be submerged by a minimum of 18 in below the water level in the LHO Sump.

2) The LHO vessel shall be completely gas-tight when a water seal is maintained over the distribution plate.

3) The LHO shall have internal baffles with gas transfer holes alternating at opposing ends of baffles. Gas transfer holes shall be located less than 12 in below the orifice distribution plate to prevent them from flooding. The internal baffle walls shall be located flush with the bottom of the Header Box and shall provide support to the bottom of Orifice Plates.

d. Gas Fittings

1) The LHO shall be shipped complete with all required oxygen inlet fittings and off-gas vent fittings. Oxygen/(Ozone) feed gas inlet fittings should be manufactured from 316 stainless steel. Off-gas venting fittings shall be manufactured from SCH40 PVC.

4. Tower Sumps

a. General:

1) The Tower Sump shall support the LHO and/or the CO2 Stripper.

2) In normal operation the Tower Sump shall provide partial submergence of the reuse system LHO as specified and shall receive water that flows out of the bottom of the LHO.

3) The Tower Sump shall have a 60° cone bottom with a support skirt. The skirt shall have two skirt access ways for the bottom drain of the LHO Sump. The cone bottom shall have a 2 –inch SCH40 PVC outlet coupling to allow draining of the vessel.

4) The Tower Sump shall hold water to the level specified in the drawings.

5) The Tower Sump shall maintain a specified constant water level utilizing a weir in the wall of the vessel that allows water to flow into a Side Box. The side box shall have two SCH40 PVC outlets both of which shall accommodate insertion of a standpipe for adjustment of outlet height.

5. Adult Holding Aerator (DG-201):

a. General: Surface Water aerator for adult holding shall be designed to aerate 1350 gpm of surface water flow at a hydraulic loading rate of 200 gpm per square foot and shall be manufactured according to the specification for FRP vessels in Section 11 94 01 - Fiberglass Tanks. The unit shall be 36-inch diameter, 8 foot tall FRP cylinder design for full hydrostatic load

b.

6. Groundwater CO2 Stripper (DG-101):

a. General:

1) Groundwater degasser shall be a counter-current air stripper designed to remove up to 50% of dissolved carbon dioxide from 864 gpm of incoming groundwater at 35 mg/l CO2 saturation, while increasing dissolved oxygen levels to at least 80% of full saturation. Hydraulic load rate shall be 30 gpm per square foot or less. Counter current airflow shall be 15 times greater than the water flow.

2) The CO2 Stripper shall be mounted on a 6-foot diameter FRP cylinder

3) The Contractor shall be responsible for assembly of the Plastic Media, the Distribution Plate, and the Blowers onto the CO2 Stripper during installation.

4) The CO2 Stripper shall operate with air flow countercurrent to the water flow. As a minimum, the fall height of water within the gas transfer chamber shall be 36 inches.

b. Inlet Box:

1) The Inlet Box shall be located at the top of the CO2 Stripper. Reuse process water shall be delivered to a fitting on the bottom of the box and shall up-well into the box before flowing laterally onto the Distribution Plates.

2) The Inlet Box must attach directly to the CO2 Stripper. The supplier is responsible for support of the Inlet Box to prevent deflection of the CO2 Stripper when flooded.

c. Distribution Plates:

1) Distribution Plates are to provide even distribution of water into the CO2 Stripper.

2) Each plate shall be removable, shall have a series of evenly distributed orifices, and a low pressure nozzle installed in each orifice.

d. Plastic Media:

1) After passing through the CO2 Stripper Distribution Plates, process reuse water flows down through the Plastic Media that is contained within the vessel.

2) The Plastic Media shall be 2-inch polypropylene or PVC random packing with a minimum depth of 48 inches.

e. Media Retention Plate:

1) 2-inch square pattern FRP grating

7. Chilled Groundwater CO2 Stripper (DG-102):

a. General: Chilled water degasser shall be sized to remove 30% to 40% of dissolved carbon dioxide from 80 gpm of chilled groundwater and increasing dissolved oxygen levels to at least 80% of full saturation. Hydraulic load rate shall be 30 gpm per square foot or less. Counter current airflow shall be 15 times greater than the water flow.

b. This unit was procured for pilot testing during the design phase and is stored at the Cle Elum Fish Hatchery until installed in its final location.

C. **Equipment Construction:** Construction shall be as follows:

Vessels (CO2, LHO Sump)	Fiberglass (FRP)
Vessel (LHO)	Fiberglass (FRP) – ozone resistant resin
Oxygen Inlet Fittings	316 Stainless Steel
Oxygen Outlet Fittings	PVC SCH 40
Water Inlet and Outlet Fittings	PVC SCH 40
Fasteners	18-8/304 stainless steel

D. **Manufacturers, or Equal**

1. Pentair Aquatic Eco-systems

2.4 UV DISINFECTION

A. **Operating Conditions:** conform to the following operating conditions:

Service	**Influent Groundwater (UV-100)**	**Influent Surface Water (UV-200, UV-201)**	**Juvenile 2 tank (RUV-300, RUV-400)**	**Juvenile 3 tank (RUV-100, RUV101, RUV-200, RUV 201))**	**Adult Holding (UV-300)**
Quantity of UV	One (1)	Two (2)	Two (2)	Four (4)	One (1)
Design flow rate (USGPM)	864	1300	1080	810	120
UV Dosage (mJ/cm^2 EOLL)	60	90	60	60	60
UV Transmittance @ 253.7nm	90%	80%	85%	85%	90%

B. **Equipment Requirements:**

1. UV Reactor:

a. All lamp electrical connections shall be at one end of the UV lamp. The major axis of the UV lamps shall be parallel to the direction of flow in the reactor.

b. The UV reactor vessel shall be of the “L” design configuration with its inlet flange fitted inline with the vessel and its outlet flange fitted to the sidewall of the vessel at 90 degrees as to ensure a minimum hydraulic efficiency of 80%.

   1) Note: “U” & “Z” vessel configurations which have both their inlet & outlet ports at right angles to the main vessel shall not be allowed due to poor hydraulic efficiencies.

c. The UV reactor shall be manufactured from UV resistant gray PVC plastic in Sch-80 thickness or greater.

d. The UV reactor shall be of commercially proven chemical solvent welded socket/spigot joint construction and shall not have or rely on any plastic welds to bond pressure bearing surfaces.

   1) Note: Plastic welded vessel construction shall not be allowed due to its inability to handle hydraulic shock loads caused by potential water hammer situations.

e. The UV reactor shall have a drain port fixed to its outer wall.

f. The UV reactor shall accept its respective UV lamps and quartz sleeves through only one end of the vessel. This end of the UV reactor shall allow for complete reactor entry so internal inspection and/or service can be accomplished.

g. The service side of the UV reactor and the UV lamp sleeve seals shall be made using suitable O-ring materials i.e. EPDM or FVMQ.

h. UV reactors shall be able to operate safely at a maximum inlet pressure of 10 psi.

i. Each UV reactor shall have a UV intensity sensor that can be removed and cleaned.

j. A factory certified computational UV fluence (dose) calculation shall be furnished as proof of system UV fluence (dose) performance.

   1) All acceptable UV fluence (dose) calculations shall be from commercially available software i.e. UV Calc Bolton Photosciences Inc.

2. UV Lamps:

   a. The filament shall be significantly rugged to withstand shock and vibration.

   b. Lamp bases shall be ceramic to resist UV and ozone.

   c. All electrical connections to the UV lamp shall be terminated at one end.

d. UV lamps shall have a lamp stepped base design that prevents arcing between electrical pins.

e. UV lamps shall have a monochromatic spectral output, with the emissions peaking at 254 nanometers and be non-ozone producing.

f. The type of quartz used for lamp manufacture shall be compatible with wavelength emission.

g. The mercury contained in the lamps shall be mixed with a base metal and fixed to the inside wall of the UV lamp quartz.

h. Lamp type & wattage: Amalgam with 320-watt input watts.

3. Lamp End Seal and Lamp Holder:

a. The open end of the UV lamp sleeves shall be sealed to the sleeve guide by a suitable compression O-ring assembly.

b. O-ring compression shall be made by a sleeve nut, which shall require no special tools for installation or removal and be made of a translucent HDPE for quick lamp operation reference.

c. Each UV lamp electrical connection shall incorporate a sealing gland nut type cable seal which is held firmly in place by the sleeve nut to prevent emission of ultraviolet rays.

4. UV Lamp Sleeves:

a. Clear fused quartz tubing, closed at one end shall be used. Type 219 quartz shall be used for disinfection and ozone destruction applications.

5. Electrical General:

a. The UV reactor shall be powered from a remote mountable System Control Center by means of a waterproof cable interfacing with a watertight strain relief.

b. The System Control Center shall be of nonconductive wall mountable NEMA 4X enclosure.

c. The System Control Center shall operate on 230-volt AC 50/60-Hz Single phase.

d. Electronic Power Supplies:

1) Each UV lamp shall be powered by one fully electronic power supply (ballast) with a 90% or better power factor rating.

2) The electronic power supply (ballast) shall not be frequency dependent.

3) Each lamp power supply (ballast) and lamp within the system shall operate on its own circuit within the power supply so as to prevent consecutive lamp failures should one power supply (ballast) fail.

4) UV lamps are to be operated by an electronic power supply which automatically adjusts lamp output as a function of lamp age.

6. Control and Instrumentation:

a. System control shall be microprocessor based. Operator interface is to be display type only.

b. The systems local PLC displays main screen shall allow the operator to view current system operating statuses; providing information inclusive of:

1) UV intensity,

2) system operating hours,

3) total number of lamps operating,

4) individual lamp operating hours,

5) system input power,

6) reactor vessel temperature,

7) power supply enclosure temperature,

8) alarm conditions.

9) Display shall allow the operator to further view alarm conditions and history, system configuration/settings, and operation.

7. Alarm Conditions:

a. The microprocessor based local display shall allow the operator to access and view the following alarm conditions:

1) Individual lamp failure – failed lamps shall be indicated by specific address (i.e. lamp #). Position in the reactor shall be indicated via lamp numbers fixed to the lamp wiring at the service end of the UV reactor.

2) UV intensity and Low UV intensity Alarm – Intensity to be monitored by a silicon carbide photodiode (SiC) with UV Intensity being displayed in percent (%) (0 to 100%). A user settable low UV intensity alarm will occur once minimum design UV intensity has been exceeded.

3) Lamp life status – at the end of UV lamp(s) lifetime (12,000 hours) the monitoring system shall set an end of lamp life alarm. The monitoring system continually alarm for the next 72 hours to alert the operator that all lamps in the reactor require change out.

b. Remote ON/OFF capabilities are to be provided via a discrete input circuit to allow either “Remote on” or “Remote/Local” control.

8. Alarm Signals:

a. Each system, through its microprocessor board shall be capable of providing the following outputs for remote monitoring and control:

1) One (1) master analog output relay for remote monitoring of any alarm condition.

2) The master alarm relay shall be a normally open “Form A” contacts rated at 200 milliamps at 24 VDC/AC.

C. **Equipment Construction:** Construction shall be as follows:

Reactor	Body: UV resistant grey PVC plastic Seals: EPDM or FVMQ
Lamp Sleeve	Clear-fused Quartz (Type 219)
Electrical Cabinet	Fiberglass (FRP)

D. **Manufacturers, or Equal**

1. Pentair Aquatic Eco-Systems

2.5 OXYGEN CONTROL PANELS

A. **Operating Conditions:** conform to the following operating conditions:

Module	**Reuse Module 300 and 400**		**Reuse Module 100 and 200**	
Equipment	Culture Tank Diffuser Panel	Gas Control Tower Panel	Culture Tank Diffuser Panel	Gas Control Tower Panel
Quantity	4	2	6	2
Flow	18 lpm	20 lpm	27 lpm	30 lpm
Pressure	50 psi	50 psi	50 psi	50 psi

B. **Equipment Requirements:**

1. Oxygen Control Panels:

    a. Shall consist of an isolation valve, flow meter, pressure gauge throttling valve and solenoid valves.

    b. The flow meter shall be coupled with a needle valve for manual flow control and shall be sized such that the design flow rate is approximately 50% of the capacity of the meter

    c. The pressure gauge shall be selected such that the design pressure is approximately 50% of the capacity of the gauge

    d. The plumbing shall be sized such that pressure drop through the oxygen control panel at design flow is less than 3 psid from inlet to outlet fitting

    e. Shall have a flow table identifying standard flow rate based on flow meter reading and pressure gauge

    f. Shall consist of solenoid valves on the LHO feed and micropore diffuser feed that operates on 24VDC:

        1) Solenoid valves on micropore diffuser feed shall be closed when energized, (normally closed operationally) and shall open based on a low dissolved oxygen signal to the controller and shall fail open to supply emergency diffusers on power loss

        2) Solenoid valves on LHO supply shall be open when energized (normally open operationally) and shall fail closed when not energized.

    g. Shall have solenoid valve bypass plumbing that allows the solenoid valve to be isolated.

    h. Shall include a dissolved oxygen/pH sensor probe with adequate cable length to connect from grow-out tanks sidebox to the control panel.

    i. Shall have ability for Remote Interface Unit to be integrated into enclosure to allow automated operation of solenoid valve

    j. Shall have barbed fittings for the gas inlet and gas outlet plumbing connection

    k. Shall be cleaned for oxygen service

C. **Equipment Construction:** Construction shall be as follows:

Valves	Body: Brass or stainless steel Seals: Viton or PTFE
Flow Meter	Body: Clear acrylic

	Seals: Viton or PTFE Fittings: Brass or stainless steel
Plumbing	Brass or flexible hose rated for use with oxygen gas

D. **Manufacturers, or Equal**

1. Pentair Aquatic Eco-systems

2.6 BACKUP OXYGEN DIFFUSERS

A. **Operating Conditions:** conform to the following operating conditions:

Module	**Juvenile 2 tank (2J)**	**Juvenile 3 tank (3J)**
Quantity	3 per tank x 4 tanks = 12	3 per tank x 6 tanks = 18
Flow	9 lpm per diffuser	9 lpm per diffuser
Pressure	25 psi	25 psi

B. **Equipment Requirements:**

1. Oxygen Diffusers:

   a. Diffusers shall be ultra-fine pore ceramic plate type

   b. Shall have barbed fittings for the gas inlet and gas outlet plumbing connection

   c. Shall be suitable for supply pressure of oxygen up to 50psig

C. **Manufacturers, or Equal**

1. Type MX-600 Pentair Aquatic Eco-systems

2.7 SURFACE WATER BOOSTER PUMPS (SP-203, SP-204, SP-205)

A. Booster pumps shall be close coupled end suction centrifugal type in accordance to Article 2.2 of this Section above.

SW Booster Pumps	**SP-203, SP-204, SP-205**

Quantity of Pumps	Three (3)
Design flow rate (USGPM)	1350 gpm
Design TDH	50ft TDH

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Equipment shall be installed in accordance with manufacturer's instructions and Shop Drawings and as indicated.

B. Start-Up and Commissioning shall comply with Section 01 60 60 – Facility Start-Up.

- END OF SECTION -

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SECTION 43 25 00 - VALVES, GENERAL

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide valves, actuators, and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 43 00 00 - Equipment General Provisions, apply to the WORK of this Section.

C. The provisions of this Section shall apply to valves and valve actuators except where otherwise indicated. Valves and actuators in particular locations may require a combination of units, sensors, limit switches, and controls indicated in other Sections of the Specifications.

D. Where a valve is to be supported by means other than the piping to which it is attached, the CONTRACTOR shall obtain from the valve manufacturer a design for support and foundation that satisfies the criteria in Section 43 00 00. The design, including drawings and calculations sealed by an engineer, shall be submitted with the Shop Drawings. When the design is approved, the support shall be provided.

E. **Unit Responsibility:** A single manufacturer shall be made responsible for coordination of design, assembly, testing, and furnishing each valve; however, the CONTRACTOR shall be responsible to the OWNER for compliance with the requirements of each valve section. Unless indicated otherwise, the responsible manufacturer shall be the manufacturer of the valve.

F. **Single Manufacturer:** Where two or more valves of the same type and size are required, the valves shall be furnished by the same manufacturer.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.

B. **Shop Drawings:** Shop Drawings shall contain the following information:

1. Valve name, size, Cv factor, pressure rating, identification number (if any), and specification section number.

2. Complete information on valve actuator, including size, manufacturer, model number, limit switches, and mounting.

3. Cavitation limits for control valves.

4. Assembly drawings showing part nomenclature, materials, dimensions, weights, and relationships of valve handles, handwheels, position indicators, limit switches, integral control systems, needle valves, and control systems.

5. Data in accordance with Section 26 05 10 - Electric Motors for electric motor-actuated valves.

6. Complete wiring diagrams and control system schematics.

7. Valve Labeling: A schedule of valves to be provided with stainless steel tags, indicating in each case the valve location and the proposed wording for the tag.

C. **Technical Manual:** The Technical Manual shall contain the required information for each valve.

D. **Spare Parts List:** A Spare Parts List shall contain the required information for each valve assembly, where indicated.

E. **Factory Test Data:** Where indicated, signed, dated, and certified factory test data for each valve requiring certification shall be submitted before shipment of the valve. The data shall also include certification of quality and test results for factory-applied coatings.

PART 2 -- PRODUCTS

2.1 PRODUCTS

A. **General:** Valves and gates shall be new and of current manufacture. Shut-off valves 6-inches and larger shall have actuators with position indicators. Gate valves 18-inches and larger or where chain wheel is required, shall be furnished with spur gear and hand wheel. Buried valves shall be provided with valve boxes and covers containing position indicators and valve extensions. Manual shut-off valves mounted higher than 7-feet above working level shall be provided with chain actuators.

B. **Valve Actuators:** Unless otherwise indicated, actuators shall be in accordance with Section 43 25 01 - Valve and Gate Actuators.

C. **Protective Coating:** The exterior surfaces of valves and the wet interior surfaces of ferrous valves of sizes 4-inches and larger shall be coated in accordance with Section 09 96 00 - Protective Coating. The valve manufacturer shall certify in writing that the required coating has been applied and tested in the manufacturing plant prior to shipment, in accordance with these Specifications. Flange faces of valves shall not be epoxy coated.

D. **Valve Labeling:** Except when such requirement is waived by the ENGINEER in writing, a label shall be provided on shut-off valves and control valves except for hose bibbs and chlorine cylinder valves. The label shall be of 1/16-inch plastic or stainless steel, minimum 2-inches by 4-inches in size, as indicated in Section 40 23 01 - Piping Identification Systems, and shall be permanently attached to the valve or on the wall adjacent to the valve as directed by the ENGINEER.

E. **Valve Testing:** As a minimum, unless otherwise indicated or recommended by the reference standards, valves 3-inches in diameter and smaller shall be tested in accordance with manufacturer's standard and 4-inches in diameter and larger shall be factory tested as follows:

1. Hydrostatic Testing: Valve bodies shall be subjected to internal hydrostatic pressure equivalent to twice the water rated pressure of the valve. Metallic valve rating pressures shall be at 100 degrees F and plastic valves shall be 73 degrees, or at

higher temperature according to type of material. During the hydrostatic test, there shall be no leakage through the valve body, end joints, or shaft seals, nor shall any part of the valve be permanently deformed. The duration shall be sufficient time to allow visual examination for leakage. Test duration shall be at least 10 minutes.

2. Seat Testing: Valves shall be tested for leaks in the closed position with the pressure differential across the seat equal to the water rated pressure of the valve. The duration of test shall be sufficient time to allow visual examination for leakage. Test duration shall be at least 10 minutes. Leakage past the closed valve shall not exceed 1 fluid ounce per hour per inch diameter for metal seated valves. Resilient-seated valves shall be drop-tight.

3. Performance Testing: Valves shall be shop-operated from fully closed to fully open position and reverse under no-flow conditions in order to demonstrate the valve assembly operates properly.

F. **Certification:** Prior to shipment, the CONTRACTOR shall submit for valves over 12-inches in size, certified, notarized copies of the hydrostatic factory tests, showing compliance with the applicable standards of AWWA, ANSI, or ASTM.

G. **Valve Marking:** Valve bodies shall be permanently marked in accordance with MSS SP25 - Standard Marking Systems for Valves, Fittings, Flanges, and Unions.

2.2 MATERIALS

A. **General:** Materials shall be suitable for the intended application. Materials in contact with potable water shall be listed as compliant with NSF Standard 61. Materials not indicated shall be high-grade standard commercial quality, free from defects and imperfections that might affect the serviceability of the product for the purpose for which it is intended. Unless otherwise indicated, valve and actuator bodies shall conform to the following requirements:

1. Cast Iron: Close-grained gray cast iron, conforming to ASTM A 48 - Gray Iron Castings, Class 30, or to ASTM A 126 - Gray Iron Castings for Valves, Flanges, and Pipe Fittings.

2. Ductile Iron: ASTM A 536 - Ductile Iron Castings, or to ASTM A 395 - Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.

3. Steel: ASTM A 216 - Steel Castings, Carbon Suitable for Fusion Welding for High-Temperature Service, or to ASTM A 515 - Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service.

4. Bronze: ASTM B 62 - Composition Bronze or Ounce Metal Castings, and valve stems not subject to dezincification shall conform to ASTM B 584 - Copper Alloy Sand Castings for General Applications.

5. Stainless Steel: Stainless steel valve and operator bodies and trim shall conform to ASTM A 351 - Steel Castings, Austenitic, for High-Temperature Service, Grade CF8M, or shall be Type 316 stainless steel.

6. PVC: Poly vinyl chloride materials for valve body, flanges, and cover shall conform to Cell Classification 12454.

7. CPVC: Chlorinated poly vinyl chloride materials for valve body, flanges, and cover shall conform to Cell Classification 23447.

8. NSF Standard 14: Materials shall be listed for use in contact with potable water.

2.3 VALVE CONSTRUCTION

A. **Bodies:** Valve bodies shall be cast, molded (in the case of plastic valves), forged, or welded of the materials indicated, with smooth interior passages. Wall thicknesses shall be uniform in agreement with the applicable standards for each type of valve, without casting defects, pinholes, or other defects that could weaken the body. Welds on welded bodies shall be done by certified welders and shall be ground smooth. Valve ends shall be as indicated, and be rated for the maximum temperature and pressure to which the valve will be subjected.

B. **Valve End Connections:** Unless otherwise indicated, valves 2-1/2 inches diameter and smaller may be provided with threaded end connections. Valves 3-inches and larger shall have flanged end connections.

C. **Bonnets:** Valve bonnets shall be clamped, screwed, or flanged to the body and shall be of the same material, temperature, and pressure rating as the body. The bonnets shall have provision for the stem seal with the necessary glands, packing nuts, or yokes.

D. **Stems:** Valve stems shall be of the materials indicated, or, if not indicated, of the best commercial material for the specific service, with adjustable stem packing, O-rings, Chevron V-type packing, or other suitable seal.

E. **Stem Guides:** Stem guides shall be provided, spaced 10-feet on centers unless the manufacturer can demonstrate by calculation that a different spacing is acceptable. Submerged stem guides shall be 304 stainless steel.

F. **Internal Parts:** Internal parts and valve trim shall be as indicated for each individual valve. Where not indicated, valve trim shall be of Type 316 stainless steel or other best suited material.

G. **Nuts and Bolts:** Nuts and bolts on valve flanges and supports shall be in accordance with Section 05 50 00 – Metal Fabrications & Miscellaneous Metals.

2.4 VALVE ACCESSORIES

A. Valves shall be furnished complete with the accessories required to provide a functional system.

2.5 SPARE PARTS

A. The CONTRACTOR shall furnish the required spare parts suitably packaged and labeled with the valve name, location, and identification number. The CONTRACTOR shall also furnish the name, address, and telephone number of the nearest distributor for the spare parts of each valve. Spare parts are intended for use by the OWNER, after expiration of the correction of defects period.

2.6 MANUFACTURERS

A. **Manufacturer's Qualifications:** Valve manufacturers shall have a successful record of not less than 5 years in the manufacture of the valves indicated.

PART 3 -- EXECUTION

3.1 VALVE INSTALLATION

A. **General:** Valves, actuating units, stem extensions, valve boxes, and accessories shall be installed in accordance with the manufacturer's written instructions and as indicated. Gates shall be adequately braced to prevent warpage and bending under the intended use. Valves shall be firmly supported to avoid undue stresses on the pipe.

B. **Access:** Valves shall be installed with easy access for actuation, removal, and maintenance and to avoid interference between valve actuators and structural members, handrails, or other equipment.

C. **Valve Accessories:** Where combinations of valves, sensors, switches, and controls are indicated, the CONTRACTOR shall properly assemble and install such items so that systems are compatible and operating properly. The relationship between interrelated items shall be clearly noted on Shop Drawing submittals.

- END OF SECTION -

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SECTION 43 25 01 - VALVE AND GATE ACTUATORS

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide valve and gate actuators and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The provisions of this Section shall apply to valves and gates except where otherwise indicated in the Contract Documents.

C. **Unit Responsibility:** The valve or gate manufacturer shall be made responsible for coordination of design, assembly, testing, and installation of actuators on the valves and gates; however, the CONTRACTOR shall be responsible to the OWNER for compliance of the valves, gates, and actuators with the Contract Documents.

D. **Single Manufacturer:** Where 2 or more valve or gate actuators of the same type or size are required, the actuators shall be produced by the same manufacturer.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals and Section 43 25 00 - Valves, General.

B. **Shop Drawings:** Shop Drawing information for actuators shall be submitted together with the valve and gate submittals as a complete package.

C. **Calculations:** Selection calculations showing dynamic seating and unseating torques versus output torque of actuator.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Unless otherwise indicated, shut-off and throttling valves and externally actuated valves and gates shall be provided with manual or power actuators. The CONTRACTOR shall furnish actuators complete and operable with mounting hardware, motors, gears, controls, wiring, solenoids, handwheels, levers, chains, and extensions, as applicable. Actuators shall have the torque ratings equal to or greater than required for valve seating and dynamic torques, whichever is greater, and shall be capable of holding the valve in any intermediate position between fully-open and fully-closed without creeping or fluttering. Actuator torque ratings for butterfly valves shall be determined in accordance with AWWA C504 - Rubber-Seated Butterfly Valves. Wires of motor-driven actuators shall be identified by unique numbers.

B. **Manufacturers:** Where indicated, certain valves and gates may be provided with actuators manufactured by the valve or gate manufacturer. Where actuators are furnished by different manufacturers, the CONTRACTOR shall coordinate selection to have the fewest number of manufacturers possible.

C. **Materials:** Actuators shall be current models of the best commercial quality materials and be liberally-sized for the required torque. Materials shall be suitable for the environment in which the valve or gate is to be installed.

D. **Actuator Mounting and Position Indicators:** Actuators shall be securely mounted by means of brackets or hardware specially designed and sized for this purpose and be of ample strength. The word "open" shall be cast on each valve or actuator with an arrow indicating the direction to open in the counter-clockwise direction. Gear and power actuators shall be equipped with position indicators. Where possible, manual actuators shall be located between 48- and 60-inches above the floor or the permanent working platform.

E. **Standard:** Unless otherwise indicated and where applicable, actuators shall be in accordance with AWWA C 540 - Power-Actuating Devices for Valves and Slide Gates.

F. **Functionality:** Electric, pneumatic, and hydraulic actuators shall be coordinated with the power requirements of Division 16 and instrumentation equipment indicated in Section 40 90 00 - Process Control and Instrumentation Systems.

G. Fasteners shall be in accordance with Section 05 50 00 – Metal Fabrications & Miscellaneous Metals.

H. Protective coatings shall be in accordance with Section 09 96 00 - Protective Coatings.

2.2 MANUAL ACTUATORS

A. **General:** Unless otherwise indicated, valves and gates shall be furnished with manual actuators. Valves in sizes up to and including 4-inches shall have direct acting lever or handwheel actuators of the manufacturer's best standard design. Larger valves and gates shall have gear-assisted manual actuators, with an operating pull of maximum 60 pounds on the rim of the handwheel. Buried and submerged gear-assisted valves, gates, gear-assisted valves for pressures higher than 250 psi, valves 30-inches in diameter and larger, and where so indicated, shall have worm gear actuators, hermetically-sealed water-tight and grease-packed. Other valves 6-inches to 24-inches in diameter may have traveling nut actuators, worm gear actuators, spur or bevel gear actuators, as appropriate for each valve.

B. **Buried Valves:** Unless otherwise indicated, buried valves shall have extension stems to grade, with square nuts or floor stands, position indicators, and cast-iron or steel pipe extensions with valve boxes, covers, and operating keys. Where so indicated, buried valves shall be in cast-iron, concrete, or similar valve boxes with covers of ample size to allow operation of the valve actuators. Covers of valve boxes shall be permanently labeled as required by the local Utility Company or the ENGINEER. Wrench nuts shall comply with AWWA C 500 - Metal - Seated Gate Valves for Water Supply Service.

C. **Chain Actuator:** Manually-activated valves with the stem located more than 7-feet above the floor or operating level shall be provided with chain drives consisting of sprocket-rim chain wheels, chain guides, and operating chains provided by the valve manufacturer. The wheel and guide shall be of ductile iron, cast iron, or steel, and the chain shall be hot-dip galvanized steel or stainless steel, extending to 5-feet 6-inches above the operating floor level. The valve stem of chain-actuated valves shall be extra strong to allow for the extra weight and chain pull. Hooks shall be provided for chain storage where chains interfere with pedestrian traffic.

D. **Floor Boxes:** Hot dip galvanized cast iron or steel floor boxes and covers to fit the slab thickness shall be provided for operating nuts in or below concrete slabs. For operating nuts in the concrete slab, the cover shall be bronze-bushed.

E. **Tee Wrenches:** Buried valves with floor boxes shall be furnished with 2 operating keys or 1 key per 10 valves, whichever is greater. Tee wrenches sized so that the tee handle will be 2 to 4 feet above ground shall fit the operating nuts.

F. **Manual Worm Gear Actuator:** The actuator shall consist of a single or double reduction gear unit contained in a weather-proof cast iron or steel body with cover and minimum 12-inch diameter handwheel. The actuator shall be capable of 90 degree rotation and shall be equipped with travel stops capable of limiting the valve opening and closing. The actuator shall consist of spur or helical gears or worm gearing. The gear ratio shall be self-locking to prevent "back-driving." The spur or helical gears shall be of hardened alloy steel and the worm gear shall be alloy bronze. The worm gear shaft and the handwheel shaft shall be of 17-4 PH or similar stainless steel. Gearing shall be accurately cut with hobbing machines. Ball or roller bearings shall be used throughout. Output shaft end shall be provided with spline to allow adjustable alignment. Actuator output gear changes shall be mechanically possible by simply changing the exposed or helical gearset ratio without further disassembly of the actuator. Gearing shall be designed for a 100 percent overload. The entire gear assembly shall be sealed weatherproof. **ALL BURIED VALVES SHALL BE OF THE MANURAL WORM GEAR TYPE.**

G. **Traveling-Nut Actuator:** The actuator shall consist of a traveling-nut with screw (Scotch yoke) contained in a weatherproof cast iron or steel housing with spur gear and minimum 12-inch diameter handwheel. The screw shall run in 2 end bearings, and the actuator shall be self-locking to maintain the valve position under any flow condition. The screw and gear shall be of hardened alloy steel or stainless steel, and the nut and bushings shall be of alloy bronze. The bearings and gear shall be grease-lubricated by means of nipples. Gearing shall be designed for a 100 percent overload.

PART 3 -- EXECUTION

3.1 SERVICES OF MANUFACTURER

A. **Field Adjustments:** Field representatives of manufacturers of valves or gates with pneumatic, hydraulic, or electric actuators shall adjust actuator controls and limit-switches in the field for the required function.

3.2 INSTALLATION

A. Valve and gate actuators and accessories shall be installed in accordance with Section 15200 - Valves, General. Actuators shall be located to be readily accessible for operation and maintenance without obstructing walkways. Actuators shall not be mounted where shock or vibrations will impair their operation, nor shall the support systems be attached to handrails, process piping, or mechanical equipment.

- END OF SECTION -

SECTION 43 25 02 - BUTTERFLY VALVES

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide butterfly valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 44 05 00 – Equipment General Provisions apply to this Section.

C. The requirements of Section 43 25 00 - Valves, General apply to this Section.

D. The requirements of Section 43 25 01 - Valve and Gate Actuators apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 43 25 00 – Valves, General.

B. Shop Drawings

1. Complete Shop Drawings of butterfly valves and actuators.

2. Drawings showing valve port diameter complete with dimensions, part numbers, and materials of construction.

3. Dynamic seating and unseating torque for any motor actuated valves.

4. Certified statement of proof-of-design tests from the valve manufacturer. Valve manufacturer shall state that the valves proposed for this project will be manufactured with identical basic type of seat design and materials of construction to the prototype evaluated under the proof of design testing.

5. Manufacturer's certification that the valve complies with applicable provisions of AWWA C504 – Rubber-Seated Butterfly Valves.

1.3 QUALITY ASSURANCE

A. Valves shall be subjected to performance, leakage, and hydrostatic tests in accordance with procedures and acceptance criteria established by AWWA C504.

PART 2 -- PRODUCTS

2.1 EXPOSED BUTTERFLY VALVES – PVC WAFER

A. **General:** Exposed butterfly valves shall be rubber seated, tight closing and shall be suitable for throttling service, with wafer style PVC body and disc, stainless steel shaft, handwheel gear operator with position indicator and EPDM liners. Valves shall be designed for steady-state water working pressures and steady-state differential pressure up to 150 psi and for fresh water service having a pH range from 6 to 10 and temperature range from 33 to 125 degrees F shall conform to ANSI B16.10 dimensions.

B. **Valve Schedule**. Valves of 3-inch diameter and larger shall be of the body type, pressure class, end joint, and actuator type as indicated on the valve schedules on **Contract Drawings.**

C. **Manufacturers, or Equal**

1. Hayward
2. Asahi America Style 57
3. Pentair Aquatic Eco-Systems

2.2 BURIED BUTTERFLY VALVES

A. **General:** Butterfly valves for steady-state water working pressures and steady-state differential pressure up to 150 psi and for fresh water service having a pH range from 6 to 9 and temperature range from 35 to 60 degrees F shall conform to AWWA C504 and be as indicated.

1. Valves subjected to steady state working pressures and steady state differential pressures from 25 to 150 psi in sizes 3-inches through 30-inches shall be rated for either Class 75B or Class 150B with actuator sized for Class 150B.

B. **Valve Schedule**. Valves of 3-inch diameter and larger shall be of the body type, pressure class, end joint, and actuator type as indicated on the valve schedules on **Contract Drawings**. If the operating conditions such as flow, velocity, and differential pressures are not indicated, the valve body and shaft shall be sized for the pressure class rating of the valve.

C. **Construction:** Unless otherwise indicated, materials of construction shall be in accordance with AWWA C504, suitable for the service. Seats shall be positively clamped or bonded into the disc or body of the valve, but cartridge-type seats that rely on a high coefficient of friction for retention shall not be acceptable. Seat material shall be guaranteed to last for at least 75 percent of the number of cycles in the AWWA C504 proof-of-design test without premature damage.

Description	Material Standards
Valve bodies	Gray iron, ASTM A 48, Class 40 or Gray iron, ASTM A 126, Class B, or Ductile iron, ASTM A 536, grade 65-45-12 or 70-50-05
End flanges	Same material as valve bodies
Valve shafts	Stainless steel ASTM A 240 or A 276, Type 316

Valve discs	Same material as valve bodies.
Rubber seats	New natural or synthetic rubber
Seat mating surfaces	Stainless steel, ASTM A 240 or A 276, Type 316
Clamps and retaining rings	Type 316 retaining rings and cap screws.
Valve bearings	Self lubricating materials per AWWA C504
Shaft seals	Resilient non-metallic materials suitable for service
Painting and coating	Refer to Part 2.1.G below.

D. **Manual Actuators:** Unless otherwise indicated, manually-actuated butterfly valves shall be equipped with a handwheel and 2-inch square actuating nut and position indicator. Screw-type (traveling nut) actuators will not be permitted for valves 30-inches in diameter and larger.

E. **Worm Gear Actuators**: Valves 30-inches and larger, as well as submerged and buried valves, shall be equipped with worm-gear actuators, lubricated and sealed to prevent entry of dirt or water into the housing.

F. **Ferrous Surface Coating:** All corrosive ferrous surfaces of valves 3-inches and larger, exclusive of flange faces, shall be properly primed and epoxy-coated per the Manufacturer's standard liquid-applied epoxy coating system. For buried valves, all ferrous surfaces, exclusive of flange faces, shall be given proper primer and fusion-bonded epoxy coatings, per AWWA C550, for buried service.

G. **Manufacturers, or Equal**

1. Clow / M & H Valve Company

2. DeZURIK Water Controls, Corporation

3. Henry Pratt / Mueller Company. (Series 2FII for valves 20" dia and smaller indoors. Series "Groundhog" for all buried valves.)

4. Val Matic / American Darling. (Series 2000 for valves 20" dia and smaller – indoors, and Series 2030 for all buried valves)

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Exposed butterfly valves shall be installed with a means of removing the complete valve assembly without dismantling the valve or operator. Installation shall be in accordance with Section 43 25 00.

3.2 **Inspection, Startup, and Field Adjustment:** An authorized representative of the cast-iron body Valve Manufacturer shall visit the Site on the number of occasions identified below and provide assistance to the CONTRACTOR and OWNER for the following:

1. Installation inspection, adjusting, startup and field-testing for proper operation of the equipment for not less than two (2) separate trips for no less than one (1) Work Day on-site each trip.

3.3 **Instruction of OWNER's and CONTRACTOR’s Personnel:** During the final startup and field testing visit listed above, the AM(s) authorized service representative shall provide at least 4-hours additional time on-site to instruct the CONTRACTOR’s and OWNER's personnel in the operation and maintenance of the equipment including step-by-step troubleshooting procedures with necessary test equipment.

- END OF SECTION -

SECTION 43 25 03 - CHECK VALVES

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide check valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 43 25 00 - Valves, General apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 43 25 00 – Valves, General.

PART 2 -- PRODUCTS

2.1 SILENT CHECK VALVES (3-INCHES AND LARGER)

A. **General:** Check valves for reuse system service shall be of the silent wafer check style

B. **Body:** The valve body and cover shall be of cast iron conforming to ASTM A 126 - Gray Iron Castings for Valves, Flanges, and Pipe Fittings, with enamel primer exterior and uncoated interior, suitable for mounting between ANSI Class 125 flat faced companion flanges.

C. **Plug and Seat:** The valve plug and spring shall be type 316 stainless steel.

D. **O- Rings:** The O- rings shall be Buna-N.

E. Manufacturers, or Equal

1. **Valmatic**
2. **Kennedy Valve**
3. **Mueller Company**
4. **Stockham Valves and Fittings**
5. **Golden Anderson**

PART 3 -- EXECUTION

3.1 GENERAL

A. Valves shall be installed in accordance with provisions of Section 43 25 00 – Valves, General.

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SECTION 43 25 04 - BALL VALVES

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide ball valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 43 25 00 - Valves, General apply to this Section.

C. The requirements of Section 43 25 01 - Valve and Gate Actuators apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 43 25 00 - Valves, General.

PART 2 -- PRODUCTS

2.1 METAL BALL VALVES (4-INCHES AND SMALLER)

A. **General:** Unless otherwise indicated, general purpose metal ball valves in sizes up to 4-inches shall have actuators in accordance with Section 43 25 01 - Valve and Gate Actuators.

B. **Body:** Ball valves up to and including 1-1/2 inches in size shall have bronze or carbon steel 2 or 3 piece bodies with screwed ends for a pressure rating of not less than 600 psi WOG. Valves 2-inches to 4-inches in size shall have bronze or carbon steel 2 or 3 piece bodies with flanged ends for a pressure rating of ANSI 125 psi or 150 psi unless otherwise indicated.

C. **Balls:** The balls shall be solid chrome-plated brass or bronze, or stainless steel, with standard port (single reduction) or full port openings.

D. **Stems:** The valve stems shall be of the blow-out proof design, of bronze, stainless steel, or other acceptable construction, with reinforced Teflon seal.

E. **Seats:** The valve seats shall be of Teflon or Buna-N, for bi-directional service and easy replacement.

F. Manufacturers, or Equal

1. **Conbraco Industries, Inc. (Apollo)**

2. **ITT Engineered Valves**

3. **Neles-Jamesbury, Inc.**

4. **Watts Regulator**

5. **Worcester Controls**

2.2 PLASTIC BALL VALVES

A. **General:** Plastic ball valves 2-inch and smaller, shall be made of polyvinyl chloride (PVC). Valves shall have manual actuators in accordance with Section 15201 - Valve and Gate Actuators, unless otherwise indicated.

B. **Construction:** Plastic ball valves shall have union ends or flanged ends to mate with ANSI B 16.5, class 150 flanges for easy removal. The balls shall have full size ports and Teflon seats. External (without entering into the wetted area) seat packing adjustment is preferred. Metal reinforced stems to prevent accidental breakage are preferred. The valves shall be suitable for a maximum working non-shock pressure of 150 psi at 73 degrees F for PVC and CPVC, with decreasing ratings for higher temperatures and other plastics.

C. Manufacturers, or Equal

1. **ASAHI-America**

2. **George Fischer, Inc.**

3. **NIBCO Inc., (Chemtrol)**

4. **Hayward**

5. **Plast-O-Matic Valves, Inc.**

PART 3 -- EXECUTION

3.1 GENERAL

A. Valves shall be installed in accordance with Section 43 25 00. Care shall be taken that valves in plastic lines are well supported at each end of the valve.

- END OF SECTION -

SECTION 43 25 42 - MISCELLANEOUS VALVES

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide miscellaneous valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 43 25 00 - Valves, General, apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 43 00 00.

PART 2 -- PRODUCTS

2.1 AIR-VACUUM AND AIR-RELEASE VALVES

A. **Air and Vacuum Valves:** Air and vacuum valves shall be capable of venting large quantities of air while pipelines are being filled, and allowing air to re-enter while pipelines are being drained. They shall be of the size indicated, with flanged or screwed ends to match piping. Bodies shall be of high-strength cast iron. The float, seat, and moving parts shall be constructed of Type 316 stainless steel. Seat washers and gaskets shall be of a material insuring water tightness with a minimum of maintenance. Valves shall be designed for minimum 150 psi water-working pressure, unless otherwise indicated.

B. **Air-Release Valves:** Air-release valves shall vent accumulating air while system is in service under pressure and be of the size indicated. Valves shall meet the same general requirements as indicated for air and vacuum valves except that the vacuum feature will not be required. Valves shall be designed for a minimum water-working pressure of 150 psi, unless otherwise indicated.

C. **Combination Air Valves:** Combination air valves shall combine the characteristics of air and vacuum valves and air release valves by exhausting accumulated air in systems under pressure and releasing or re-admitting large quantities of air while a system is being filled or drained, respectively. Valves shall have the same general requirements as indicated for air and vacuum valves.

D. **Sewage Air Release Valves:** Sewage air release valves shall vent accumulating gases during system operation. Valves shall have long float stems and bodies to minimize clogging. The same general requirements shall apply as indicated for air and vacuum valves. Each sewage air release valve shall be furnished with the following backwash accessories, fully assembled on the valve:

1. Inlet shut-off valve.
2. Blow-off valve.
3. Clear water inlet valve.

4. Rubber supply hose.

5. Quick disconnect couplings.

E. Manufacturers, or Equal

1. **APCO (Valve and Primer Corporation)**

2. **Crispin - Multiplex Manufacturing Company**

3. **GA Industries**

4. **Val-Matic (Valve and Manufacturing Corporation)**

2.2 VACUUM RELIEF/AIR INLET VALVE FOR SURGE TANK

A. A vacuum relief/air inlet valve shall be installed on the surge tank. The vacuum relief/air inlet valve shall be normally closed, capable of admitting large quantities of air into the system immediately should the system pressure become negative and preventing a vacuum from forming during draining, pipeline rupture, or water column separation. The valve shall be of the size indicated, with flanged ends to match piping connections. Bodies shall be of high-strength cast iron with a steel hood. The float, seat, spring, and moving parts shall be constructed of Type 316 stainless steel. The internal valve-plug and seat shall be heavy cast brass. The plug shall be normally closed by means of a stainless steel spring and shall open when a vacuum/pressure differential exceeds 0.25 psi or less. Seat seal shall be of Buna-N providing a drip-tight seal. Valves shall be designed for minimum 150 psi water-working pressure, unless otherwise indicated.

B. Manufacturers, or Equal

1. **APCO (Valve and Primer Corporation)**

2. **Val-Matic (Valve and Manufacturing Corporation)**

2.3 BACKFLOW PREVENTER VALVES

A. **General:** Backflow preventers shall work on the reduced pressure principle. They shall consist of 2 spring-loaded check valves, automatic differential pressure relief valve, drain valves, and shut-off valves. The body material shall be bronze or cast iron for a working pressure of not less than 150 psi, with bronze or stainless steel trim. Drain lines with air gaps shall be provided. The backflow preventer valves shall be in accordance with AWWA C511 standard.

B. Manufacturers, or Equal

1. **Cla-Val Company**

2. **Febco (CMB Industries)**

3. **Hersey Products**

4. **Watts, ACV**

5. **Wilkins Regulator Division (Zurn Industries)**

2.4 BACKFLOW PREVENTERS FOR AUTOMATIC FIRE SPRINKLER SYSTEMS

A. **General:** Backflow preventers for automatic fire sprinkler systems shall be UL and Factory Mutual approved for fire protection. Flow curves shall be generated by the Foundation for Cross-Connection Control and Hydraulic Research at the University of Southern California. Backflow preventers shall work on the reduced pressure principle. In a non-flow condition, the check valves in the bypass and mainline shall be closed. Flows from zero to approximately 5 gpm shall flow through the bypass. This operation at low flow rates shall be accomplished by designing the differential pressure drop across the bypass line to be slightly less than the mainline check valve. Any flow through the fireline shall be registered by the bypass meter. Flows in excess of approximately 5 gpm shall open the mainline check valves causing flow to occur through the mainline assembly and the bypass line. Preventers shall consist of 2 spring-loaded check valves, automatic differential pressure relief valve, drain valves, bypass double check valve, flow meter, and shut-off valves. The body material shall be bronze or cast iron for a working pressure of not less than 150 psi, with bronze or stainless steel trim. Drain lines with air gaps shall be provided. The backflow preventer valves shall be in accordance with AWWA C511 standard.

B. Manufacturers, or Equal

1. **Cla-Val Company**

2. **Febco (CMB Industries)**

3. **Hersey Products**

4. **Watts, ACV**

5. **Wilkins Regulator Division (Zurn Industries)**

2.5 CORPORATION STOPS

A. Unless otherwise indicated, corporation stops shall be made of solid brass for key operation, with screwed ends with corporation thread or iron pipe thread, as required.

B. Manufacturer, or Equal

1. **Ford Meter Box Company, Inc.**

2. **James Jones Company (Watts, ACV)**

3. **Mueller Company**

2.6 MUD VALVES

A. Mud valves shall be flanged, non-rising stem type, with threaded stem, seat ring, and gate ring of bronze. Valves shall be provided with coupling nut, extension stem, stem guides, and operating stand, and wheel or wrench nut as indicated. Mud valve shall be installed with valve seats level.

B. Manufacturers or Equal

1. **Clow**

2. **Mueller**

2.7 SEWAGE SURGE RELIEF VALVES

A. **Operating Requirements:** The valve shall open immediately when the system pressure exceeds the load setting, 50 psi, of the counterweights and shall close slowly at an adjustable speed upon return of system pressure to normal.

B. **Valve Body:** Sewage surge relief valves shall be constructed of a heavy cast-iron or cast-steel body with a welded steel disc having rubber seating face, a non-corrosive shaft for attachment of counterweight or spring-loaded arms and lever, and a complete non-corrosive cushion chamber.

C. **Cushion Chamber:** The cushion chamber shall be attached to the side of the valve body externally and be constructed with a piston operating in a chamber that will effectively permit the valve to be operated without any hammering action. The cushioning shall be by oil stored in an oil reservoir attached by piping and fittings to the cushion chamber. The cushion chamber shall be so arranged that the closing speed will be adjustable to meet the service requirements.

D. Manufacturers, or Equal

1. **APCO (Valve and Primer Corporation)**

2. **GA Industries**

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Backflow preventers shall be installed in potable water lines where required by applicable codes or regulations, wherever there is any danger of contamination, and where indicated.

B. Valves shall be installed in accordance with the manufacturer's printed recommendations, and with Section 43 25 00.

C. Backflow preventers, as well as air and vacuum release valves, shall have piped outlets to the nearest acceptable drain, firmly-supported, and installed in such a way as to avoid splashing and wetting of floors and obstruction of traffic.

- END OF SECTION -

SECTION 44 05 00 - EQUIPMENT GENERAL PROVISIONS

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide equipment and appurtenant WORK, complete and operable, in accordance with the Contract Documents.

B. The provisions of this Section shall apply to equipment throughout the Contract except where otherwise indicated.

C. **Equipment Arrangement:** Unless specifically indicated otherwise, the arrangement of equipment indicated is based upon information available at the time of design and is not intended to show exact dimensions particular to a specific manufacturer. Some aspects of the Drawings are diagrammatic and some features of the illustrated equipment arrangement may require revision to meet the actual equipment requirements. Structural supports, foundations, piping and valve connections, and electrical and instrumentation connections indicated may have to be altered to accommodate the equipment provided. No additional payment will be made for such revisions and alterations. Substantiating calculations and drawings shall be submitted prior to beginning the installation of equipment.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Equipment shall be in accordance with the following standards, as applicable and as indicated in each equipment specification:

1. American Society for Testing and Materials (ASTM).
2. American National Standards Institute (ANSI).
3. American Society of Mechanical Engineers (ASME).
4. American Water Works Association (AWWA).
5. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE).
6. American Welding Society (AWS).
7. National Fire Protection Association (NFPA).
8. Federal Specifications (FS).
9. National Electrical Manufacturers Association (NEMA).
10. Manufacturer's published recommendations and specifications.
11. General Industry Safety Orders (OSHA).

B. The following standards are referenced in this Section:

ASME B16.1	Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800
ASME B16.5	Pipe Flanges and Flanged Fittings, Steel, Nickel Alloy and other Special Alloys
ASME B46.1	Surface Texture
ANSI S12.6	Method for the Measurement of the Real-Ear Attenuation of Hearing Protectors
ASME B1.20.1	General Purpose Pipe Threads (Inch)
ASME B31.1	Power Piping
AWWA C206	Field Welding of Steel Water Pipe
AWWA C207	Steel Pipe Flanges for Waterworks Service - Sizes 4 In. Through 144 In. (100 mm through 3,600 mm)
AWWA D100	Welded Steel Tanks for Water Storage
ASTM A 48	Gray Iron Castings
ASTM A 108	Steel Bars, Carbon, Cold-Finished, Standard Quality

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 - Contractor Submittals.

B. **Shop Drawings:** Furnish complete drawings and technical information for equipment, piping, valves, and controls. Where indicated or required by the ENGINEER, Shop Drawings shall include clear, concise calculations showing equipment anchorage forces and the capacities of the anchorage elements proposed by the CONTRACTOR.

C. **Spare Parts List:** The CONTRACTOR shall obtain from the manufacturer and submit at the same time as Shop Drawings a list of suggested spare parts for each piece of equipment. CONTRACTOR shall also furnish the name, address, and telephone number of the nearest distributor for each piece of equipment.

1.4 QUALITY ASSURANCE

A. **Costs:** The CONTRACTOR shall perform and pay the costs of inspection, startup, testing, adjustment, and instruction services performed by factory representatives.

1. The CONTRACTOR shall be required to provide and pay for the cost of providing all temporary utilities, including electrical power and utility water, related to the startup, testing, and instruction services of equipment.

2. If electrical power or utility water is specified to be provided or derived from permanent OWNER's facilities, the OWNER shall be responsible to pay for the consumed electricity and utility water.

B. **Assistance by OWNER's Staff:** None of the OWNER's on-site staff will be available to provide operational assistance related to support facilities only, during field startup and testing of new equipment

C. **Inspection** The CONTRACTOR shall inform the local county and state authorities, such as building and plumbing inspectors, fire marshal, OSHA inspectors, and others, to witness required tests for piping, plumbing, fire protection systems, pressure vessels, safety systems, and related items to obtain required permits and certificates.

1. All fees required for such local and state permits and inspections shall be paid for by CONTRACTOR.

D. **Quality and Tolerances:** Tolerances and clearances shall be as shown on the approved Shop Drawings and shall meet the following criteria:

1. Machine WORK shall be of high-grade workmanship and finish, with proper consideration to the special nature or function of the parts. Members without milled ends and which are to be framed to other steel parts of the structure may have a variation in the detailed length of not greater than 1/16-inch for members 30-feet or less in length, and not greater than 1/8-inch for members over 30-feet in length.

2. Castings shall be homogeneous and free from non-metallic inclusions and defects. Surfaces of castings which are not machined shall be cleaned to remove foundry irregularities. Casting defects not exceeding 12.5 percent of the total thickness and where defects will not affect the strength and serviceability of the casting may be repaired by approved welding procedures. The ENGINEER shall be notified of larger defects. No repair welding of such defects shall be carried out without the ENGINEER'S written approval. If the removal of metal for repair reduces the stress resisting cross-section of the casting by more than 25 percent or to such an extent that the computed stress in the remaining metal exceeds the allowable stress by more than 25 percent, then the casting may be rejected. Costs of casting new material shall be the CONTRACTOR'S responsibility as part of the WORK.

3. Materials shall meet the physical and mechanical properties in accordance with the reference standards.

E. **Machine Finish:** The type of finish shall be the most suitable for the application and shall be shown in micro-inches in accordance with ANSI B46.1. The following finishes shall be used:

1. Surface roughness not greater than 63 micro-inches shall be required for surfaces in sliding contact.

2. Surface roughness not greater than 250 micro-inches shall be required for surfaces in contact where a tight joint is not required.

3. Rough finish not greater than 500 micro-inches shall be required for other machined surfaces.

4. Contact surfaces of shafts and stems which pass through stuffing boxes and contact surfaces of bearings shall be finished to not greater than 32 micro-inches.

F. **Manufacturer's Experience:** Equipment manufacturer shall have a record of at least 5 years of successful, trouble-free operation in similar applications and of size equal to or greater than the equipment required in this Contract. For any “or Equal” supplier or manufacturer submitted upon by the CONTRACTOR, the ENGINEER and OWNER shall maintain the right to require the CONTRACTOR to provide at least three (3) prior installation references (with contact names and phone numbers) who may be contacted by the ENGINEER for verification of acceptable performance.

PART 2 -- PRODUCTS

2.1 GENERAL REQUIREMENTS

A. **Noise Level:** When in operation, no single piece of equipment shall exceed the OSHA noise level requirement of 105 dBA for one hour exposure per day.

B. **Drive Trains and Service Factors:** Service factors shall be applied in the selection or design of mechanical power transmission components. Components of drive train assemblies between the prime mover and the driven equipment shall be designed and rated to deliver the maximum peak or starting torque, speed, and horsepower. All of the applicable service factors shall be considered, such as mechanical (type of prime mover), load class, start frequency, ventilation, ambient temperature, and fan factors. Drive train components include couplings, shafts, gears and gear drives, drive chains, sprockets, and V-belt drives. Unless otherwise indicated, the following load classifications shall apply in determining service factors:

Type of Equipment	Service Factor	Load Classification
Reciprocating Air Compressors multi-cylinder	2.0	Heavy Shock
Pumps Centrifugal or rotary	1.0	Uniform
Blowers: Centrifugal or vane	1.0	Uniform
Centrifugal Fans	1.0	Uniform

C. **Mechanical Service Factors**

	Mechanical Service Factors	
	Electric Motor	**Internal Combustion**

		Engine
Uniform	1.25	1.50
Moderate Shock	1.50	1.75
Heavy Shock	2.00	2.25

D. For thermal rating adjustments such as start frequency, ambient temperature, and hourly duty cycle factor, ventilation factor, and fan factor, refer to gear manufacturer sizing information.

E. **Electric Motor Service Factors**. Service factors of electric motors shall be a minimum of 1.15 unless noted otherwise in Section 26 05 10 - Electric Motors.

F. Where load classifications are not indicated, service factors shall be for standard load classifications and for flexible couplings.

G. **Welding:** Unless otherwise indicated, welding shall conform to the following:

1. Latest revision of AWWA D100.

2. Latest revision of AWWA C206.

3. Composite fabricated steel assemblies that are to be erected or installed inside a hydraulic structure, including any fixed or movable structural components of mechanical equipment, shall have continuous seal welds to prevent entrance of air or moisture.

4. Welding shall be by the metal-arc method or gas-shielded arc method as described in the American Welding Society's "Welding Handbook" as supplemented by other pertinent standards of the AWS. Qualification of welders shall be in accordance with the AWS Standards.

5. In assembly and during welding, the component parts shall be adequately clamped, supported, and restrained to minimize distortion and for control of dimensions. Weld reinforcement shall be as specified by the AWS code. Upon completion of welding, weld splatter, flux, slag, and burrs left by attachments shall be removed. Welds shall be repaired to produce a workmanlike appearance with uniform weld contours and dimensions. Sharp corners of material that are to be painted or coated shall be ground to a minimum of 1/32-inch on the flat.

H. **Protective Coating:** Equipment shall be painted or coated in accordance with Section 09 96 00 - Protective Coating, unless otherwise indicated. Non-ferrous metal and corrosion-resisting, rotating or moving steel surfaces shall be coated with grease or lubricating oil. Coated surfaces shall be protected from abrasion or other damage during handling, testing, storing, assembly, and shipping.

I. **Fisheries Process water contact**: Materials immersed in or exposed to fisheries process water shall be listed as compliant with NSF Standard 61.

J. **Protection of Equipment:** Equipment shall be boxed, crated, or otherwise protected from damage and moisture during shipment, handling, and storage. Equipment shall be protected from exposure to corrosive fumes and shall be kept thoroughly dry. Pumps, motors, drives, electrical equipment, and other equipment having anti-friction or sleeve bearings shall be stored in weather-tight storage facilities prior to installation. For extended storage periods, plastic equipment wrappers should be avoided to prevent accumulation of condensate in gears and bearings. In addition, motor space heaters shall be energized and shafts shall be rotated. Equipment delivered to the Site with rust or corroded parts shall be rejected. If equipment develops defects during storage, it shall be disassembled, cleaned, and recoated to restore it to original condition.

K. **Identification of Equipment Items**

1. At the time of shipping, each item of equipment shall have a legible identifying mark corresponding to the equipment number in the Contract Documents for the particular item.

2. After installation, each item of equipment shall be given permanent identification.

    a. Pumps, compressors, and blowers of 100 horsepower or less shall receive acrylic plastic nametags in accordance with Section 10 14 00 - Signage.

L. **Vibration Isolators:** Air compressors, blowers, inline fans shall be provided with restrained spring-type vibration isolators or pads per manufacturer's written recommendations. Vibration isolations shall be provided with seismic restraint.

M. **Shop Fabrication:** Shop fabrication shall be performed in accordance with the Contract Documents and the Shop Drawings.

N. **Controls:** Equipment and system controls shall be in accordance with Divisions 26 and 27.

2.2 EQUIPMENT SUPPORTS AND FOUNDATIONS

A. **Equipment Supports.** Unless otherwise indicated, equipment supports, anchors, and restrainers shall be adequately designed by the Supplier for worst case static, dynamic, wind, and seismic loads. The design horizontal seismic forces shall be the greater of: that noted in the general structural notes (see Contract Drawing GS-1) or as required by the governing building code, or 10 percent of gravity. Submitted design calculations for equipment supports shall bear the signature and seal of an engineer registered in the State wherein the project is to be built, unless otherwise indicated.

Calculations shall account for forces and distribution of forces on supporting structures resulting from normal operation, normal operation plus seismic loadings, and normal operation plus wind loadings.

1. Wall-mounted equipment weighing more than 250 pounds or which is within 18-inches above the floor shall be provided with fabricated steel supports. Pedestals shall be of welded steel. If the supported equipment is a panel or cabinet or is enclosed with removable sides, the pedestal shall match the supported equipment in appearance and dimensions.

2. Seismic requirements: Freestanding and wall-hung equipment shall be anchored in place by methods that satisfy the building code. Calculations shall be performed and signed and stamped for equipment weighing more that 400 pounds. Calculations shall analyze lateral and overturning forces and shall include a factor of safety against overturning equal to 1.5. Calculations shall include the distribution of forces imposed on the supporting structure and anchors, verifying that each anchor can develop the required resistance forces.

3. Wind requirements: Exterior freestanding equipment shall be anchored in place by methods that satisfy the building code. Calculations shall be performed and signed and stamped, analyzing lateral and overturning forces and shall include a minimum factor of safety against overturning equal to 1.5. Calculations shall include the distribution of forces imposed on the supporting structure and anchors, verifying that each anchor can develop the required resistance forces.

B. **Equipment Foundations.**

1. Mechanical equipment, tanks, control cabinets, enclosures, and related equipment shall be mounted on minimum 4-inch high concrete equipment bases, unless otherwise indicated, and shall extend at least 4-inches further horizontally than the extent of the equipment frame or skid.

2. Estimates of the required equipment foundations are indicated on the Contract Drawings. The CONTRACTOR through the equipment manufacturer shall verify the size and weight of equipment foundations to insure compatibility with equipment.

C. **Anchors.** Anchor bolts shall be in accordance with Section 05 50 00 - Miscellaneous Metalwork. CONTRACTOR shall determine the size, type, capacity, location, and other placement requirements of anchorage elements. Anchoring methods and leveling criteria in the manufacturer's literature shall be followed. Submit anchor bolt criteria, sizes, and installation methods with the Shop Drawings.

2.3 COUPLINGS

A. Mechanical couplings shall be provided between the driver and the driven equipment. Flexible couplings shall be provided between the driver and the driven equipment to accommodate slight angular misalignment, parallel misalignment, end float, and to cushion shock loads. Unless otherwise indicated or recommended by the equipment manufacturer, coupling type shall be furnished with the respective equipment as follows:

Equipment Type	Coupling Type
Horizontal and end suction pumps	Flexible rubber
Vertical turbine pumps	3 piece spacer for solid shaft or double nut for hollow shaft
Single stage centrifugal blowers	Flexible disc pack
Air compressors	Gear or flexible disc pack

B. Each coupling size shall be determined based on the rated horsepower of the motor, speed of the shaft, and the load classification service factor. The CONTRACTOR shall have the equipment manufacturer select or recommend the size and type of coupling required to suit each specific application.

C. **Differential Settlement:** Where differential settlement between the driver and the driven equipment may occur, 2 sets of universal type couplings shall be provided.

D. **Taper-Lock** or equal bushings may be used to provide for easy installation and removal of shafts of various diameters.

2.4 SHAFTING

A. **General:** Shafting shall be continuous between bearings and shall be sized to transmit the power required. Keyways shall be accurately cut in line. Shafting shall not be turned down at the ends to accommodate bearings or sprockets whose bore is less than the diameter of the shaft. Shafts shall rotate in the end bearings and shall be turned and polished, straight, and true.

B. **Design Criteria**: Shafts shall be designed to carry the steady state and transient loads suitable for unlimited number of load applications, in accordance with ASME B106.1M - Design of Transmission Shafting. Where shafts are subjected to fatigue stresses, such as frequent start and stop cycles, the mean stress shall be determined by using the modified Goodman Diagram. The maximum torsional stress shall not exceed the endurance limit of the shaft after application of the factor of safety of 2 in the endurance limit and the stress concentration factor of the fillets in the shaft and keyway. Stress concentration factor shall be in accordance with ASME Standard B17.1 - Keys and Keyseats.

C. **Materials:** Shafting materials shall be appropriate for the type of service and torque transmitted. Environmental elements such as corrosive gases, moisture, and fluids shall be taken into consideration. Materials shall be as indicated unless furnished as part of an equipment assembly.

1. Low carbon cold-rolled steel shafting shall conform to ASTM A 108, Grade 1018.

2. Medium carbon cold-rolled shafting shall conform to ASTM A 108, Grade 1045.

3. Other grades of carbon steel alloys shall be suitable for service and load.

4. Corrosion-resistant shafting shall be stainless steel or Monel, whichever is most suitable for the intended service.

D. **Differential Settlement:** Where differential settlement between the driver and the driven equipment may occur, a shaft of sufficient length with 2 sets of universal type couplings shall be provided.

2.5 V-BELT DRIVES

A. V-belts and sheaves shall be of the best commercial grade and shall conform to ASME, MPTA, and RMA Standards.

B. Unless otherwise indicated, sheaves shall be machined from the finest quality gray cast iron.

C. Sheaves shall be statically balanced. In some applications where vibration is a problem, sheaves shall be dynamically balanced. Sheaves operating at belt speeds exceeding 6,500 fpm may be required to be of special materials and construction.

D. To facilitate installation and disassembly, sheaves shall be provided complete with **Taper-Lock** or **QD** bushings as required.

E. Finish bored sheaves shall be complete with keyseat and set screws.

F. Sliding motor bases shall be provided to adjust the tension of V-belts.

2.6 DRIVE GUARDS

A. Power transmission trains, prime movers, machines, shaft extensions, and moving machine parts shall be guarded to conform with the OSHA Safety and Health Standards (29CFR1910). The guards shall be constructed of minimum 10-gauge expanded, flattened steel with smooth edges and corners, galvanized after fabrication, and securely fastened. Where required for lubrication or maintenance, guards shall have hinged and latched access doors.

2.7 BEARINGS

A. Bearings shall conform to the standards of the American Bearing Manufacturers Association, Inc. (ABMA).

B. To assure satisfactory bearing application, fitting practice, mounting, lubrication, sealing, static rating, housing strength, and lubrication shall be considered in bearing selection.

C. **Bearing Lubrication**.

1. Re-lubricatable type bearings shall be equipped with a hydraulic grease fitting in an accessible location and shall have sufficient grease capacity in the bearing chamber.

2. Lubricated-for-life bearings shall be factory-lubricated with the manufacturer's recommended grease to insure maximum bearing life and best performance

D. **Anti-Friction Type Bearing Life:** Except where otherwise indicated, bearings shall have a minimum L-10 life expectancy of 5 years or 20,000 hours, whichever occurs first. Where so indicated, bearings shall have a minimum rated L-10 life expectancy corresponding to the type of service, as follows:

Type of Service	Design Life, years	L-10 Design Life, hours
	(whichever comes first)	
8-hour shift	10	20,000
16-hour shift	10	40,000
Continuous	10	60,000

E. **Bearing Housings**. Bearing housings shall be of cast iron or steel and bearing mounting arrangement shall be as indicated or as recommended in the published standards of the manufacturer. Split-type housings may be used to facilitate installation, inspection, and disassembly.

F. **Sleeve Type Bearings**: Sleeve-type bearings shall have a cast iron or ductile iron housing and Babbitt or bronze liner. Bearing housing shall be bolted and doweled to the lower casing half. These housings shall be provided with cast iron caps bolted in place and the bearing end caps shall be bored to receive the bearing shells. Sleeve bearings shall be designed on the basis of the maximum allowable load permitted by the bearing manufacturer. If the sleeve bearing is connected to an equipment shaft with a coupling, the coupling transmitted thrust will be assumed to be the maximum motor or equipment thrust. Lubricant, lubrication system, and cooling system shall be as recommended by the bearing manufacturer.

G. **Plate Thrust Bearings**: Thrust bearings shall be the **Kingsbury** Type, designed and manufactured to maintain the shaft in the fixed axial position without undue heating or the necessity of adjustment or attention. Bearings shall be oil lubricated to suit the manufacturer's standard method of lubrication for the specific bearing. If bearing cooling is required, manufacturer shall provide necessary piping, filters, and valves.

2.8 PIPING CONNECTIONS

A. **Pipe Hangers, Supports, and Guides:** Pipe connections to equipment shall be supported, anchored, and guided to avoid stresses and loads on equipment flanges and equipment. Supports and hangers shall be in accordance with Section 40 23 02 - Pipe Supports.

B. **Flanges and Pipe Threads:** Flanges on equipment and appurtenances shall conform to ASME B16.1, Class 125, or B16.5, Class 150, unless otherwise indicated. Pipe threads shall be in accordance with ASME B1.20.1 and Section 40 23 00 - Piping, General.

C. **Insulating Connections:** Insulating bushings, unions, couplings, or flanges, as appropriate, shall be used in accordance with the requirements of the Section 40 23 00.

2.9 GASKETS AND PACKINGS

A. Gaskets shall be in accordance with Section 40 23 00 – Piping, General.

B. Packing around valve stems and reciprocating shafts shall be of compressible material, compatible with the fluid being used. Chevron-type "V" packing shall be **Garlock No. 432, John Crane Everseal,** or equal.

C. Packing around rotating shafts (other than valve stems) shall be "O" rings, stuffing boxes, or mechanical seals, as recommended by the manufacturer and approved by the ENGINEER, in accordance with Section 44 35 00 - Pumps, General.

2.10 EQUIPMENT LUBRICANTS

A. The CONTRACTOR shall provide lubricants for equipment during shipping, storage, and prior to testing, in accordance with the manufacturer's recommendations. Lubricants that could come in contact with potable water shall be food grade lubricants. After successful initial testing, final testing, and satisfactory completion startup testing, the CONTRACTOR shall conduct one complete lubricant change on all equipment. In addition, the CONTRACTOR shall be responsible for the proper disposal of used lubricants. The OWNER will then be responsible for subsequent lubricant changes.

2.11 NAMEPLATES

A. Equipment nameplates of stainless steel shall be engraved or stamped and fastened to the equipment in an accessible location with No. 4 or larger oval head stainless steel screws or drive pins. Nameplates shall contain the manufacturer's name, model, serial number, size, characteristics, and appropriate data describing the machine performance ratings.

2.12 TOOLS AND SPARE PARTS

A. **Tools:** The CONTRACTOR shall furnish one complete set of special wrenches and other special tools necessary for the assembly, adjustment, and dismantling of the equipment. Tools shall be of best quality hardened steel forgings with bright finish. Wrench heads shall have work faces dressed to fit nuts. Tools shall be suitable for professional work and manufactured by **Snap On, Crescent, Stanley,** or equal. The set of tools shall be neatly mounted in a labeled toolbox of suitable design provided with a hinged cover.

B. **Spare Parts**: Spare parts shall be furnished as indicated in the individual equipment sections. Spare parts shall be suitably packaged in a metal box and labeled with equipment numbers by means of stainless steel or solid plastic nametags attached to the box.

PART 3 -- EXECUTION

3.1 SERVICES OF MANUFACTURER

A. **Inspection, Startup, and Field Adjustment**: Where required by individual sections, an authorized, experienced, and competent service representative of the manufacturer shall visit the Site for the number of Days indicated in those sections to witness or perform the following and to certify in writing that the equipment and controls have been properly installed, aligned, lubricated, adjusted, and readied for operation.

1. Installation of equipment

2. Inspection, checking, and adjusting the equipment and approving its installation

3. Startup and field testing for proper operation, efficiency, and capacity

4. Performing field adjustments during the test period to ensure that the equipment installation and operation comply with requirements

B. **Instruction of the OWNER'S Personnel**

1. Where required by the individual equipment sections, an authorized training representative of the manufacturer shall visit the Site for the number of Days indicated in those sections to instruct the OWNER'S personnel in the operation and maintenance of the equipment, including step-by-step troubleshooting with necessary test equipment. Instruction shall be specific to the models of equipment provided.

2. The representative shall have at least 2 years experience in training. A resume of the representative shall be submitted.

3. Training shall be scheduled 3 weeks in advance of the scheduled session.

4. Proposed training material and a detailed outline of each lesson shall be submitted for review. Review comments from the ENGINEER shall be incorporated into the material.

5. The training materials shall remain with the trainees after the session.

6. The OWNER may videotape the training for later use by the OWNER'S personnel.

3.2 INSTALLATION

A. **General:** Equipment shall be installed in accordance with the manufacturer's written recommendations.

B. **Alignment**: Equipment shall be field tested to verify proper alignment.

3.3 PACKAGED EQUIPMENT

A. When any system is furnished as pre-packaged equipment, the CONTRACTOR shall coordinate space and structural requirements, clearances, utility connections, signals, and outputs with Subcontractors to avoid later change orders.

B. If the packaged system has any additional features (as safety interlocks, etc.) other than required by the Contract Documents, the CONTRACTOR shall coordinate such features with the ENGINEER and provide material and labor necessary for a complete installation as required by the manufacturer.

3.4 FIELD ASSEMBLY

A. Studs, cap screws, bolt and nuts used in field assembly shall be coated with **Never Seize** compound or equal.

3.5 WELDING

A. Welds shall be cleaned of weld-slag, splatter, etc. to provide a smooth surface.

3.6 FIELD TESTS

A. Where indicated by the individual equipment sections, equipment shall be field tested after installation to demonstrate satisfactory operation without excessive noise, vibration, or overheating of bearings or motor.

B. The following field testing shall be conducted:

1. Start equipment, check, and operate the equipment over its entire operating range. Vibration level shall be within the amplitude limits as indicated or as recommended by the reference applicable standards.

2. Obtain concurrent readings of motor voltage, amperage, capacity, vibration, and bearing temperatures.

C. The ENGINEER shall witness field-testing. The CONTRACTOR shall notify the ENGINEER or OWNER of the test schedule no less than 3 Days in advance.

D. In the event that any equipment fails to meet the test requirements, the equipment shall be modified and retested until it satisfies the requirement.

- END OF SECTION -

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SECTION 44 35 00 – WATER PUMPS, GENERAL

PART 1 -- GENERAL

1.1 SUMMARY

A. Provide pumps and pumping appurtenances, complete and operable, as indicated in accordance with the Contract Documents.

B. The provisions of this Section shall apply to pumps and pumping equipment throughout the Contract Documents, except where otherwise indicated.

C. The requirements of Section 41 00 00 – Equipment General Provisions, apply to this Section.

D. Unit Responsibility

1. The pump manufacturer shall be made responsible for furnishing the WORK and for the coordination of design, assembly, testing, and installation of the WORK of each specific pump Section.

2. The CONTRACTOR shall be responsible to the OWNER for compliance with the requirements of each specific pump Section.

E. Single Manufacturer

1. Where 2 or more pump systems of the same type or size are required, provide pumps produced by the same manufacturer.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.

B. Shop Drawings

1. Submit pump name, identification number, and specification Section number.

2. Performance Information

a. Submit performance data curves showing head, capacity, horsepower demand, NPSH required, and pump efficiency over the entire operating range of the pump.

b. Require the equipment manufacturer to indicate separately the head, capacity, horsepower demand, overall efficiency, and minimum submergence required at the design flow conditions and the maximum and minimum flow conditions.

c. Submit performance curves at intervals of 100 RPM from minimum speed to maximum speed for each centrifugal pump equipped with a variable speed drive.

3. Operating Range

    a. Require the manufacturer to indicate the limits on the performance curves recommended for stable operation without surge, cavitation, or excessive vibration.

    b. Provide a stable operating range as wide as possible, based on actual hydraulic and mechanical tests.

4. Submit assembly and installation drawings including shaft size, seal, coupling, bearings, anchor bolt plan, part nomenclature, material list, outline dimensions, and shipping weights.

5. Submit data, in accordance with the requirements of Section 26 05 10 – Electric Motors, for the electric motor proposed for each pump.

6. Submit an elevation of the proposed local control panel, showing panel-mounted devices, details of enclosure type, a single-line diagram of power distribution, current draw of the panel, and a list of all terminals required to receive inputs or to transmit outputs from the local control panel.

7. Submit a wiring diagram of field connections, with identification of terminations between local control panels, junction terminal boxes, and equipment items.

8. Submit a complete electrical schematic diagram.

C. Technical Manual

1. Submit a Technical Manual containing the required information indicated in Section 01 33 00 – Contractor Submittals and each specific pump Section.

D. Spare Parts List

1. Submit a spare parts list containing the required information indicated in Section 01 33 00 – Contractor Submittals and each specific pump Section.

E. Factory Test Data

1. Submit signed, dated, and certified factory test data for each pump system which requires factory testing.

2. Submit these data before shipment of equipment.

F. Certifications

1. Submit the manufacturer's certification of proper installation.

2. Submit the CONTRACTOR's certification of satisfactory field testing.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Compliance with the requirements of the specific pump Sections may necessitate modifications to the manufacturer's standard equipment.

B. Performance Curves

1. Provide centrifugal pumps with a continuously rising curve or with the system operating range not crossing the pump curve at 2 different capacities or “dip region.”

2. Unless otherwise indicated, the required shaft horsepower for the entire pump assembly at any point on the performance curve shall not exceed the rated horsepower of the motor or engine or encroach on the service factor.

C. Compatibility

1. Provide entirely compatible components of each pump system provided under the specific pump Section.

2. In each unit of pumping equipment, incorporate basic mechanisms, couplings, electric motors or engine drives, variable speed controls, necessary mountings, and appurtenances.

2.2 MATERIALS

A. Provide materials suitable for the intended application.

B. For materials not indicated, provide high-grade, standard commercial quality, free from defects and imperfections that might affect the serviceability of the product for the purpose for which it is intended, and conforming to the following requirements:

1. Provide cast iron pump casings and bowls constructed of close-grained gray cast iron, conforming to ASTM A 48 - Gray Iron Castings, Class 30, or equal.

2. Provide bronze pump impellers conforming to ASTM B 62 - Composition Bronze or Ounce Metal Castings, or B 584 - Copper Alloy Sand Castings for General Applications, where dezincification does not occur.

3. Provide pump shafts constructed of Type 416 or 316 stainless steel.

4. Miscellaneous stainless steel parts shall be of Type 316.

5. Provide anchor bolts, washers, and nuts in standard service (non-corrosive application) of galvanized steel in accordance with the requirements of Section 05 50 00 – Metal Fabrication & Miscellaneous Metals.

6. Provide anchor bolts, washers, and nuts in corrosive service as defined in Section 05 50 00 – Metal Fabrication & Miscellaneous Metals of stainless steel in

accordance with Section 05 50 00 – Metal Fabrication & Miscellaneous Metals Materials in contact with potable water shall be listed as compliant with NSF Standard 61.

2.3 PUMP COMPONENTS - GENERAL

A. Flanges and Bolts

B. Provide suction and discharge flanges conforming to ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800 or ASME B16.5 - Pipe Flanges and Flanged Fittings dimensions.

C. Provide bolts shall be in accordance with the requirements of Section 05 50 00 – Metal Fabrication & Miscellaneous Metals.

D. Lubrication

1. Vertical pump shafts of clean water pumps shall be product water-lubricated, unless otherwise indicated.

2. Provide deep-well pumps and pumps with dry barrels with water- or oil-lubricated bearings and seals, and enclosed line shafts.

3. Pumps for sewage, sludge, and other process fluids shall be lubricated as indicated.

E. Hand holes

1. Provide hand holes on pump casings shaped to follow the contours of the casing in order to avoid any obstructions in the water passage.

F. Drains

1. Pipe gland seals, air valves, cooling water drains, and drains from variable speed drive equipment to the nearest floor sink or drain, using galvanized steel pipe or copper tube that is properly supported with brackets.

G. Grease Lubrication

1. For vertical propeller, mixed-flow, and turbine pumps, other than deep well pumps, of bowl sizes 10-inch and larger, provide a stainless steel tube attached to the column for grease lubrication of the bottom bearing.

H. Stuffing Boxes

1. Where stuffing boxes are indicated for the pump seal, provide stuffing boxes of the best quality, using the manufacturer's suggested materials best suited for the specific application.

2. For sewage, sludge, drainage, and liquids containing sediments, provide fresh-water-flushed seals, using lantern rings.

3. If fresh water is not available, the seal shall be flushed with product water cleaned by a solids separator as manufactured by **John Crane Co., Lakos (Claude Laval Corp.),** or equal.

4. Conventional Packing Gland Type Seal

   a. Unless otherwise indicated, provide packing material of Teflon braiding, containing 50 percent ultrafine graphite impregnation in order to satisfy the requirements listed in the table below.

   b. Acceptable ring materials are asbestos-free die-molded packing rings of braided graphite material free of PTFE, **Chesterton 1400R** or equal, for non-potable water service, and braided PTFE material, **Chesterton 1725** or equal, that is listed under NSF Standard 61 for potable water service.

   c. Seal Requirements

Shaft speeds	up to 2500 fpm
Temperature	up to 500 deg F
pH range	0 - 14

5. Mechanical Seals (Conventional Non-Split-Type)

   a. Provide mechanical seals of the fresh water-flushed-type, unless otherwise indicated in which case use product water cleaned by a solids separator as indicated above.

   b. Provide mechanical seals as manufactured by the following, or equal:

Sewage, Sludge, or Wastewater Pumps	Double seals	**John Crane Type 5620P, Flowserve Type ISCPP, Chesterton Type GDS** or **255**
Abrasives, Grit, or Lime Slurry Pumps	Double seals	**John Crane Type 5620P** (hard faces)**, Flowserve Type ISCPP** or **SLC** (check with pump manufacturer)**, Chesterton Type GDS** or **255**
Chemicals or Corrosive Liquid Pumps	Single seals	**John Crane Type 8-1** or **9, Flowserve Type ISCPX,** or **Chesterton Type UV, GSS,** or **155**
Water Pumps (hot and cold)	Single seals	**John Crane Type 5610Q, Flowserve Type ISCPX, Chesterton Type UV, GSS,** or

		155

6. Where indicated, circulate a buffer fluid at a minimum 20 psi above discharge pressure, or as required by the manufacturer, in order to maintain reliable seal performance.

7. Equip mechanical seals with nonclogging, flexible–mounted seats with elastomer secondary seals.

8. Provide wetted metal parts constructed of Type 316 stainless steel, Alloy 20, or Hastelloy B or C, whichever has the best corrosion resistance to the pumped fluid.

9. Provide double-balanced dual cartridge seals in order to allow for seal integrity in case of flush water pressure reversal.

10. Provide springs in single and double seals, in the non-wetted end of the seal.

11. Deliver fresh water to the seals through appropriate size piping with plug valves, strainers, pressure regulators, electrically operated solenoid valves, and rotameters.

12. Wiring shall comply with the requirements of Division 26 – Electrical, and solenoid control shall comply with the requirements of Division 25 – Integrated Automation.

2.4 PUMP APPURTENANCES

A. Nameplates

1. Equip each pump with a stainless steel nameplate indicating serial number(s), rated head and flow, impeller size, pump speed, and manufacturer's name and model number.

B. Solenoid Valves

1. Require the pump manufacturer to provide solenoid valves on the water or oil lubrication lines and on cooling water lines.

2. Provide solenoid valve electrical ratings compatible with the motor control voltage.

C. Gauges

1. Except for sample pumps, sump pumps, and hot water circulating pumps, equip pumps with pressure gauges installed at the pump discharge lines.

2. Provide pump suction lines with compound gauges.

3. Located gauges in a representative location, where not subject to shock or vibrations, in order to achieve true and accurate readings.

4. Where subject to shock or vibrations, wall-mount the gauges or attach the gauges to galvanized channel floor stands and connect by means of flexible connectors.

5. Provide pressure and compound gauges on each blower system

2.5 FACTORY TESTING

A. Conduct the following tests on each indicated pump system:

1. Motors

a. Test electric motors in accordance with the requirements of Section 26 05 10 – Electric Motors.

b. Furnish test results to the pump manufacturer prior to the pump test.

2. Variable Frequency Drives

a. Test variable frequency drives in accordance with the requirements of

b. Furnish test results to the pump manufacturer prior to the pump test.

3. Factory Non-witnessed Test

a. Test centrifugal pump systems with drives 10 hp up to and including 125 hp at the pump factory in accordance with the American National Standard for Centrifugal Pump Tests (ANSI/HI 1.6) acceptance Level "1U" or the American National Standard for Vertical Pump Tests (ANSI/HI 2.6) as approved by ANSI and published by the Hydraulic Institute.

b. For sump pumps and sample pumps, acceptance shall be in accordance with Level "2" of ANSI/HI 1.6, unless otherwise indicated.

c. Perform tests using the complete pump system to be furnished, including the Project motor and variable speed drive if equipped with variable speed drive.

d. For pumps with motors smaller than 100 hp, the manufacturer's certified test motor will be accepted.

e. Testing of prototype models will not be accepted.

f. Conduct the following minimum tests and submit the test results:

1) hydrostatic test;

2) Performance Test:

a) Conduct performance testing at maximum speed, obtain a minimum of 5 hydraulic test readings between shutoff head and 25 percent beyond the maximum indicated capacity, and record on data sheets as defined by the Hydraulic Institute standards;

b) For variable speed driven pumps, test each pump between maximum and minimum speed at 100-RPM increments;

c) Submit pump curves showing head, flow, bhp, and efficiency results;

3) Mechanical test;

4) NPSH

a) Perform a net positive suction head required test (NPSHr3), if required by the specific pump Section.

b) If not required by the specific pump Section, submit the published manufacturer-calculated NPSHr3 curve.

g. Submit certification signed by a senior official of the pump manufacturer that the pump shaft horsepower demand did not exceed the rated motor horsepower of 1.0 service rating at any point on the curve.

h. Submit test results to the ENGINEER for review prior to delivery to the Site.

4. Factory Witnessed Tests

a. Factory-test pumps, variable speed drives, and motors, 150 hp and larger, as complete assembled systems in accordance with the indicated factory test procedure and witnessed above by the OWNER and ENGINEER.

b. Give the ENGINEER a minimum of 2 weeks notification prior to the test.

c. Costs for OWNER and ENGINEER shall be borne by the CONTRACTOR and shall be included in the Contract Price, including travel and subsistence costs for 2 people excluding salaries.

d. Submit test results to the ENGINEER.

e. No equipment shall be shipped until the test data have been approved by the ENGINEER.

5. Acceptance

a. In the event of failure of any pump to meet any of the requirements, make necessary modifications, repairs, or replacements in order to conform to the requirements of the Contract Documents, and re-test the pump until found satisfactory.

PART 3 -- EXECUTION

3.1 MANUFACTURER'S SERVICES

A. Inspection, Startup, and Field Adjustment

1. Where required by the specific pump Section, furnish an authorized service representative of the manufacturer at the Site continuously to supervise the following items and to certify in writing that the equipment and controls have been properly installed, aligned, lubricated, adjusted, and readied for operation:

a. Installation of the equipment;

b. Inspection, checking, and adjusting the equipment;

c. Startup and field testing for proper operation; and

d. Performance of field adjustments to ensure that the equipment installation and operation comply with the indicated requirements.

B. Instruction of OWNER's Personnel

1. Where required by the individual pump Section, furnish an authorized training representative of the manufacturer at the Site for the number of Days indicated in the specific pump Section, to instruct the OWNER's personnel in the operation and maintenance of the equipment, including step-by-step troubleshooting with necessary test equipment.

2. Furnish instruction specific to the model of equipment provided.

3. Qualifications

a. Furnish a representative with at least 2 years' experience in training.

b. Submit a resume for the representative.

4. Schedule the training a minimum of 3 weeks in advance of the first session.

5. Lesson Plan Review

a. Submit the proposed training material and a detailed outline of each lesson for review.

b. Incorporate review comments into the material.

6. The trainees will keep the training materials.

7. The OWNER may videotape the training for later use with the OWNER's personnel.

3.2 INSTALLATION

A. General

1. Install pumping equipment in accordance with the manufacturer's written recommendations.

B. Alignment

1. Field-test the equipment in order to verify proper alignment and freedom from binding, scraping, shaft runout, or other defects.

2. Measure the pump drive shafts just prior to assembly in order to ensure correct alignment without forcing.

3. Ensure that the equipment is secure in position and neat in appearance.

C. Lubricants

1. Provide the necessary oil and grease for initial operation.

3.3 PROTECTIVE COATING

A. Coat materials and equipment in accordance with the requirements of Section 09 96 00 – Protective Coating.

3.4 FIELD TESTS

A. Field-test each pump system after installation in order to demonstrate:

1. Satisfactory operation without excessive noise and vibration;

2. No material loss caused by cavitation;

3. No overheating of bearings; and,

4. Indicated head, flow, and efficiency at the design point.

B. Conduct the following field testing:

1. Startup, check, and operate the pump system over its entire speed range.

2. If the pump is driven by a variable speed drive, test the pump and motor at 100-RPM increments.

3. If the pump is driven at constant speed, test the pump and motor at the maximum RPM.

4. Unless otherwise indicated, vibration shall be within the amplitude limits recommended by the Hydraulic Institute standards at a minimum of 4 pumping conditions defined by the ENGINEER.

5. Obtain concurrent readings of motor voltage, amperage, pump suction head, and pump discharge head for at least 4 pumping conditions at each pump rotational speed, at 100-RPM increments if equipped with a variable speed drive or at maximum RPM if equipped with a constant speed drive.

6. Check each power lead to the motor for proper current balance.

7. Bearing Temperatures

a. Determine bearing temperatures by a contact-type thermometer.

b. Precede this test with a run time sufficient to stabilize bearing temperatures, unless an insufficient liquid volume is available to furnish such a run time.

8. Ensure that electrical and instrumentation tests conform to the requirements of the Section under which that equipment is specified.

C. Witnessing

1. Field testing will be witnessed by the ENGINEER.

2. Furnish 3 Days advance notice of field testing.

D. If the pumping system fails to meet the indicated requirements, modify or replace the pump and re-test as indicated above until it satisfies the indicated requirements.

E. Certification

1. After each pumping system has satisfied the requirements, certify in writing that it has been satisfactorily tested and that final adjustments have been performed.

2. Certification shall include the date of the field tests, a listing of persons present during the tests, and the test data.

F. The CONTRACTOR shall be responsible for costs of field tests, including related services of the manufacturer's representative, except for power and water, which the OWNER will bear.

G. If available, the OWNER'S operating personnel will provide assistance in field testing.

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SECTION 44 35 04 - PACKAGED BOOSTER PUMP SYSTEM

PART 1 -- GENERAL

1.1 DESCRIPTION OF WORK

A. Work includes furnishing all labor, material, and equipment required to supply, install, and test process water handling pumps, drive units, controls, and appurtenances to pumping equipment as specified herein and required to make the units complete and fully operable.

1.2 SUBMITTALS

A. Submit product data and shop drawings in accordance with SECTION 01 33 00 and operating and maintenance instructions

B. Submit manufacturer's product data on pump and driver. Submittals shall include the following features:
1. Manufacturer's specifications data and descriptive literature.
2. Factory certified performance curves showing capacity in gpm, NPSH, head, efficiency and pump horsepower from 0 gpm to 110% of design capacity.
3. Motor efficiency and power factor at all design operating points.
4. Drawings showing general dimension, confirming the size of the pump, openings, connections, construction details of the equipment, wiring diagrams, piping drawings, and weights of major components.
5. Procedures for proper installation.
6. Manufacturer's guarantee.
7. Information about the nature and location of parts, service crews, and repair facilities.

1.3 OPERATION AND MAINTENANCE DATA

A. Operating and adjustment instructions.

B. Parts lists.

C. Disassembly, repair, and assembly instruction including drawings.

D. Maintenance procedures and recommended maintenance intervals.

PART 2 -- PRODUCTS

2.1 UTILITY WATER PUMP

A. The utility water pump shall be a packaged booster pump system consisting of a pump, hydropneumatic tank and controls to automatically start and stop the pump.

B. System operation: Upon water demand, water will flow from the pressure tank to the system. This will cause the pressure to drop as sensed by a pressure switch. Upon drop in pressure, the pump will start and run continuously until the water in the volute of the pump heats up (indicating a dead head condition) and trips a temperature switch.

C. System components shall include: Pressure tank, pressure and temperature switch, suction check valve, pressure and temperature relief valve, completely wired motor control and a steel base.

D. Pump shall be a bronze fitted, end suction centrifugal pump, with mechanical. Pump volute shall be constructed of cast iron and shall be fitted with bronze wear rings.

E. Pump shall be Paco model 848A or Tiger Flow System Bengal Duplex Vertical Booster System..

F. Pump Schedule

Equipment No.	Location	Design Flow	TDM	Hp
PB-201	Water Treatment Room	100	130	5

G. Performance and Configuration Requirements
  a. Design Condition: 100 gpm @ 130 TDM with minimum pump efficiency of 70 percent.
  b. Secondary Design Condition: 150 gpm @ 100 TDM with minimum pump efficiency of 70 percent.
  c. Shut Off Condition: 0 gpm @ 175 TDM.

2.2 SUMP PUMPS

A. Pump Design and Construction
  1. Pump shall be designed for pumping effluent water.
  2. Pump Construction
    a. The impeller, casing, bearing/seal housing and motor cover shall be of ASTM A48 Class 30 high quality cast iron.
  3. Cooling System
    a. Motors must be sufficiently cooled by the surrounding environment or pumped media. A water jacket may be required. Temperature of surrounding water is 90°F-100°F.
  4. Motor
    a. The integral motor shall be completely sealed from the environment. The motor shall be rated for continuous duty under full nameplate load while at full submergence. Motor bearing shall be designed for a B-10 life of 30,000 hours minimum. The motor shall be designed and tested to withstand an 18 day locked-rotor operation without damage.
  5. Power Cable
    a. The power cable shall be sealed at the motor end as it enters the motor casing.
  6. Impeller
    a. The impeller shall be semi-open with ejector vanes on the top of the. The impeller shall be threaded to the solid stainless steel shaft and secured by a thread-locking nut which will

prevent the impeller from loosening during short periods of reverse rotation might occur.

7. Casing
   a. The casing shall be cast from ASTM A48 class 30 gray cast iron of sufficient thickness to withstand 1.5 times the shut off pressure. Integral feet of cast iron shall be made a part of the casing for accurately positioning the pump suction opening at the correct elevation off the sump floor.
8. Corrosion Protection
   a. The pump/motor shaft wetted-end shall be stainless steel. Both inner and outer surfaces of cast iron shall be electrocoat-painted with thermo-setting Acrylic Enamel.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. All equipment shall be installed in accordance with the manufacturer's recommendations. Alignment and adjusting shall be verified after installation.

B. The pumps shall have an electrical disconnect complying with the NEC.

3.2 TESTING

A. In addition to testing that may be required by codes, the Design Builder shall perform all tests specified in this section and shall furnish and pay for all material and labor required for tests. Prior to start-up, the pump shall be tested in place. These tests shall duplicate all normal operating modes. Should tests indicate unsatisfactory operation, conditions shall be corrected and the test repeated at the Design Builder's expense.

PART 4 -- WARRANTY

4.1 GENERAL

A. The pumps shall be warranted for labor, equipment and all components for a one (1) year period after final acceptance.

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SECTION 44 35 23 – SUBMERSIBLE TURBINE WELL PUMPS

PART 1 -- GENERAL

1.1 SUMMARY

A. The requirements of Section 44 35 00 - Pumps General, apply to this Section.

B. The requirements of Section 26 29 23 – Variable Frequency Drives, apply to this Section.

C. The Submersible Well Pump Supplier (SWPS) shall supply a total of nine (9) submersible turbine (ST) vertical well-style pumps, motors, pump column and couplings, fabricated steel discharge heads, motor shrouds where required, submersible power cables, and any in-well instrumentation and cabling required, installation and startup services for a complete and operable system, in accordance with these Contract Documents.

D. **Pump Starters and Local Disconnects.** Pump starters including Variable Frequency Drives (VFD) for each of the ST pumps, any local control panels (LCP), local pump disconnects, and all conductor and wiring from the local disconnects back to the pump starters or VFD located back in the hatchery electrical room shall be by the CONTRACTOR.

E. **Wiring from Local Disconnect to Junction Box at Well Head.** The CONTRACTOR's electrician shall be responsible to provide both conduit and appropriate wiring from the local disconnect switch (located within ~15-ft of the well head) to the junction box at the well head. The SWPS's submersible power cable shall terminate at the junction box and connect to the electrician's standard power cable for conduit service.

F. Terminology and standards pertaining to pumping unit performance and construction shall conform to the American National Standard for Vertical Pumps ANSI/HI 2.1-2.5.

G. The SWPS shall examine the Contract Documents, intended application, and operation of the pump system and recommend the pumps that will best satisfy the indicated requirements.

H. The SWPS motor manufacturer shall be ISO 9001:2000 certified.

1.2 EXISTING WELL FACILITIES

A. Table 1.2B below provides information on existing wells for reference. Water temperature in the wells is expected to vary seasonally from 44 to 60 degrees F for motor cooling purposes. The amount of sand drawn into the new well pump is expected to be low. Contract Drawing M160 provides well construction and pump setting details.

B. **Well Information** – This Table to be completed as part wellfield development process.

Well No. - (Year Installed)	Approx Ground Elev	Casing/Screen (Dia & Mat'l)	Screen Slot Size & Interval	Total Well Depth (ft.)	Static Water Level

	(MSL)		(in. and ft bgs)		(ft. bgs)
1 - (2011)	1582	8” Stl & St. Stl.	0.06” 21-26	26	0.5
2 - (2016)	1584.5	10” PVC & St. Stl.	0.05” 5-30	30	1.1
3 - (2018)	1583.0				
4 - (2018)	1585.25				
5 – (2018)	1586.5				
6 – (2018)	1586.25				
7 – (2018)	1586.4				
8 – (2018)	TBD				
9 – (2018)	1584.9				

1.3 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

ANSI/HI 2.1–2.5 Vertical Pumps Nomenclature, Definitions, Application, and Operation

ASTM A743 Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application

ASTM B148 Aluminum – Bronze Sand Castings

ASTM B177 Standard Guide for Engineering Chromium Electroplating

ASTM B505 Alloy 836 and Alloy 932 for enhanced lubrication performance on pump shaft and bearing materials

ASTM B584 Copper Alloy Sand Castings for General Applications

ASTM B650 Electrodeposited Engin. Chromium Coatings of Ferrous Substrates

NSF International Std 61 Drinking Water Systems Components – Health Effects.

1.4 EXPERIENCE QUALIFICATIONS

A. The SWPS shall be experienced in the manufacture of ST pumps for shallow and medium depth well installations. At the request of the ENGINEER, SWPS shall submit a list of five (5) references of their ST pumps installations in North America which have been in successful operation pumping water for at least five (5) years. Each reference shall have the following minimum capacities / characteristics:

1. Flow capacity of at least 1 cfs (449 gpm) per pump

2. Column length of at least 50 feet

3. Pumping head requirements of at least 50 ft of TDH

B. The SWPS shall have performed installation and start-up services, and operator's training instruction at those installations. The reference list shall include the following information for each project.

1. Name of facility, owner of facility, contact name(s), address, and telephone number

2. Fluid service and application.

3. Pump capacity and head.

4. Pump motor manufacturer, horsepower, and speed.

1.5 SUBMITTALS

A. The SWPS shall furnish complete submittals on the ST pumps and appurtenances in accordance with the requirements of Section 44 35 00 – Pumps, General.

B. Shop drawings shall include detailed plan and sectional drawings of any special fabricated discharge elbows to be mounted on or near the top of the well casing.

C. Complete motor data on the ST pumps shall be submitted including:

1. Machine name and specification number of driven machine
2. Motor manufacturer
3. Motor type or model and dimension drawing. Include motor weight.
4. Nominal horsepower
5. NEMA design
6. Enclosure type and dimensions
7. Winding insulation class and temperature rise class
8. Voltage, phase, and frequency ratings
9. Service factor
10. Full load current at rated horsepower for application voltage
11. Full load speed
12. Guaranteed minimum full load motor efficiency.
13. Type of thermal protection or over-temperature protection, if included
14. Wiring diagram for devices such as motor leak detection, temperature, or zero speed switches, as applicable
15. Thrust Bearing data. Include recommendation for minimum and maximum startup times for the thrust bearing when using RVSS or VFDs with the pump motors.

1.6 PRE-PROPOSAL SITE VISIT TO EXISTING WELL FACILITIES

A. None required.

1.7 OWNER'S MANUALS

A. The SWPS shall furnish complete Owner's Operations and Maintenance (O&M) Manuals on the ST pump and appurtenances in accordance with the requirements of Section 44 35 00 and Section 01 33 00 – Submittals.

1.8 WARRANTY

A. The SWPS shall warrant each ST pump and motor assembly against defects in the workmanship and material for a minimum period of **one (1)** year starting at the time in which the CONTRACTR is granted substantial Completion from the OWNER or the first day in which water is delivered to the hatchery head tank box, whichever comes first. Warranty documents shall be issued by the SWPS and submitted by the CONTRACTOR prior to final acceptance of the project.

B. If at any time during the startup, testing or 1-year warranty period, any of the ST pumps require full or partial removal from the existing intake shaft for servicing or replacement of parts, then

1. The SWPS shall be required to perform such removal of the pumps and reinstallation of the pumps after servicing, at no added cost to the CONTRACTOR or OWNER.

2. The cost of any additional engineering, parts, materials, and other equipment needed to fix a defective or damaged ST pump, including labor costs of field and factory pump technicians for work performed on the pump, motor, and power / instrument cable assemblies, shall be paid entirely by the SWPS.

PART 2 -- PRODUCTS

2.1 GENERAL DESCRIPTION

A. **Identification**

Pump Names	Well Submersible Pumps No. 1 through 9,
Equipment Numbers	GWP-101 through GWP-109
Quantity	9
Location	Inside well casings (submerged in groundwater)

B. **Typical Operating Conditions:** The WORK of this Section shall be suitable for long term operation under the following conditions:

Pump No.	All

Duty	Continuous w/ VFD speed control
Drive	VFD controlled speed, 480 VAC, 3-phase, 60-hz motors, with a min. service factor of 1.15. Pump motor shall be fully compatible with across-the-line full voltage starters.
Ambient environment	Motor, pump assembly, and pump discharge column submerged in steel well casing.
Fluid service	Unfiltered, fresh groundwater
Fluid / groundwater temperature, degrees F	45 to 55
Fluid pH range	6.5 to 7.5
Well screen slot-opening width, inches	0.05
Fluid Total Suspended Solids level, mg/l	< 20, (99% of time)
Fluid Total Dissolved Solids range, mg/l	200 to 500
Fluid specific gravity	1.0
Fluid viscosity, absolute centipoises at 50 deg F (10 deg C)	1.31
Well head ground elevations, ft, msl	~1585 +/-3’
Approx. pump bowl elevation, ft below ground	25 ft
Available NPSH (absolute) at static aquifer WSEL, ft	TBD
Available NPSH (absolute) at minimum future aquifer WSEL, ft	TBD
Max. Design static lift to Hatchery Headbox degas column, ft	60

2.2 ST PUMP PERFORMANCE REQUIREMENTS & DIMENSIONS

A. **Typical Pump Performance Requirements.** This pump shall meet or exceed the performance requirements as follows. The pump flow rate will be controlled with a VFD controller based on actual drawdown levels in aquifer as transmitted by level sensors in each well.

Minimum pump shutoff head at full speed, ft	90
Design flow pump speed, rpm	3,450
Design flow capacity at min TDH, gpm (cfs)	TBD
Design bowl minimum (TDH), ft	60
Design static lift, ft	40
Min. efficiency at design, % (motor input wire to water)	70
NPSH (absolute) required at design point, ft	< 12
Number of Pump Stages	2
Maximum motor speed, rpm	3,600
Minimum motor size, hp	TBD
Minimum motor service factor	1.15
Pump Mfr and Model, or Equal	Goulds 5CLC (3-stage), or Equal

B. **Pump Column and Well Dimensions – To be completed for each well after drilling**

Well casing inside diameter (inches)	
Maximum allowable bowl size (inches)	
Max. allowable pump motor frame dia (inches)	
Length from well casing top flange of tee to pump discharge connection. (ft)	
Column PVC pipe outside diameter, inches	
Column PVC pipe minimum wall thickness, inches	0.24 (sch. 120)
Column pipe maximum section length, (ft)	20.0
Column pipe end types	NPT (threaded)

Max OD of PVC pipe couplings, inches	
Max. Allowable pump and motor outside diameter, inches	
Pitless adapter discharge dia, in	4
Pump motor shroud outside diameter, inches	Not required

2.3 PUMP REQUIREMENTS

A. **Supplier of Pump Components. All pump components and accessories shall be supplied by the SWPS,** unless specifically noted otherwise, as supplied by the CONTRACTOR.

B. **Pump Construction:** All metallic components of the pump shall be 304 or 316 stainless steel, unless specified otherwise. Construction of ST pumps shall conform to the following requirements:

Bowls	Cast-iron, ASTM A48, Class 30 CIE, of minimum tensile strength of 30,000 psi and Brinell Hardness of 210. Interior water passages shall be coated with either liquid applied epoxy system, or porcelain finish system, or a vitreous enamel system. Exterior surfaces shall be coated with a 10 to 12-mils vitreous enamel system. Castings shall be smooth, fine-grained, high density and free of sand pockets, blowholes and all other detrimental flaws and defects.
Pump Bowl Case Bearings	Each bowl shall include its own shaft sleeve bearing and the pump suction / strainer shall also be equipped with a bearing. Bearing materials shall be of bronze ASTM B584-844. Bearing assembly grease lubricated, protected from abrasives by bronze sand collars of ASTM B584 alloy C83800, or approved equal.
Impeller	Type 316 stainless steel statically and dynamically balanced, enclosed impeller
Impeller shaft method of connection	Type 400 series stainless steel construction. Impellers to be held rigidly in place with collets or keys.
Bowl wear rings	Aluminum Bronze

Impeller wear rings	Aluminum Bronze
Bowl shaft	Type 416 stainless steel, turned, ground, and polished. Shaft size shall be no less than that determined by ANSI / AWWA Specification E101-88 and the requirements of ASTM A582.
Motor Coupling	A276 Type 416 stainless steel, keyed to fit motor shaft.
Bottom Bearing	Close tolerance sleeve type with length minimum of 2-1/2 times shaft diameter; permanently grease-lubricated for suction bell with Vesconite bearings.
Pump to Motor Adaptor & Bearing Assembly	Shall be either a 1-piece suction or a 2-piece system (adapter bracket and strainer-body) to insure easy pump to motor adaptation. The shaft coupling shall consist of a solid rigid coupling, keyed to the pump shaft and either splined or keyed to the motor shaft, and be capable of transferring the pump thrust to the motor up and down thrust bearings. Bearing assembly shall be grease lubricated, protected from abrasives by bronze sand collars of ASTM B584 alloy C83800
Motor Shroud	None required for project. (If SWPS requires use of shroud, shroud shall be 304 stainless steel, minimum thickness of 1/8-inch.)
Suction bell / Strainer Body	Cast iron bell of the same material or better as specified for the pump series cases. Suction bell shall have grease-packed bottom bearing and streamlined ribs, with a sand cap over bearing. Same lining and coating as bowls
Intake Strainer Openings	Total open area shall be at least four times the impeller suction eye area of the first stage impeller, and shall be no greater than 75% of minimum opening or water passage opening through the bowl or impeller.
Column Pipe (Supplied by SWPS)	Schedule 120 PVC Column pipe shall be furnished in maximum 20-ft lengths.
Column Pipe Joints. (Supplied by SWPS)	NPT male threaded ends. Steel coupling wall thickness shall not be more than 5/8 (0.625) inches.

C. **ST Motors**

1. Each pump shall be provided with an inverter rated submersible, VFD compatible high- efficiency, 480-volt AC, 3-phase, 60-Hertz, electric motor designed for continuous underwater operation in conformance with NEMA standards, specifically NEMA MG-1. Each motor shall be rated for across-the-line full-voltage starting, rated for the maximum starting amperages required of the pump motor at full-speed. Each pump motor shall be operated by a fully rated VFD.See Section 26 29 23.

2. **Sizing**. The SWPS shall size motors for the larger of the following criteria:

   a. Size motors to continuously carry the maximum load that develops across the full range of driven equipment operation.

   b. Size motors for minimum size indicated

3. **Operating Conditions and Service Factor**. Motor shall be designed for continuous underwater operation at a maximum water temperature of 62 degrees F such that the service factor shall be a minimum of 1.15. The motor rating shall be selected so that the load at design is not greater than the nameplate horsepower rating at 1.0 service factor and at no point on the pump curve shall the motor load exceed the name plate rating plus 10 percent.

4. **Motor Design**. Motor shall be of the wet-wound stator design with the stator windings directly submerged in water. The winding wire insulation shall consist of a waterproof, non-aging material of high dielectric strength. The winding insulation shall be PE2+PA and rated Class Y per IEC 85. Hermetically sealed or resin encased stators are not acceptable. Winding wire shall be copper conductors. Only re-windable motor designs will be accepted. Stator tubes shall be 316 S.S. through 19-inch designs.

5. **Stand-Off Rings or Clips**. The top and bottom of each submersible motor shall be equipped with hard rubber or plastic stand-off clips or rings that are 0.75 to 1.0 inch in length and designed to insure that the motor housing can be located no closer than 1-inch to the well casing steel wall. This minimum off-set shall be such to insure that proper cooling flow by the motor occurs with well water ambient temperatures as defined in Part 2.1.B.

6. **Motor Thrust Bearing**. Pump axial load / down-thrust shall be absorbed by a Kingsbury style or approved equal motor thrust bearing. Bearings shall be of 316 stainless steel, bidirectional style with a stainless steel pivot shoe running against a hard carbon – graphite, steel encased disk. Axial thrust bearing shall be capable of carrying a minimum of 300 percent of the calculated pump down thrust load at design and a minimum of 150 percent of the calculated pump down thrust load at shutoff conditions. Motor thrust bearings shall be designed for a minimum L-10 life of 100,000 hours (coupled).

a. The motor design shall include the capability to carry continuously, the total sum of the weight of the rotating components of the pump and motor, and the hydraulic thrust that the pump may develop in both the up and down direction.

7. **Radial Bearings.** Radial loads shall be supported by close tolerance, sleeve-type bearings constructed of solid hard carbon (graphite). Bearings shall be minimum length of 2.5 times shaft diameter.

   a. Each motor shall be mounted in the vertical position with the motor shaft at approximately 90-degrees off of horizontal. The motor radial bearings shall be designed to support the entire load absorbed by the motor while operating in a vertical position.

8. For motors driven by variable frequency drives (VFDs) shall have bearings equipped with proper electrical insulation around the bearing that meet the VFDs manufacturers recommendations for eliminating electrical current running across the bearing assemblies.

9. The stator windings shall be Hi-Pot tested to twice rated voltage plus 1000 volts. The insulation resistance shall be not less than 100 Megohms.

10. **Rotor**. The rotor shall be statically and dynamically balanced. Rotor bars shall be copper. Aluminum rotor bars are not acceptable. The rotor shaft end extension shall be of solid, 304 stainless steel construction.

11. **Rotor Shaft and Seal.** The rotor shaft shall be sealed with a single, spring-loaded mechanical shaft seal of John Crane manufacture or equal. Mechanical seal faces shall be silicon carbide by silicon carbide. An expansion diaphragm shall be installed in the bottom of the motor to equalize the pressure inside the motor with the external pressure exerted on the outside of the motor by hydrostatic forces

12. Motor shall be filled with a water solution with a minimum concentration of glycol for cooling and lubrication. After installation, pumps shall never be exposed to freezing temperatures, as water temperature shall always be 8^{o}C or higher. Pumping water temperature averages approximately 10^{o}C. No oils or grease lubrication shall be used. A flexible diaphragm shall be provided to permit expansion of internal motor fluid. The shaft face seal shall be a silicon carbide on silicon carbide. A mercury type shaft seal will not be acceptable.

13. Motor stator housings shall be constructed of 316 stainless steel. The end bells on the motor shall be Class 30 cast-iron coated with an approved NSF-61 system, either liquid applied epoxy or enamel coating.

14. **Lifting Devices**: Motor and pump assemblies weighing 250 lb (115 kg) or more shall have suitable lifting eyes for installation and removal.

D. **Motor Leads and Power Cable**

1. The power cable to motor lead connection may be by either of the following methods:

a. An internal connection within the motor housing, made at the factory, and shipped with the entire power cable reels attached to the pump

2. For external field connections of the power cable, the motor leads shall be of sufficient length to allow them to be spliced above the bowl assembly. Leads shall be protected by a stainless steel cable guard for the entire bowl length. The motor leads to electrical cable splice shall conform to IEEE and NEC standards. Plug-in leads are not acceptable.

3. For submersible motors of 50 HP or smaller, SWPS shall supply only one (1) power cable per pump supplied. Power cables and conductors shall be flat-jacket style and sized to meet the criteria specified below.

4. All submersible pump power cables shall have an overall metallic shield around the group of three conductors to prevent electrical interferences with other electrical cables. The cable is not required to be an armored cable. In addition, the shielded cable shall have a stranded tinned copper drain wire that is connected to ground at both ends of the cable.

5. The electrical wire shall be annealed bare stranded copper conductors insulated with PVC. All power cable conductors plus a ground conductor shall be jacketed in a heavy duty PVC jacketing. All cable conductors shall be UL listed with temperature rise limited to a maximum of 90°C. Cables shall be UL rated for Deep Well Submersible Cable applications.

6. The SWPS shall supply the entire length of motor electrical cable for each pump originating from the local disconnect switch (located within the hatchery building) and terminating at the submersible motors. Submersible well cable shall not be run in closed conduit, except that a short length (<10-ft) of oversized conduit (2.5-inch minimum) may be used to get the pump cable from the well head to the local disconnect switch. The SWPS shall plan on a maximum length of motor cables of 50 feet from the new local disconnect switches to each ST pump as follows:

7. **Power conductors shall be sized to allow no more than two (2) percent of voltage loss** at the motor rated full-load current and voltage, over the entire length of the cable starting at the across-the-line starter in the hatchery electrical room and terminating at the submersible pump motor.

   The SWPS shall supply only one power cable per pump to meet the voltage drop requirements, with each cable consisting of four (4) conductors, one of which shall be a grounding conductor. Grounding conductors shall be sized per Table 24.3 of UL83. The SWPS shall provide appropriate non-metallic, industrial grade straps, at minimum every 10 feet in column pipe length, to secure the power cable to the pump discharge column. The material and style of the cable straps shall be submitted to the ENGINEER for approval.

8. Grounding Lugs: Provide motor grounding lug suitable to terminate ground wire, sized as indicated.

E. **Variable Frequency Drives:** See Specification 26 29 23 for full details.

F. **Discharge Heads / Pitless Adapters**. For each of the ST pumps, the SWPS shall supply a pitless adapter to be installed.

G. **Nameplates**. Each pump shall be equipped with a stainless steel nameplate indicating SWPS's serial and model numbers, rated head and flow, impeller size, pump speed and motor data.

2.4 PUMP CONTROLS

A. The well water pumps shall be controlled from the VFD located in a central motor control center (MCC) in the Hatchery Building. Each pump shall have a Hand-Off-Auto switch. Pumps are controlled manually, with setting made at the VFD control panel. Pump operates continuously at the set fixed speed. Pump start/stop and set points shall made at the local control panel or through the SCADA system. Pump operation is supervised by a water level sensor located in the well. Well level sensor sends a signal to the VFD controller which controls the pumps to maintain a minimum water level elevation in the well casing. The VFD shall be programmed to throttle back and initiate an alarm condition if the minimum water level is reached.

2.5 SPARE PARTS

A. The SWPS shall supply the following spare parts for each model of ST pump:

1. None required

2.6 SWPS MANUFACTURERS, "or Equals"

A. **Flowserve**

B. **Goulds Pump**

C. **Peerless**

PART 3 -- EXECUTION

3.1 FACTORY TESTING

A. **General.** All centrifugal pump systems shall be tested by the SWPS at their manufacturing / testing facilities in accordance with the American National Standard for Centrifugal Pump Tests (ANSI / HI 1.6) or the American National Standard for Vertical Pump Tests (ANSI / HI 2.6), as approved by ANSI and published by the Hydraulic Institute (HI).

1. All ST pumps shall meet the HI Acceptance Level "A" criteria for factory tests.

2. Tests shall be performed using the complete pump system to be furnished, including the motor and bearing assemblies.

3. Tests shall be conducted after the impeller diameters have been trimmed to meet the specified duty head requirements.

4. Standard factory pump shrouds or test well configurations may be substituted in place of any special project pump shrouds required.

5. The tests shall be conducted on the actual ST pump and motor assembly along with the pump discharge column concentric increaser and a minimum of one (1) of 10-ft column sections attached to the pump discharge.

6. Each pump unit shall be performance tested in the factory in the vertical position.

7. Four (4) copies of the certified test results shall be furnished to the ENGINEER within three days after completion of all specified tests.

3.2 DELIVERY OF ST PUMPS TO PROEJCT SITE

A. Delivery of the new ST pumps, motor and all accessories to the project site shall be in accordance to the schedule requirements identified in Division 01.

3.3 FIELD TESTING AND INSTALLATION SERVICES

A. **Motor Testing.** The SWPS qualified field representative shall perform the following field tests within 7 days prior to installation or after installation of the new pump-motor assemblies by the CONTRACTOR:

1. Inspect each motor installation for any deviation from rated voltage, phase, frequency, and improper installation.

2. Visually check for proper phase and ground connections. Verify that multi-voltage motors are connected for proper voltage.

3. Test for proper rotation prior to connection to the driven equipment.

4. Test insulation (megger test) of new and re-used motors in accordance with NEMA MG-1. Test voltage shall be 1000 VAC plus twice the rated voltage of the motor.

5. If supplied, check winding and bearing temperature detectors for functional operation.

6. If supplied, visually check that motor overload heaters are properly sized and that MCP breaker settings are correct for the motor installed.

B. **ST Pumps Installation.**

1. All submersible pumping equipment and instrumentation shall be installed by the SWPS in accordance with approved procedures submitted with the shop drawings, and the pump manufacturer's recommendations.

3.4 SERVICES OF SWPS

A. **Inspection, Startup, and Field Adjustment:** The service representative of the SWPS shall be at the site for a minimum of 1 Day each (total of two (2) Days) during installation of each ST pump to furnish the services required by Section 44 35 00 – Pumps General. These services shall be provided on either 1 or 2 different trips.

1. SWPS shall witness and certify in writing that the pump has been properly installed, aligned, lubricated, adjusted, and prepared for operation by the OWNER.

B. **Instruction of OWNER'S Personnel:** The training representative of the SWPS shall be present at the Site for a minimum of one (1) full Day to furnish the services required by Section 44 35 00.

C. For the purposes of this paragraph, a Day is defined as an 8-hour period at the Site, excluding travel time.

D. The OWNER requires that the inspection, startup, and field adjustment services above be furnished in a minimum of one (1) separate trip.

3.5 VIBRATION AND FREQUENCY TESTING

A. **Field Vibration Tests:** During startup services, the SWPS shall perform field inspection and observations of pump vibrations at full speed and under the flow ranges as specified above. If the vibration inspections determine that the pump and/or the motor do not meet the vibration limits as required by the pump manufacturer, the SWPS shall take appropriate corrective action to bring the pump and motor vibration into compliance.

- END OF SECTION –

44 35 27– AXIAL FLOW SURFACE WATER PUMPS

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide vertical mixed-flow pumps and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The **Axial Flow Pump Supplier (AFPS)** shall examine the Site conditions, intended application, and operation of the pump system and recommend the pump which will best satisfy the indicated water delivery requirements.

C. The requirements of Section 44 35 00 - Pumps, General apply to this Section. The AFPS shall enter into a contract with the CONTRACTOR to furnish and install the pumps, motors, discharge heads, and columns, and all other services as defined in this specification and in Section 44 35 00 - Pumps General.

D. **General.** The AFPS shall provide and install, complete and fully operable, two (2) water-lubricated, shallow-set, axial-flow vertical pumps within at precast concrete wet well at the project site. The AFPS shall provide and install the entire pump assemblies, as described in this specification Section. New steel well casing is estimated to be 16-inch OD steel pipe with an inside diameter of 15.5 inches. Water flow to the pump intakes will be entirely from screened surface water via a buried 18-inch pipeline.

The following pumps are included in the work, along with a possible AFPS, or equal:.

1. **SP-201 and SP-202**– Variable Speed, 25-hp at 1180 rpm with inverter duty motor, design flow > 2700 gpm at 30 feet TDH, Goulds Model 16RGLC or equal

E. **Submittals.** The AFPS shall submit to the CONTRACTOR shop drawing submittals, with material documentation, according to the requirements of Section 44 35 00 - Pumps General. Materials documentation shall be approved by the Engineer prior to fabrication and installation.

F. **Warranty**. The AFPS shall provide a copy of the manufacturer's warranties covering the AFPS -furnished items and shall include the cost of such warranties in their quote. The warranties shall provide for repair and/or replacement of any defective AFPS - furnished item for a period of one year from the date of operational acceptance of the pumps. The AFPS shall warranty all AFPS -furnished components of the system: this warranty shall include all parts and labor, including the removal, shipment, and reinstallation as required during this period.

G. **Access to Site**. Provisions for access to the work site will be provided by the OWNER. Other contractors, employees, or agents of the OWNER or ENGINEER may enter the work site and premises used by the CONTRACTOR for business purposes.

PART 2 -- PRODUCTS

2.1 **Pump Performance**. In the following performance tables, Design Points A, and B define the general shape and requirements of the performance curve for each pump at full speed.

Mixed Flow Pump General Information					
Service:	Surface Water				
Pump Name:	**SP-201, SP-202**				
Number of Pumps:	2				
Mftr. Model Number or equal:		Manufacturer Reference:	Goulds, Pentair, or Equal		

Liquid		**Operating Conditions (at 1100 rpm)**			**Service Conditions**	
			Flow(gpm):	TDH (ft):	Altitude (ft):	1,600
Temperature, Average (F):	49.6	Design Point A:	2700	30		
Temperature, Design (F):	50	Design Point B:	1350	25	☒Indoor	☒Heated
		Design Point C:				
		Minimum NPSHA (ft):			Seismic Zone:	2B
Abrasion Caused By:	sand	Maximum Suction Static Head (ft):		10	Exposure Classification:	Type 1
		Minimum Suction Static Head (ft):		5		
		Minimum Bowl Submergence (ft):		30		
		Well Casing Inside Diameter (in):				
Min Pump Column Length (ft below special Artesian Tee Fitting):				12	(excludes hght of bowl & intake assbly)	

Performance Requirements		
Minimum Continuous Flow (gpm):	1350	
Pump Speed Range (rpm):	Min: 900	Max: 1180
Bowl Efficiency at Design Point B:	>81%	Note: efficiency shall reflect adjustments for stages and specified pump material.
NPSHR (ft):	Min: 20	Max: 35

Pump Construction Details				
Discharge Head:	12-inch / Flanged			
Mounting Type:	☒Sump	☐Can Mounted	☐Well	Mount pump disch head on top of existing 20-inch flanged tee on well head.
Lineshaft Type:	☒Open	☐Closed	☐N/A	

Impeller			**Column Pipe**			
Impeller Type:	☒Open	☐Closed	Outside Diameter of Steel Shell (in):			
			Wall thickness Schedule:	40		
			Column Pipe Connector Type:	Couplings, Threaded		
Impeller Diameter, Rated:	Determined by AFPS		**Lubrication**			
Impeller Diameter, Max:	Determined by AFPS		Pump Impeller Bowl Bearing	☐Oil	☐Grease	☒Pumped Liquid
Maximum Bowl Size (in):			Suction Bowl Bearing	☐Oil	☐Grease	☒Pumped Liquid
Maximum Number of Stages	1		Line Shaft	☐Oil	☐Grease	☒Pumped Liquid
Pass Sphere Size, Min (in):	0.5					

Motor Data					
Type:	Vertical shaft, high thrust electric motor		Motor Horsepower (hp):	75 Minimum	
Hazardous Location:	☐Yes	☒No	Voltage:	460	
Service Factor:	1.15 (115 for VFD Driven Motors)		Phase:	3	
Minimum Efficiency (%):	Provide in shop drawing submittal		Drive Type:	☐Constant Speed	☒Variable Speed
Mounting Type:	Vertical		Special Features:	☒Inverter Duty Rated	
Enclosure Type:	WP 1			☐Soft Starter	☒Premium Efficiency

2.2 **Pump Construction**: Construction of vertical turbine pumps shall conform to the following requirements:

Bowls	The bowls shall be flanged type constructed of close grained cast iron with 316 stainless steel bolting conforming to ASTM A48, class 30. Bowl and suction bell shall be coated with 10-12 mils fusion bonded epoxy coating, Scotchkote 134, or equal. They shall be capable of withstanding a hydrostatic pressure equal to twice the pressure at rated flow or 1.5 times shut-off head, whichever is greater. When applicable, intermediate bowls shall have enamel or epoxy lined waterways for maximum efficiency and wear protection. All intermediate bowls shall be provided with bronze bearings.
Bowl shaft	Shall be constructed from 17-4 PH stainless steel ASTM A564M-99. It shall be precision ground and polished with surface finish better than 40 RMS.
Suction bell / case	Cast iron bell, with bottom bearing and streamlined ribs. Suction bell interior and exterior surfaces shall be properly prepared and coated with a fusion bonded epoxy coating system, of minimum dry thickness of 10 to 12 mils, and designed for maximum abrasion resistance to sand.
Bottom suction & bowl bearing	Close tolerance sleeve type with length min 2.5 times shaft diameter, permanently grease-lubricated for suction bell with non-soluble grease or bronze sleeve.
Wear rings (Bowl & Impeller)	Not applicable.
Bowl liners (where applicable)	Bronze, replaceable
Propeller	Silicon Bronze C87600 ASTM B584-00 statically and dynamically balanced, open impeller.
Propeller shaft and method of connection	Type 316 or 416 stainless steel impeller collets
Column	Schedule 40 steel pipe, threaded column in maximum 10-ft lengths. Threaded couplings will be fabricated from high tensile steel. To serve primarily as a protection against sand abrasion and interior corrosion, all column pipe and couplings interior surfaces only shall be properly prepared and coated with a liquid applied epoxy coating system, minimum of 2 coats, that complies with AWWA C210.
Shaft lubrication	Open line-shaft; product water lubricated. (No enclosing tube or UW flush water required.)
Shaft Seal	Shaft seal shall consist of a stuffed packing box. The packing box in the discharge head shall use a stuffed packing consisting of five rings of packing and a lantern ring. The packing shall be lubricated by the product being pumped. Provide a rubber slinger on the shaft above the packing box. Pipe water drippings to floor drain with sched. 40 galv. steel pipe
Line shaft and couplings	ASTM 582 Type 416 stainless steel shaft in maximum 10-ft lengths, sized for a critical speed of min 20 percent above max operating speed. Stub shaft shall also be constructed of type 416 stainless steel. Shaft lengths shall be no more than 5-ft for

	the top and very bottom sections. Shaft coupling shall be Type 316 stainless steel, threaded or keyed to the shaft. Open line-shaft construction required.
Line shaft bearings	Rubber with bronze integral bearing retainers at each joint for open lineshaft.
Journals at stuffing box	Shafts turned, ground, and polished with min 8-mils thick hard chrome journals
Discharge head	Fabricated steel, reinforced to withstand pipe thrust, epoxy-lined with flanged base. Discharge head I.D. will be coated with 10-12 mils fusion bonded epoxy coating. Provide a gasket (or approved equal) between the discharge head base and the connection to the existing tee, which must seal watertight.
Motor shaft coupling	For hollow shaft motors, a 416 stainless steel threaded coupling will be used.
Suction Strainer	None

2.3 **Motor**: Electric motors shall be inverter duty for variable speed drives with vertical hollow shaft, heavy-duty, high thrust, premium efficiency motor capable of accepting the total, unbalanced thrust imposed by the pump. Motors shall be suitable for 460 volt, 3-phase, 60 Hz power supply, and shall be in accordance with the requirements of Section 26 05 10 - Electric Motors, including but not limited to

1. Furnished with Class F insulation, rated to operate at the altitude where the motor will be installed and operated approximately 1,600 feet above sea level.
2. Equipped with a top shaft adjusting nut, a lock bar to hold shaft during adjustment,
3. Equipped with lifting lugs, cast iron conduit box of the split type, lubrication port and gage.
4. Equipped with angular contact ball bearings of the oil-lubricated type. The bearings shall be shielded to protect against the entrance of moisture, and shall be designed for a minimum B-10 service life of 80,000 hours.
5. The motor shall have a minimum service factor of 1.15.
6. Where rotating parts are joined by threaded connections, a non-reverse type rachet mechanism shall be provided to lock the shaft against reverse rotation.

2.4 **Variable Frequency Drives**. Pump motors shall be inverter duty with the same service factor as defined above with the pump and fully warranted for operation with variable frequency drives at speeds ranging from 40 to 100 percent of full speed. The variable frequency drives shall comply with Section 26 29 23 - Variable Frequency Drive Units.

2.5 **Testing Requirements** (for all pumps)

<table>
<tr><th colspan="6">Factory Testing</th></tr>
<tr><td>General Equipment Performance Test:</td><td colspan="2">☒Required</td><td colspan="3">☐Not Required</td></tr>
<tr><td>Pump Performance Test:</td><td colspan="2">☒Required</td><td colspan="3">☐Not Required</td></tr>
<tr><td>Vibration Test:</td><td colspan="2">☐Required</td><td colspan="3">☒Not Required</td></tr>
<tr><td>Noise Test:</td><td colspan="2">☐Required</td><td colspan="3">☒Not Required</td></tr>
<tr><th colspan="6">Field Testing</th></tr>
<tr><td>General Equipment Performance Test:</td><td colspan="2">☒Required</td><td colspan="3">☐Not Required</td></tr>
<tr><td>Pump Performance Test:</td><td colspan="2">☐Required</td><td colspan="3">☒Not Required</td></tr>
<tr><td>Vibration Test:</td><td colspan="2">☒Required</td><td colspan="3">☐Not Required</td></tr>
<tr><td>Noise Test:</td><td colspan="2">☐Required</td><td colspan="3">☒Not Required</td></tr>
<tr><th colspan="6">Other Testing Requirements</th></tr>
<tr><td>Torsional Analysis:</td><td>☐Required</td><td>☒Not Required</td><td>Factory Test Witnessing:</td><td>☐Required</td><td>☒Not Required</td></tr>
<tr><td>Max. Noise, dBA at 3-ft:</td><td>N/A</td><td></td><td>Field Test Witnessing:</td><td>☒Required</td><td>☐Not Required</td></tr>
</table>

2.6 **Well Pump Control:**

2.7 SPARE PARTS

A. The following spare parts shall be furnished for each different pump model provided on the Project:

1. One suction case bearing assembly
2. One set of bowl and discharge case bearings
3. One impeller
4. One set of pump shaft bearings
5. One packing assembly
6. Two complete sets of gaskets and O-rings

2.8 MANUFACTURERS OR EQUAL

A. **Goulds Pumps**

B. **Pentair Pumps**

C. **Worthington (Ingersoll-Dresser Pump Company)**

D. **Floway**

PART 3 -- EXECUTION

3.1 **Pump Installation and Field Adjustment.** Pumping equipment shall be installed by factory trained technicians of the Pump Manufacturer. Installation shall be in accordance with approved procedures submitted with the shop drawings and as shown, unless otherwise approved by the Engineer. A service representative of the manufacturer shall be present continuously at the Site to furnish the services required by Section 44 35 00.

3.2 Pumping equipment shall be field tested to verify proper alignment, operation as specified, and freedom from binding, scraping, vibration, and other defects. Pump drive shafts shall be measured just prior to assembly to ensure correct alignment without forcing.

3.3 The installation work shall include furnishing any necessary oil and grease for initial operation.

3.4 **Site Protection**. The AFPS shall at all times protect any and all equipment and property of the OWNER and shall be responsible to the OWNER for any and all damage that may results from his operation or negligence.

3.5 **Safety Precautions**. The AFPS shall take all necessary precautions for the safety of the employees and shall comply with all applicable regulations and laws to prevent accidents or injury to persons on or adjacent to the job site. They shall erect and properly maintain at all times the necessary safeguards for protection of workmen and the public and shall post danger or warning signs against hazards created by the construction. Said work is to be conducted so that no liability will accrue under the Employer's Act of Idaho.

3.6 **Start Up**. Furnishing and installing of motor controls, and final electrical connection from the motor controls to the pump motor shall be provided by Others. The AFPS shall have the opportunity to witness and inspect the electrical connection, prior to start up of the pump motor. The AFPS shall witness start up and testing of the pumps.

3.7 **Instruction of OWNER'S Personnel:** The training representative of the manufacturer shall be present at the Site for a minimum of 2-Days to furnish the services required by Section 44 35 00.

1. For the purposes of this paragraph, a Day is defined as an 8 hour period at the Site, excluding travel time.

3.8 **Measurement and Payment**. Costs for furnishing and installing all components described in this specification shall be included in the Pump Supplier's bid. The Pump Supplier's bid price shall include full compensation for materials, rigs, equipment, power, tools, labor, and incidentals necessary to complete the work as described.

- END OF SECTION-

SECTION 44 35 45 – CHEMICAL METERING PUMPS

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide chemical metering pumps and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 44 05 00 - Equipment General Provisions apply to the WORK of this Section.

PART 2 -- PRODUCTS

2.1 GENERAL

A. The pumps shall be of corrosion-resistant construction, and diaphragm and seals shall be a suitable material for pumping formalin and hydrogen peroxide at maximum temperature of 80 degrees F. Each pump shall be complete with pump base, drive, diaphragm, check valves, back-pressure valve, internal relief valve, pulsation dampener, coupling guard and electric motor. Size and characteristics of the pumps shall be as indicated.

2.2 CONSTRUCTION

A. **Type and Range:** The pumps shall be of hydraulically actuated diaphragm type, suitable for metering service, with an adjustable stroke (dosage) control range of 10:1 with accuracy of 1.0 percent of the full-scale range. Pumps requiring variable speed drives shall have a set speed range of 10:1 which, in conjunction with the stroke control, shall provide a total feeding range of 100:1, minimum.

B. **Materials:** Wetted parts of metering pumps shall be selected by the manufacturer to ensure optimum, corrosion-free, and erosion-free operation for the chemicals involved.

C. **Alternative Type:** At the option of the CONTRACTOR and after approval by the ENGINEER, a progressive cavity type pump of suitable construction and materials may be furnished in lieu of a hydraulic diaphragm pump. The pump must be capable of continuous operation with the chemical solution listed, and the variable speed drive must be capable of covering the entire feed range with an accuracy of one percent of the full scale range. The progressive cavity pump shall be as manufactured by **Robbins and Meyers (Moyno), Allweiler Pump, Inc.,** or equal.

2.3 CONTROL

A. The dosage of each metering pump shall be set at each metering pump control station. .

2.4 SCHEDULE OF METERING PUMPS

I D No.	Chemical	Feed Range (gph)	Min Head (psi)	Min Motor (hp)	Type of Drive
FFP- 1	Formalin	0-60	25	1/8	Pos Disp.
FFP-2	Formalin	0-60	25	1/8	Pos.Disp

2.5 PUMP ACCESSORIES

A. **Mounting and Connections:** Unless otherwise indicated, metering pumps shall be mounted on galvanized steel wall shelves and shall be provided with corrosion-resistant pulsation dampeners, sample valves, pressure gages with diaphragm seals, shut-off valves, check valves, relief valves, and isolation valves. Pipe connections to pumps shall be firmly supported to avoid any stress on the pump or on the piping system.

B. **Flow Monitoring:**

2.6 SPARE PARTS

A. A complete set of extra diaphragms and seals shall be furnished with each pump. Where applicable, one set of spare bearings shall be furnished with each piece of equipment.

2.7 MANUFACTURER

A. **Manufacturer's Experience:** The pumps shall be the product of a manufacturer who has designed and manufactured similar equipment and has a record of at least 5 years of successful operation of this type of process.

B. Manufacturers, or Equal

1. **Milton Roy Company (Sunstrand)**
2. **Pulsafeeder (Chemwest)**
3. **U.S. Filter/Wallace and Tiernan**

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Pumping equipment shall be installed in accordance with the Shop Drawings and as indicated.

B. General installation requirements shall be in accordance with Section 44 35 00 – Water Pumps, General.

- END OF SECTION -

SECTION 44 35 55 - SUBMERSIBLE NON-CLOG PUMPS

PART 1 -- PRODUCTS

1.1 SUMMARY

A. The CONTRACTOR shall provide submersible non-clog pumps and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 44 35 00 - Pumps, General apply to this Section.

C. The Supplier shall examine the Site conditions, intended application, and operation of the pump system and recommend the pump which will best satisfy the indicated requirements.

PART 2 -- GENERAL

2.1 GENERAL DESCRIPTION

A. Identification

Pump Name	Clarifier Pump
Equipment number	P-601
Quantity	1
Location	Clarifier

B. **Operating Conditions:** The WORK of this Section shall be suitable for long term operation under the following conditions:

Duty	Intermittent
Drive	Constant Speed
Ambient environment	Outdoors/submerged
Ambient temperature, deg F	0-90
Ambient relative humidity, percent	Submerged
Fluid service	Fish Waste Solids Pumping 10% Solids Max
Fluid temperature, deg F	60
Fluid pH range	6-9
Fluid specific gravity	1

Project site elevation, msl	4300
Minimum available NPSH, feet absolute	3
Maximum size spheres to pass, inches dia	2
Sump classification in accordance with National Electrical Code	
Pump removal method	Cables
Power supply	480 volt 3 phase 60 Hz

C. Performance Requirements

Maximum shutoff head, feet	60
Design flow capacity, gpm	200
Design flow pump head, TDH, feet	30
Design flow minimum wire-to-water pump efficiency, percent	60
Maximum pump speed, rpm	3400
Maximum motor speed, rpm	3400
Minimum motor size, hp	3

D. Pump Dimensions

Overall pump size, inches	14x14x14
Size of discharge flange, inches	3
Flange rating, ANSI, psi	

2.2 PUMP REQUIREMENTS

A. General

1. Each pump shall be capable of continuous operation at full load with a water level of 36inches above the invert of the wet pit, without cavitation or overheating of the motor.

2. Each pump, with its cable and appurtenances, shall be able to withstand continuous submergence to a minimum depth of 65 feet, whether running or off, without leakage.

3. Each pump shall be able to operate for short periods at zero static suction head without causing any damage to any part of the unit.

B. **Pump Construction:** Construction of submersible non-clog pumps shall conform to the following requirements:

Connections	Machined metal-to-metal quick disconnect type, for withdrawal of unit from above without disconnecting pipe. When lowered into place, the pump shall automatically connect and lock into the discharge pipe, allowing for zero leakage at all anticipated pump heads.
Pump Design	Single stage, centrifugal type, close-coupled to sealed or submersible electric motor, for operation in dry or wet pit, without external cooling.
Impeller	Maximum 3-port non-clog type with replaceable wear rings on impeller and in casing, to handle raw unscreened sewage, solids, and fibrous materials.
Bearings	Permanently-lubricated, heavy-duty axial and radial ball or roller bearings top and bottom, with a minimum L-10 life of 50,000 hours, at continuous, maximum load and speed, supported by detailed calculations, to be submitted with the Shop Drawings.
Seals	Dual mechanical tandem, one stationary and one revolving shaft seals with individual springs, tungsten carbide or silicon carbide ring, each not requiring any maintenance, and capable of withstanding 1.5 times pump shutoff head. The seals shall be oil lubricated, with moisture detector probes, alarm, and test circuits.
Oil Chamber	To supply oil for lubrication and cooling of the shaft seals.
Support	Cast duckfoot bend or discharge elbow with machined face, anchored to sump floor.
Cables	Include necessary cables for power connection, moisture detection, and overload protection, sheathed, coded, and suitable for

	submersible pumps, and of sufficient length for direct connection to the terminal boxes indicated. Cables shall be connected to the pumps and tested at the factory.
Lifting Devices	Type 316 stainless steel guide rails with brackets and stainless steel lifting system of sufficient operating length, or with a stainless steel guide cable system with hooks and tension device, all rated at least 5 times the weight of the pump and motor.

C. Materials

Pump, volute, oil casing, sliding bracket, motor frame	cast iron
Impeller	cast iron, statically and dynamically balanced
Pump shaft	Type 420 stainless steel, or 1045 carbon steel with Type 420 stainless steel sleeve
Exposed bolts, nuts, washers	Type 316 stainless steel
Mechanical seals	Independently operating tandem tungsten-carbide or silicon carbide and carbon rings with stainless steel springs
Wear rings	Type 304 or 416 stainless steel and nitrile rubber with steel insert, with a Brinnell hardness of 300 on impeller and 350 on case

2.3 MOTOR

A. **Insulation:** The pump motors shall be designed for continuous duty in hazardous locations. The stator and stator leads shall be moisture-resistant, triple varnished and insulated according to Class F, capable of withstanding a temperature rise of up to 155 deg C. The allowable temperature rise of the motor at full load condition shall not exceed 80 deg C.

B. **Stator:** The motor stator shall be mounted in an air-filled, watertight casing and shall not be fixed in place by externally-mounted screws which may cause leakage in the motor.

C. **Motor Rating:** Motors shall have service factors of 1.10 or greater. For motors driven by variable frequency drives, motor horsepower shall be the greater of:

1. Non-overloading conditions throughout the pump curve.

2. 1.15 times the horsepower required by the pump at maximum indicated flow.

D. **Junction Box:** The motor shall have a junction box capable of being sealed completely from the stator casing to prevent leakage through the junction box into the stator housing should a motor cable be damaged or have some other means to prevent leakage into the junction box under any condition.

E. **Cable Entry:** The cable entry water seal design shall be such that it precludes specific torque requirements to ensure a watertight and submersible seal. It shall permit no entry of water into any high voltage area even if the cable is severed below the water level.

F. **Cooling System:** Each pump shall be provided with an adequately designed cooling system using a wastewater jacket or glycol solution and thermal radiator integrally cast with the stator casing. Cooling medium channels and ports shall be non-clogging by virtue of their dimensions. Alternately, wastewater cooling jackets are not required for motors that are designed to operate continuously at full load with ambient cooling.

G. **Motor Protection:** Integral thermal sensors in the motors, one for each phase, shall be provided to monitor stator temperatures. These sensors shall be used in conjunction with and supplemented by external motor over-current protection located at the control panel.

2.4 FACTORY TESTING AND SHIPMENT

A. The following procedures shall be included with the factory test prior to shipment:

1. Hydrostatic testing of fluid end.

2. Leakage test of submersible motor.

3. Verification of the pump characteristic curves by testing at shut-off head, 25, 50, 75, 100, and 125 percent of the indicated design flow and at maximum "run-out" flow and recording the measured head and motor current for each flow.

4. Verification of cavitation-free service and absence of motor overheating during conditions simulating the actual operating conditions after installation, whether submerged, semi-submerged, or dry.

5. Pump seals shall be designed for complete water tightness at 65-feet submergence for 30 minutes and data on factory testing and quality control shall be submitted with the Shop Drawings.

6. Parts shall be properly lubricated and protected so that no damage or deterioration will occur even during a prolonged delay from the time of shipment until installation is completed and the pumps are ready for operation.

7. Finished ferrous surfaces not painted shall be properly protected to prevent rust and corrosion.

8. The finished surfaces of exposed flanges shall be protected by strong wooden blind flanges.

9. Each pump shall be properly crated to protect against damage during shipment.

2.5 MANUFACTURERS, OR EQUAL

A. **Flygt Corporation**

B. **K.S.B. Pumps**

PART 3 -- EXECUTION

3.1 INSTALLATION

A. The CONTRACTOR shall ensure that anchor bolts are set only after the discharge piping has been properly installed, to ensure exact fit with embedded piping components.

B. Field Startup and Testing: After installation, each pump, motor, shall be tested with the process service fluid. Record the following:

1. Flow, discharge pressure, motor horsepower, and winding temperatures.

2. Check instruments attached to the pump and motor and record conditions. Each instrument shall read normal readings. If any instrument indicates abnormal conditions, notify the ENGINEER, and have the manufacturer qquickly resolve the problem.

- END OF SECTION -