Hilliard N. Fletcher Water Resource Recovery Facility Phase II Improvements

City of Tuscaloosa

SPECIFICATIONS AND CONTRACT DOCUMENTS

For the Construction of

HILLARD N. FLETCHER WATER RESOURCE AND RECOVERY FACILITY PHASE II IMPROVEMENTS

TUSCALOOSA, ALABAMA

File No. OCA-23-1043
Garver Project No. 19W10160

VOLUME 2 OF 4
DIVISIONS 26 - 44

Prepared For:

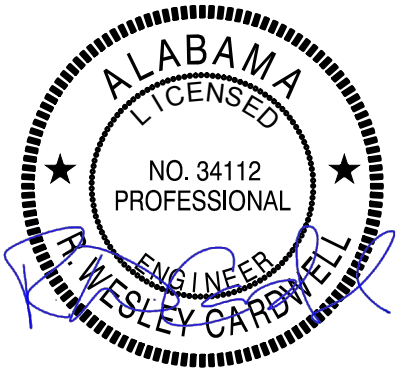
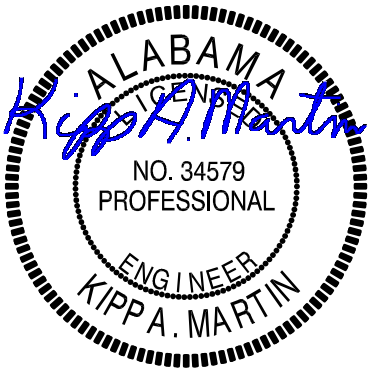
City of Tuscaloosa

November 2023

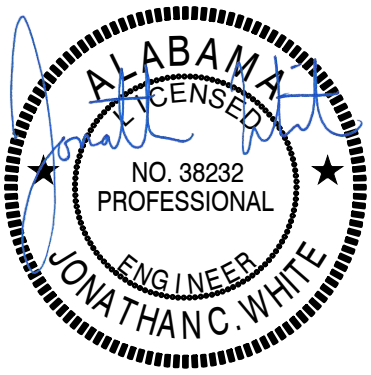
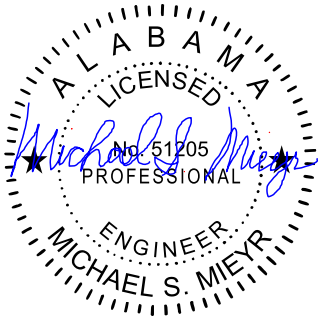
GARVER
GarverUSA.com

HFWRRF PHASE II IMPROVEMENTS
GARVER PROJECT NO. 19W10160
FILE NO. OCA-23-1043

I hereby certify that the applicable portions of this project's specifications, details, and plans were prepared by me or under my direct supervision and that I am a duly Licensed Engineer under the laws of the State of Alabama.

SEAL AND SIGNATURE	APPLICABLE DIVISION OR PROJECT RESPONSIBILITY
Wes Cardwell, P.E.  Digitally Signed: November 10, 2023	Division 01 Division 02 Division 23 Division 40 Division 41 Division 44
Kipp Martin, P.E.  Digitally Signed: November 10, 2023	Division 03 Division 04 Division 05 Division 07 Division 08 Division 09

CERTIFICATIONS

SEAL AND SIGNATURE	APPLICABLE DIVISION OR PROJECT RESPONSIBILITY
Jonathan White, P.E.  Digitally Signed: November 10, 2023	Division 26
Michael S. Mieyr, P.E.  Digitally Signed: November 10, 2023	Division 31

GARVER, LLC CERTIFICATE OF AUTHORIZATION:
AL ENGINEERING COA NO. 500-E Expiration Date: December 31, 2023

HILLARD N. FLETCHER WATER RESOURCE AND RECOVERY FACILITY PHASE II IMPROVEMENTS
TABLE OF CONTENTS

VOLUME 1 OF 4
CONTRACT DOCUMENTS, GENERAL REQUIREMENTS, AND TECHNICAL SPECIFICATIONS

VOLUME 2 OF 4
TECHNICAL SPECIFICATIONS

DIVISION 26

ELECTRICAL

SECTION 26 05 00 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. This Section specifies the basic requirements for electrical installations and includes requirements common to more than one section of Division 26. It expands and supplements the requirements specified in the General and Supplementary Conditions.
   2. This project consists of construction of the new building structures, associated facilities, and all related electrical systems as defined in the plans and in these specifications.
   3. The work includes the installation, connection, and testing of new electrical equipment, including power distribution equipment, lighting equipment, underground electrical work, grounding systems, control systems, conduit and wiring, temporary power systems, special electrical systems, and all appurtenances to construct and demonstrate proper operation of the completed electrical systems.
   4. The Contractor shall be responsible for the coordination of power, communication, and controls for the project.
   5. The electrical plans do not give exact locations, etc., and do not show all the offsets, control lines, pilot lines, and other installation details. Each contractor shall carefully lay out the work at the sites to conform to the job conditions, to conform to details of installation supplied by the manufacturers of the equipment to be installed, and thereby to provide complete operating systems.
   6. The electrical plans show diagrammatically the locations of the various electrical outlets and apparatus and the general method of circuiting and controlling. Exact locations of these outlets and apparatus shall be determined by reference to the general plans and to all detail drawings, etc., by measurements at the buildings, and in cooperation with other crafts, and in all cases shall be subject to the approval of the Owner and Engineer. The Engineer reserves the right to make any reasonable change in location of any outlet or apparatus before installation, without additional cost to the Owner.
   7. These specifications and the accompanying drawings are intended to cover systems which will not interfere with the structure of the buildings, which will fit into the several available spaces, and which will ensure complete and satisfactory systems. Each bidder shall be responsible for the proper fitting of the material and apparatus into the buildings.
   8. Should the particular equipment which any bidder proposes to install require other space conditions than those indicated on the Drawings, the Bidder shall arrange for such space with the Engineer before submitting the bid. Should changes become necessary on account of failure to comply with this clause, the Contractor shall make such changes at the Contractor’s expense.
   9. Where wire sizes, conduit and other items of construction are shown or required for a complete installation but are not adequately identified as to size or material requirements, the materials furnished shall be in accordance with “Code” requirements as though shown in detail on the Drawings.
   10. All equipment shall be leveled and made plumb. Metal junction boxes, equipment enclosures and metal raceways mounted on water or earth-bearing walls shall be separated from walls not less than 1/4 inch by corrosion-resistant spacers. All electrical conduits and items of equipment shall be run or set parallel to walls, floors, and other items of construction.

1.2 REFERENCE STANDARDS

A. The Contractor shall perform work specified in Division 26 in accordance with standards listed below. Where these specifications are more stringent, the most stringent standard shall take precedence. In case of conflict, obtain a decision from the Engineer.
   1. Applicable National Fire Protection Association (NFPA) codes, including but not limited to:

a. NFPA 70 – National Electrical Code.
b. NFPA 70E – Standard for Electrical Safety in the Workplace.
c. NFPA 72 - National Fire Alarm Code.
d. NFPA 101 – Life Safety Code.
e. Internet Website: http://www.nfpa.org

2. Applicable Code of Federal Regulations (CFR) codes, including but not limited to:
   a. 29 CFR 1910 – Occupational Safety and Health Standards (OSHA).
   b. 29 CFR 1926 – Safety and Health Regulations for Construction.
   c. Internet Website: http://www.gpo.gov/fdsys
3. ANSI/IEEE C2 – National Electrical Safety Code.
4. Applicable Federal, State and Local Fire codes.
5. Applicable Federal, State and Local Energy Codes.
6. Applicable Federal, State and Local Building Codes.
7. Applicable City Electrical Code.
8. Applicable City Ordinances pertaining to electrical work.
9. Applicable Federal, State and Local – Environmental, Health and Safety Laws and Regulations.

B. Contractor shall utilize the most current editions of standards, which are current at time of bid and as recognized by the Authority Having Jurisdiction for the respective standard.

1.3 SUBMITTALS

A. Submittals shall comply with Section 01 33 00, SUBMITTAL PROCEDURES, and the General and Supplementary Conditions.

B. Submittals shall be furnished by the Contractor for the work involved in sufficient time so that no delay or changes will be caused. Fax copies are not acceptable.

C. Submittals shall consist of manufacturing information, schematics, wiring diagrams, ladder logic diagrams, instrument loop diagrams, outline drawings, clearances and related information. Shop Drawings shall be so marked as to indicate the EXACT items offered.

D. Submittals shall bear Contractor's certification that the item complies in all respects with the item originally specified. It is the Contractor's responsibility to procure the proper sizes, quantities, rearrangements, structural modifications or other modifications in order for the substituted item to comply with the established requirements.

E. The Contractor shall combine each submittal set into one electronic file (pdf format). Group materials submitted by their Specification numbers, but do not submit the entire electrical within one submittal. Provide electronic bookmarks in the pdf to indicate the included equipment types and a title sheet to separate each section.

F. The Contractor shall submit complete descriptions, illustrations, specification data, etc., of all materials, fittings, devices, fixtures, special systems, etc., as required by the individual sections of this Division.

G. Submittal of shop drawings, product data and samples will be accepted only when submitted by the Contractor. Data submitted from subcontractors and material suppliers directly to the Engineer will not be processed.

H. All submittals shall provide the following information:
1. General Contractor.
2. Sub-Contractor.
3. Distributor and/or Supplier.

4. Sales Agency.
5. Submittals not supplying this information will be rejected.

I. Shop Drawings: In addition to the above, submit shop drawings for major materials where called for and when requested by the Engineer.
1. Lockout/Tagout Program.
2. Switchboard, motor control centers, panelboards, surge arresters, and safety switches.
3. Motor starters and contactors including custom wiring diagrams for all motors.
4. Lighting fixtures and lamps including light pole foundation requirements.
5. Wire, cable and conduit.
6. Dry type transformers including weight and dimensions.
7. Wiring devices and plates.
8. Dimensioned layout of electrical room drawn to scale, with equipment location shown therein. Clearances shall be in accordance with NEC and local codes.
9. Dimensioned layout of all below grade conduit installations.
10. Grounding system and layout.
11. Seismic protection materials and methods for all electrical equipment.
12. Mounting brackets, supports and assembly for walkway mounted equipment including instruments, lighting and control panels

1.4 QUALITY ASSURANCE

A. Any electrical equipment provided under this Division shall be turned over to the Owner in operating condition. Instruction on further operation and maintenance shall be included in the operating and maintenance instructions.

1.5 PRODUCT LISTING

A. Prepare listing of major electrical equipment and materials for the project.

B. Provide all information requested.

C. Submit this listing as a part of the submittal requirements.

D. When two or more items of same material or equipment are required they shall be of the same manufacturer when available. Product manufacturer uniformity does not apply to raw materials, bulk materials, wire, conduit, fittings, sheet metal, steel bar stock, welding rods, solder, fasteners, motors for dissimilar equipment kits, and similar items used in Work, except as otherwise indicated.

E. Provide products that are compatible within systems and other connected items.

1.6 NAMEPLATE DATA

A. Provide permanent operational data nameplate on each item of power operated equipment, indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Locate nameplates in an accessible location.

1.7 WORK SUPERVISION

A. The Contractor shall designate in writing the qualified electrical supervisor who shall provide supervision to all electrical work on this project. The minimum qualifications for the electrical supervisor shall be a master electrician as defined by the statutes of the State of the work being performed. The supervisor or his appointed alternate possessing at least a master electrician

license shall be on site whenever electrical work is being performed. The qualifications of the electrical supervisor shall be subject to approval of the Owner and the Engineer.

B. All master and journeyman electricians shall be licensed in accordance with the statutes of the State of the work being performed. No unlicensed electrical workers shall perform work on this project. Apprentice electricians in a ratio of not more than one apprentice per journeyman electrician will be allowed if the apprentices are licensed and actively participating in an apprentice-ship program recognized and approved by the statutes of the State of the work being performed.

1.8 LOCKOUT / TAGOUT PROGRAM

A. The Contractor shall provide a complete copy of and electrical energy source Lockout/Tagout Program to the Owner, with copy to the Engineer. The document shall clearly identify the on-site master electricians and their contact information, including office and mobile telephone numbers.

B. The Lockout/Tagout Program shall comply with Part 1910 - Occupational Safety and Health Standards (OSHA) Subpart S – Electrical, and meet the requirements of 29 CFR 1910.147, The Control of Hazardous Energy (Lockout/Tagout), including requirements listed in 1910.331 through 1910.335.

C. Implementation of the Lockout/Tagout Program and all other related safety requirements are the sole responsibility of the Contractor.

1.9 SAFETY PROGRAM

A. The Contractor shall implement an electrical safety program that complies with NFPA 70E and 29 CFR 1926.

B. Implementation of the Electrical Safety Program, determining and providing proper Personal Protective Equipment (PPE), training and enforcing personnel to wear the prescribed PPE, conducting work area safety inspections (including correcting deficiencies), and all other related safety requirements are the sole responsibility of the Contractor.

1.10 EQUIPMENT CONNECTIONS

A. General: Provide connections for all equipment installed or modified by this contract, regardless of who furnished the equipment.

B. Provide all disconnect switches required by Code whether or not shown on the plans.

C. Contractor shall connect Owner-furnished equipment when specified.

1.11 GENERAL CONDITIONS

A. The work under this heading is subject to the General and Supplementary Conditions, special conditions for mechanical and electrical work, and the Contractor or subcontractor will be responsible for and be governed by all requirements thereunder as though specifically repeated herein.

1.12 COORDINATION

A. The Contractor shall coordinate arrangement, mounting and support of all electrical equipment:
   1. To allow maximum possible headroom unless specific mounting heights are indicated.

2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
3. To allow right of way for piping and conduit installed at a required slope.
4. So connecting raceways, cables and wireways will be clear of obstructions and of the working and access space of other equipment.

B. The Contractor shall coordinate electrical equipment to be mounted on vendor supplied walkways with supplier.

1.13 SPECIAL NOTE

A. The mechanical, structural and process plans and specifications, including the general conditions and all supplements issued thereto, information to bidders, and other pertinent documents issued by the Engineer, are a part of these specifications and the accompanying electrical plans, and shall be complied with in every respect. All the above is included herewith, and shall be examined by all bidders. Failure to comply shall not relieve the Contractor of responsibility or be used as a basis for additional compensation due to omission of mechanical, process and structural details from the electrical drawings.

1.14 CONTINUATION OF SERVICES

A. The Contractor shall install any temporary lines and connections required to maintain electric services and safely remove and dispose of them when complete. The Contractor shall supply emergency power whenever any existing electrical service is without power. In general, the existing facility shall remain operational during construction.

B. Planned outages shall be coordinated two weeks in advance with duration and time of start approved by the Owner. Changeover work which may be required after normal hours or weekends shall not constitute the basis for additional cost to the Owner. When an outage begins, the Contractor shall proceed directly to completion of the work without unscheduled interruptions or delays due to lack of manpower, equipment or tools.

C. The Contractor shall refer to the sequence of construction and shall provide temporary connections as may be required to complete each phase of construction as may be required. The Contractor shall submit proposed electrical service plans for each phase of construction to the Owner and Engineer for consideration.

1.15 LAYOUT

A. The Contractor shall coordinate and establish all benchmarks and control lines. The Contractor shall lay out all work. The lay out shall be reviewed by the Engineer and Owner prior to starting any work.

1.16 RELATED WORK SPECIFIED ELSEWHERE

A. Mechanical Equipment: The Contractor shall rough-in for and make final electrical connections to all motor, panels, fixtures, and equipment furnished under other sections of the specifications, providing all material and equipment required for such final connections, except hereinbefore described. This includes, but is not limited to, control panels and other miscellaneous equipment.

B. The Contractor shall refer to other sections of these specifications for all information relating to the requirements of all electrical connections to the equipment and shall furnish and install electrical items required for a complete installation, ready for operation.

C. Roughing-in shall be accomplished from approved shop drawings.

D. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

E. Refer to equipment specifications in other Divisions for rough-in requirements.

1.17 LOCAL CONDITIONS

A. Inspection of Sites: The bidder shall inspect the site, thoroughly acquaint himself with conditions to be met and work to be accomplished. Failure to comply with this shall not constitute grounds for any additional payments.

1.18 RECORD DOCUMENTS

A. Refer to the General and Supplementary Conditions for requirements. The following paragraphs supplement the requirements of the General and Supplementary Conditions:
   1. Mark Drawings to indicate revisions to conduit size and location both exterior and interior; actual equipment locations, dimensioned for column lines; concealed equipment, dimensioned to column lines; distribution and branch electrical circuitry; fuse and circuit breaker size and arrangements; support and hanger details; Change Orders; concealed control system devices.
   2. The Contractor shall locate all underground and concealed work, identifying all equipment, conduit, circuit numbers, motors, feeders, breakers, switches, and starters. The Contractor will certify accuracy by endorsement. Record drawings shall be correct in every detail, such that the Owner can properly operate, maintain, and repair exposed and concealed work.
   3. The Contractor shall store the Record drawings on the site. Drawings shall not be rolled. Make corrections, additions, etc., with pencil, with date and authorization of change.
   4. Mark specifications to indicate approved substitutions; Change Orders; actual equipment and materials used.

1.19 OPERATION AND MAINTENANCE DATA

A. Refer to Division 01 specification sections for procedures and requirements for preparation and submittal of maintenance manuals.

B. In addition to the information required by Division 01, include the following information:
   1. Installation manual: Description of function, installation and calibration manuals, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of all replaceable parts.
   2. Operations manual: Manufacturer’s printed operating instructions and procedures to include start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; summer and winter operating instructions; and all programming and equipment settings.
   3. Maintenance manual: Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
   4. Service manual: Servicing instructions and lubrication charts and schedules, including the names and telephone numbers of personnel to contact for both routine periodic and warranty service for equipment and materials provided under this Division.
   5. Final approved equipment shop drawings, clearly labeled.
   6. Final test reports, clearly labeled, including motor certification tests.
   7. Final certified calibration sheets for all equipment and instruments.

C. After approval of the O&M Manuals, the Contractor shall provide to the Owner and Engineer in accordance with 01 77 00 – Closeout Procedures.

1.20 GUARANTEE

A. Refer to the General and Supplementary Conditions for procedures and submittal requirements for warranties. Refer to individual equipment specifications for warranty requirements.

B. Provide complete warranty information for each item to include product or equipment to include date of beginning of warranty or bond; duration of warranty or bond; and names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

C. Upon completion of the installation, the Contractor shall adjust the systems to the satisfaction of the Engineer.

D. This guarantee shall include the capacity and integrated performance of the component parts of the various systems in accordance with the intent of the specifications. The Contractor shall conduct complete tests required by the Engineer to demonstrate the ability of the various systems.

1.21 CLEANING

A. Electrical systems and components shall be thoroughly cleaned inside and outside. Remove debris, dust, concrete splatter, plaster paint and lint from all enclosures.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. All materials and equipment used in carrying out these specifications shall be new and have UL listing, or listing by other recognized testing laboratory when such listings are available. Specifications and drawings indicate name, type, or catalog numbers of materials and equipment to be used as standards.

2.2 HEAT TRACING

A. Heat trace and insulate all exposed piping, water lines, and valves where subject to freezing and not protected by other means. Where exact sizes, panels, boxes, conduit, circuitry and other items of construction are shown or required for a complete installation but are not adequately identified as to size or material requirements, the materials furnished shall be as needed to provide freeze protection requirements as though shown in detail on the Drawings. The Contractor shall be responsible for supplying all items as required for complete heat tracing systems.

B. Contractor shall meet all National Electrical code requirements for heat tracing and particularly to Resistance Heating Elements Article 427-21, 22 and 23.

PART 3 - EXECUTION

3.1 SALVAGE

A. All salvage and equipment removed by the work shall remain the property of the Owner unless directed otherwise by the Owner. Material removed from the project shall be stored on the project site where and as directed. Debris shall be removed from the job site and disposed of by the Contractor.

3.2 DEMOLITION AND DISPOSAL

A. All conduit, wire, and other electrical appurtenances associated with equipment removed in this project, and no longer in use, shall be removed and stored or disposed of as directed by the

Owner. The Contractor shall patch and apply finish to walls, floors, and other structures from which such items are removed to match surrounding colors, textures, or other visual characteristics.

3.3 DELIVERY, STORAGE, AND HANDLING

A. Deliver equipment to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.

B. Store equipment and materials at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage.

C. Equipment and materials shall be stored in accordance with the manufacturer's recommendations and instructions.

D. All equipment, including but not limited to equipment containing coils and/or electronics, shall be stored in a clean, dry, ventilated and heated building. The storage area shall be free from condensation or other injurious environmental conditions. Freedom from condensation shall be essential and shall be accomplished by the use of auxiliary heaters as required to raise the temperature to 5-degree C above the ambient temperature. The equipment shall be protected from excessive dust.

E. In addition, certain electronic equipment that requires cooling based upon its specific storage temperature range shall be stored in an air-conditioned building.

F. All motors shall be stored in a clean, dry, ventilated and heated building. The storage area shall be free from condensation or other injurious environmental conditions. Freedom from condensation shall be essential and shall be accomplished by the use of auxiliary heaters as required to raise the temperature to 5 degree C above the ambient temperature. The motors shall be protected from excessive dust.

G. Cables and wiring shall be kept in a dry location out of the sun.

H. Outdoor storage, even when protected by a tarpaulin, is unacceptable.

I. Equipment may be rejected if the storage criteria are not followed.

3.4 INSTALLATION

A. Coordinate electrical equipment and materials installation with other building components.

B. Verify all dimensions by field measurements.

C. Arrange for chases, slots, and openings in other building components to allow for electrical installations.

D. The Contractor shall keep ends of conduits, including those extending through roofs, equipment and fixtures covered or closed with caps or plugs to prevent foreign material from entering during construction.

E. Coordinate the installation of required supporting devices and sleeves to be set in concrete and other structural components as they are constructed.

F. Sequence, coordinate, and integrate installations of electrical materials and equipment for maintaining the required operation of the facility. Give particular attention to large equipment requiring positioning prior to closing-in the building.

G. Coordinate the cutting and patching of building components to accommodate the installation of electrical equipment and materials.

H. Where mounting heights are not detailed or dimensioned, install electrical services and overhead equipment to provide the maximum headroom possible.

I. Install electrical equipment to facilitate maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

J. Coordinate the installation of electrical materials and equipment above ceilings with suspension system, mechanical equipment and systems, and structural components.

K. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

L. Coordinate installation of electrical equipment on vendor supplied walkways with supplier.

3.5 MATERIALS AND WORKMANSHIP

A. All materials shall be new and shall be of the latest standard design of a manufacturer regularly engaged in the manufacture of that type of equipment. Materials shall be in good condition and shall be free from dents, scratches or other damage incurred in shipment or installation.

B. All equipment shall comply with the National Electrical Code, Underwriters Laboratories or other appropriate agency.

C. Installation shall be made in a neat and workmanlike manner, and all materials shall be installed in accordance with the recommendations of the various manufacturers. The installation shall be subject to the approval of the Owner and Engineer.

D. Incidental materials required to complete the installation as intended by these Specifications shall be of the type and quality in keeping with specified equipment.

3.6 COORDINATION

A. Carefully examine specification and drawings to be thoroughly familiar with items which require electrical connections and coordination. (Electrical drawings are diagrammatic and shall not be scaled for exact sizes.)

B. Notify other tradesmen of any deviations or special conditions necessary for the installation of work. Interference between work of various contractors shall be resolved prior to installation. Work installed not in compliance with specifications and drawings and without properly checking and coordinating as specified above shall, if necessary, be removed and properly reinstalled without additional cost to the Owner. Engineer to be mediating authority in all disputes arising on project.

C. Equipment shall be installed in accordance with manufacturer’s recommendation. Where conflicts occur between contract documents and these recommendations, a ruling shall be requested of the Engineer for decision before proceeding with such work.

3.7 CUTTING AND PATCHING

A. Repair or replace routine damage caused by cutting in performance of work under this Division.

B. Correct unnecessary damage caused due to installation of electrical work, brought about through carelessness or lack of coordination.

C. Holes cut through floor slabs to be sleeved or core drilled with drill designed for this purpose. All openings, sleeves, and holes in slabs to be properly sealed, fire proofed and waterproofed.

D. Repairs to be performed with materials which match existing materials and to be installed in accordance with appropriate sections of these specifications.

E. All cutting and patching work shall be coordinated in advance with the Engineer and Owner prior to any work.

3.8 TRENCHING, EXCAVATION, BACKFILLING, AND REPAIRS

A. Provide trenching, excavation, and backfilling necessary for performance of work under this Division.

3.9 FOUNDATIONS AND PADS

A. Foundations and pads required for equipment shall be provided as indicated. Proper size and location of foundations, pads and anchor bolts shall be determined under this Division.

B. Provide anchors and bases for electrical equipment to withstand lateral forces and accommodate displacements.

3.10 NOISE AND VIBRATION CONTROL

A. The electrical system as installed shall be free of objectionable noise or vibration. The Contractor shall isolate motors, starters, transformers, equipment, ballasts, etc., as directed or required as to ensure acceptable noise level free from objectionable vibration in all systems.

3.11 TESTS

A. On completion of work, installation shall be completely operational and entirely free from ground, short circuits, and open circuits. Perform a thorough operational test in presence of the Owner and Engineer. Furnish all labor, materials, and instruments for above tests.

B. Furnish the Engineer, as part of closing file, a copy of such tests including identification of each circuit and readings recorded. Test information to be furnished to the Engineer includes ampere readings of all panels and major circuit breakers, isolation resistance reading of motors and transformers.

C. Prior to final observation and acceptance test, all electrical systems and equipment shall be in satisfactory operating condition. Including, but not limited to the following:
   1. Electrical power and distribution system.
   2. Lighting systems.
   3. Transformers.
   4. Electric motors for all equipment.
   5. Telecommunication system.
   6. Emergency power system.
   7. Special electrical control systems.

D. After installation of the electrical system and before operating equipment, functional checking shall be conducted in accordance with the manufacturer's recommendations, with the contract drawings and as follows:
   1. Functional checking shall include inspection, testing and repair, replacement or adjustments as necessary to ensure compliance with the requirements of the specifications. Tests and inspections shall be recorded on standard test forms and checklists to indicate that wiring and controls are in place in accordance with requirements and to form the basis of record drawings.
   2. The functional test procedures shall be signed and dated by the Contractor and presented to the Owner's construction observation personnel prior to operating any equipment.
      a. Visual Inspection – The electrical system shall be examined as outlined below:
         1) Parts of components missing.
         2) Improper assembly.
         3) Parts or components not functioning properly.
         4) Finish not as specified.
         5) Materials not as specified.
         6) Connections not tight.
         7) Mounting and supports loose or unsatisfactory.
         8) Nameplates missing or inaccurate.
      b. Grounding System Tests
         1) Measure the resistance of the counterpoise grounding system by the rate-of-fall of potential method. Record all measurements on an approved standard test form made specifically for the purpose. The resistance of the grounding system to ground shall not exceed NFPA 70 requirements.
      c. Continuity Tests
         1) Each wire and each wire in each cable rated 300 volts and below shall be tested for continuity. Record wire number and pass or fail on checklist for each wire.
      d. Dielectric Tests
         1) Each power conductor rated 600 volts and above shall be tested (meggered) for dielectric strength to ground.
         2) Prior to testing, all components that could be damaged should be disconnected. After testing, the circuit shall still register a resistance value of not less than 1 megohm at 600 volts, dc. This test shall apply between all insulated circuits and external metal parts. Record equipment name, phase or wire number and all observed values for each wire.
         3) Subsequent to wire and cable hook-ups, energize circuits and demonstrate proper functioning of all circuits. Record equipment or circuit number and pass or fail on function test checklist for each circuit.
         4) The Contractor shall develop non-conforming material reports for each failure. Repair and report failures all failures to Owner and Engineer.
         5) The Contractor shall replace defective parts, correct malfunctioning units, make all repairs and retest to demonstrate compliance. The Contractor shall document all actions taken on appropriate non-conforming material report.

3.12 INSPECTION FEES AND PERMITS

A. Obtain and pay for all necessary permits and inspection fees required for electrical installation.

3.13 IDENTIFICATION OF EQUIPMENT

A. Properly identify all electrical equipment, including but not limited to the following:
   1. Switchgear, switchboards, motor control centers, and control panels.
   2. Main distribution panel and individual devices within it.
   3. Panelboards and individual devices within it.
   4. Safety switches and disconnects.

5. Contactors and lighting control center, including all branch circuits.
6. Individually mounted circuit breakers.
7. Relays.
8. Transformers.
9. Generators and automatic transfer switches.
10. Any other type of enclosure that includes electrical equipment.

3.14 TEMPORARY LIGHTS AND POWER

A. Provide a temporary electrical lighting and power distribution system of adequate size to properly serve construction activities, including adequate feeder sizes to prevent excessive voltage drop. Temporary work to be installed in a neat and safe manner in accordance with the National Electrical Code, Article 590, and as required by OSHA or applicable local safety codes.

B. The Contractor will pay for power consumption related to construction activity.

END OF SECTION

SECTION 26 05 19 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes wire and cable for low-voltage power applications, 600V and less.

B. Related Sections:
   1. Section 26 05 53 - Identification for Electrical Systems: Product requirements for wire identification.

1.2 REFERENCES

A. International Electrical Testing Association:
   1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

B. National Fire Protection Association:
   1. NFPA 70 - National Electrical Code.
   2. NFPA 262 - Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

C. Underwriters Laboratories, Inc.:
   1. UL 1277 - Standard for Safety for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.

1.3 SUBMITTALS

A. Section 01 33 00, SUBMITTAL PROCEDURES: Requirements for submittals.

B. Product Data: Submit for building wire.

C. Test Reports: Indicate procedures and values obtained.

1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of components and circuits.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.

1.6 FIELD MEASUREMENTS

A. Verify field measurements are as indicated on Drawings.

1.7 COORDINATION

A. Where wire and cable destination is indicated and routing is not shown, determine routing and lengths required.

B. Wire and cable routing indicated is approximate unless dimensioned.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLE

A. Manufacturers: including but not limited to the following.
   1. Alan Wire.
   2. Aetna Insulated Wire, Inc.
   3. General Cable Corporation.
   4. Southwire Company.
   5. Or equal.

B. Product Description: Single conductor insulated wire.

C. Conductor: Copper.

D. Insulation Voltage Rating: 600 volts.

E. Insulation Temperature Rating: 90 degrees C

2.2 WIRING CONNECTORS

A. Manufacturers: including but not limited to the following:
   1. ABB
   2. Burndy: Hubbell Inc.
   3. ILSCO
   4. 3M
   5. Ideal Industries
   6. Leviton
   7. Or equal.

2.3 TERMINATIONS

A. Terminal Lugs for Wires 6 AWG and Smaller: Solderless, compression type copper.

B. Lugs for Wires 4 AWG and Larger: Color keyed, compression type copper, with insulating sealing collars.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Service Entrance and Feeders: Copper, stranded.

B. Branch Circuits: Copper. Stranded for No. 8 AWG and larger.

C. Motor branch circuits and other vibration applications: Copper, stranded.

D. Control circuits: Copper, stranded.

3.2 CONDUCTOR INSULATION APPLICATIONS

A. Service Entrance: Type USE-2, RHW-2, or XHHW-2, single conductors in raceway.

B. Feeders: Type XHHW-2 single conductors in raceway.

C. Feeders in Cable Tray: Type XHHW-2, single conductors in raceway for larger than 4/0 AWG; otherwise type TC tray cable.

D. Branch Circuits: Type XHHW-2 or THWN-2, single conductors in raceway.

E. Cord Drops and Portable Appliance Connection: Type SO, hard service cord with stainless steel, wire mesh, strain relief device at terminations to suit application.

F. Control Circuits: Type THWN-2 or XHHW-2, in raceway.

3.3 CONDUCTOR SIZING

A. Not smaller than 12 AWG for power and lighting circuits.

B. Not smaller than 14 AWG for control circuits.

C. Increase wire size in branch circuits to limit voltage drop to a maximum of 3 percent.

3.4 EXAMINATION

A. Verify interior of building has been protected from weather.

B. Verify mechanical work likely to damage wire and cable has been completed.

C. Verify raceway installation is complete and supported.

3.5 PREPARATION

A. Completely and thoroughly swab raceway before installing wire.

3.6 EXISTING WORK

A. Remove exposed abandoned wire and cable. Patch surfaces where removed cables pass through building finishes.

B. Disconnect abandoned circuits and remove circuit wire and cable. Remove abandoned boxes when wire and cable servicing boxes is abandoned and removed. Install blank cover for abandoned boxes not removed.

C. Provide access to existing wiring connections remaining active and requiring access. Modify installation or install access panel.

D. Extend existing circuits using materials and methods as specified.

E. Clean and repair existing wiring and cable remaining, or wire and cable to be reinstalled.

3.7 INSTALLATION

A. All wiring shall be installed in a raceway.

B. Route wire and cable to meet Project conditions.

C. Neatly train and lace wiring inside boxes, equipment, and panelboards.

D. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

E. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

F. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

G. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

H. Support cables according to Section 26 05 29 - Hangers and Supports for Electrical Systems.

I. Identify and color code wire and cable under provisions of Section 26 05 53 – Identification for Electrical Systems. Identify each conductor with its circuit number or other designation indicated.

J. Special Techniques--Building Wire in Raceway:
   1. Pull conductors into raceway at same time.
   2. Install building wire 4 AWG and larger with pulling equipment.

K. Special Techniques - Wiring Connections:
   1. Clean conductor surfaces before installing lugs and connectors.
   2. Make splices, taps, and terminations to carry full ampacity of conductors with no perceptible temperature rise.
   3. Tape uninsulated conductors and connectors with electrical tape to 150 percent of insulation rating of conductor.
   4. Install split bolt connectors for copper conductor splices and taps, 6 AWG and larger.
   5. Install solderless pressure connectors with insulating covers for copper conductor splices and taps, 8 AWG and smaller.
   6. Install insulated spring wire connectors with plastic caps for copper conductor splices and taps, 10 AWG and smaller.

L. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

M. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than un-spliced conductors.

N. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

O. Cable splicing, in general, will not be allowed without prior approval from Engineer or Owner. Where applicable, all wiring connections to be made using terminal block type connections. Wire nut use is only permitted in outlet boxes for receptacle or switch wiring.

P. Install crimp on fork terminals for device terminations with stranded wire. Do not place bare stranded conductors directly under screws.

Q. Install terminal lugs on ends of 600 volt wires unless lugs are furnished on connected device, such as circuit breakers.

R. Size lugs in accordance with manufacturer's recommendations for terminating wire sizes. Install 2-hole type lugs to connect wires 4 AWG and larger to copper bus bars.

S. For terminal lugs fastened together such as on motors, transformers, and other apparatus, or when space between studs is small enough that lugs can turn and touch each other, insulate for dielectric strength of 2-1/2 times normal potential of circuit.

3.8 WIRE COLOR

A. General:
   1. For wire sizes 10 AWG and smaller, install wire colors in accordance with the following:
      a. Black and red for single phase circuits at 120/240 volts.
      b. Black, red, and blue for circuits at 120/208 volts single or three phase.
      c. Orange, brown, and yellow for circuits at 277/480 volts single or three phase.
   2. For wire sizes 8 AWG and larger, identify wire with colored tape at terminals, splices and boxes. Colors are as follows:
      a. Black and red for single phase circuits at 120/240 volts.
      b. Black, red, and blue for circuits at 120/208 volts single or three phase.
      c. Orange, brown, and yellow for circuits at 277/480 volts single or three phase.

B. Neutral Conductors: White. When two or more neutrals are located in one conduit, individually identify each with proper circuit number.

C. Branch Circuit Conductors: Install three or four wire home runs with each phase uniquely color coded.

D. Feeder Circuit Conductors: Uniquely color code each phase.

E. Ground Conductors:
   1. For 6 AWG and smaller: Green.
   2. For 4 AWG and larger: Identify with green tape at both ends and visible points including junction boxes.

3.9 FIELD QUALITY CONTROL

A. Inspect and test in accordance with NETA ATS.

B. Perform tests and inspections and prepare test reports.
   1. Megger Test of individual conductors to ground after installation. Prepare megger test reports and submit to Engineer.
   2. Visual observation of conductor at accessible locations.

C. Tests and Inspections:
   1. After installing conductors and cables and before electrical circuitry has been energized, test the following for compliance with requirements.
      a. All panel feeders.
      b. All motor feeders.
      c. All control wires for continuity.
   2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

D. Test Reports: Prepare a written report to record the following:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

E. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION

SECTION 26 05 26 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies electrical grounding and bonding as indicated on Drawings and as specified herein. Grounding and bonding Work is defined to encompass systems, circuits, and equipment.

B. Applications of electrical grounding and bonding Work include the following:
   1. Metal underground water pipe
   2. Metal building frame.
   3. Underground structures.
   4. Concrete-encased electrode.
   5. Structural Steel.
   6. Electrical power systems.
   7. Counterpoise grounding loops.
   8. Separately derived systems.
   9. Raceways.
   10. Service equipment.
   11. Equipment.

1.2 REFERENCES

A. Institute of Electrical and Electronics Engineers:
   1. IEEE 81 – Guide for Measuring Ground Resistance, and Potential Gradient in the Earth.
   2. IEEE 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.
   3. IEEE 1100 - Recommended Practice for Powering and Grounding Electronic Equipment.

B. International Electrical Testing Association:
   1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

C. National Electrical Contractors Association (NECA) Installation Standards.

D. National Fire Protection Association:
   1. NFPA 70 - National Electrical Code.
   2. NFPA 780 – Lighting Protection Code.

E. UL LCC (UL): Comply with applicable requirements of the following standards. Provide grounding and bonding products which are UL-listed and labeled for their intended usage.
   1. 467 – Electrical Grounding and Bonding Equipment.

1.3 SYSTEM DESCRIPTION

A. Grounding systems use the following elements as grounding electrodes:
   1. Metal underground water pipe.
   2. Metal building frame.
   3. Concrete-encased electrode.
   4. Rod electrode.

1.4 PERFORMANCE REQUIREMENTS

A. Grounding System Maximum Resistance: 10 ohms maximum.

B. Excessive Ground Resistance: If resistance to ground exceeds specified value, notify Engineer promptly and include recommendations to reduce ground resistance.

1.5 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Product Data: Submit data on grounding electrodes and connections.

C. Test Reports: Indicate overall resistance to ground.

D. Manufacturer's Installation Instructions:

E. Project Record Documents: Record actual locations of components and grounding electrodes.

1.6 QUALITY ASSURANCE

A. Provide grounding materials conforming to requirements of NEC, IEEE 142, and UL labeled.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum three years documented experience.

B. Installer: Company specializing in performing work of this section with minimum 3 years documented experience approved by manufacturer.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site in original factory packaging, labeled with manufacturer's identification.

B. Protect from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original packaging.

C. Do not deliver items to project before time of installation. Limit shipment of bulk and multiple-use materials to quantities needed for immediate installation.

1.9 COORDINATION

A. Complete grounding and bonding of building reinforcing steel prior to concrete placement.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Subject to compliance with requirements, provide grounding and bonding products of one of the following (for each type of product):
   1. Grounding Products:
      a. Advanced Lightning Technology.
      b. Anderson/Square D.
      c. Burndy LLC.

d. Cadweld Div.; Erico Products Inc.
e. Crouse-Hinds Div.; Cooper Industries.
f. Erico-International Corporation.
g. Fushi-Copperweld Inc.
h. Harger Lighting and Grounding.
i. Ideal Industries, Inc.
j. Joslyn Corporation.
k. Myers Electric Products, Inc.
l. O.Z. Gedney Div.; General Signal Corp.
m. Thomas & Betts Corp.
n. Or equal.

2.2 ROD ELECTRODES

A. Product Description:
1. Material: Copper-clad steel or copper-alloy, sectional type or pointed rods.
2. Diameter: 3/4 inch.
3. Length: 10 feet.

2.3 WIRE

A. Insulated Conductors: Stranded copper wire insulated for 600V.

B. Direct Buried Bare Conductors: Stranded tinned copper.

C. Above Grade Bare Conductors: Stranded copper.

D. Foundation Electrodes: Size per NEC or as indicated on drawings, minimum #4AWG.

E. Grounding Electrode Conductor: Size per NEC or as indicated on drawings, minimum #4AWG.

2.4 GROUNDING BUS BARS

A. Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, 1/4 by 4 inches in cross section, length as required for the application. The bus bar shall be mounted using steel brackets and UL-listed standoff insulators rated for a minimum of 2500V.

2.5 Bonding Plates, Connectors, Terminals, and Clamps:

A. Description: Provide electrical bonding plates, connectors, terminals, lugs, and clamps as recommended by bonding plate, connector, terminal, and clamp manufacturers for indicated applications.
1. Bolted Connectors for Conductors and Pipes: Copper or copper-alloy, pressure type with at least two silicon bronze or stainless-steel bolts and lock washers.
2. Irreversible Compression Fittings: Pure wrought copper extrusion clamps and connectors, made to be held in the dies of an installation tool. Connectors must be factory filled with an oxide inhibitor.
3. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
4. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless exothermic-type wire terminals and long-barrel, two-bolt connection to ground bus bar.

2.6 EXOTHERMIC CONNECTIONS

A. Product Description: Exothermic materials, accessories, and tools for preparing and making permanent field connections between grounding system components.

2.7 Ground Clips: A 2-inch x 6-inch x 1/4-inch galvanized steel plate with hole for ½-inch hardware. Clip shall be welded to structural steel to facilitate bonding.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify final backfill and compaction has been completed before driving rod electrodes.

3.2 PREPARATION

A. Remove paint, rust, mill oils, surface contaminants at connection points.

3.3 GROUNDING APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.

B. Conductor Terminations and Connections:
1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Bolted connectors.

3.4 GROUNDING INSTALLATION

A. Install in accordance with IEEE 142 1100.

B. Install grounding and bonding conductors concealed from view.

C. Test Wells: Install grounding test well box with cover at rod locations as indicated on drawings, or a minimum of one per service. Install well cover flush with finished grade.

D. Bond together metal siding not attached to grounded structure; bond to ground.

E. Bond together each metallic raceway, pipe, duct, and other metal object entering a structure. Install 2 AWG bare copper bonding conductor.

F. Permanently ground entire light and power system in accordance with NEC, including service equipment, distribution panels, lighting panelboards, switch and starter enclosures, motor frames, grounding type receptacles, and other exposed non-current carrying metal parts of electrical equipment.

G. Install branch circuits feeding isolated ground receptacles with separate insulated grounding conductor, connected only at isolated ground receptacle, ground terminals, and at ground bus of serving panel.

H. Equipment Grounding Conductor: Accomplish grounding of electrical system by using insulated grounding conductor installed with feeders and branch circuit conductors in conduits. Size

grounding conductors in accordance with NEC. Install from grounding bus of serving panel to ground bus of served panel, grounding screw of receptacles, lighting fixture housing, light switch outlet boxes or metal enclosures of service equipment. Ground conduits by means of grounding bushings on conduit box fittings.

I. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact or damage.

J. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor and install in conduit.

K. Ground rods: Drive rods until tops are 2 inches below finished floor or final grade, unless otherwise indicated.
   1. Install rod electrodes at locations as indicated on Drawings. Install additional rod electrodes to achieve specified resistance to ground.
   2. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.

L. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
   1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
   2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
   3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

M. Grounding and Bonding for Piping:
   1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit from building's main service equipment, or grounding bus, to main metal water service entrance to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
   2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
   3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

N. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

O. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

P. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column and indicated item, extending around the perimeter of building.

1. Install tinned-copper conductor not less than No. 4/0 AWG for ground ring and for taps to building steel.
2. Bury ground ring not less than 24 inches from building foundation at a depth not less than 30 inches below finished grade.

Q. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, using a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.
1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.

R. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to grounding electrode external to concrete.

S. Permanently attach equipment and grounding conductors prior to energizing equipment.

3.5 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with ANSI/IEEE C2 grounding requirements.

B. Grounding Manholes: Install a driven ground rod through manhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.

D. Pad-Mounted Equipment: Install four ground rods and ground ring around the pad for outdoor transformers, generators, or switchgear. Ground pad-mounted equipment and noncurrent-carrying metal items associated with equipment by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 4/0 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.6 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.

B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers,

humidifiers and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

C. Water Heater, Heat-Tracing and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment and components.

D. Metal Poles Supporting Outdoor Lighting fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.7 FIELD QUALITY CONTROL

A. Inspect and test in accordance with NETA ATS.

B. Perform ground resistance testing in accordance with IEEE 142.

C. Perform continuity testing in accordance with IEEE 142.

D. When improper grounding is found on receptacles, check receptacles in entire project and correct. Perform retest.

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:
   1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
   2. Test completed grounding system at service disconnect enclosure grounding terminal at ground test wells. Make tests at ground rods before any conductors are connected.
      a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
      b. Perform tests by fall-of-potential method according to IEEE 81.
   3. Prepare dimensioned drawings locating each test well, ground rod and ground rod assembly and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

END OF SECTION

SECTION 26 05 29 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Conduit supports.
   2. Formed slotted support channel.
   3. Spring steel clips.
   4. Equipment bases and supports.

B. Related Sections:
   1. Section 01 33 00 – Submittal Procedures.
   2. Section 03 30 00 – Cast-In-Place Concrete.

1.2 SUBMITTALS

A. Section 01 33 00, SUBMITTAL PROCEDURES: Requirements for submittals.

B. Shop Drawings: Indicate system layout with location and detail of trapeze hangers.

C. Product Data:
   1. Hangers and Supports: Submit manufacturers catalog data including load capacity.

D. Design Data: Indicate load carrying capacity of trapeze hangers and hangers and supports.

E. Manufacturer's Installation Instructions:
   1. Hangers and Supports: Submit special procedures and assembly of components.

F. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.3 PERFORMANCE REQUIREMENTS

A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.4 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum five years documented experience.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site in original factory packaging, labeled with manufacturer's identification.

B. Protect from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original packaging.

PART 2 - PRODUCTS

2.1 CONDUIT SUPPORTS

A. Manufacturers:
1. Allied Tube & Conduit.
2. Cooper B-Line, Inc.; a division of cooper Industries.
3. ERICO International Corporation
4. GS Metals Corp.
5. Thomas & Betts Corporation.
6. Unistrut; Tyco International, Ltd.
7. Wesanco, Inc.
8. Or equal.

B. Hanger Rods: Threaded high tensile strength with free running threads.

C. Beam Clamps: With tapered hole in base and back to accept either bolt or hanger rod.

D. Conduit clamps for trapeze hangers: Notched to fit trapeze with single bolt to tighten.

E. Conduit clamps - general purpose: One hole for surface mounted conduits.

2.2 FORMED SLOTTED SUPPORT CHANNEL

A. Manufacturers:
1. Allied Tube & Conduit.
2. Cooper B-Line, Inc.; a division of cooper Industries.
3. ERICO International Corporation
4. GS Metals Corp.
5. Thomas & Betts Corporation.
6. Unistrut; Tyco International, Ltd.
7. Wesanco, Inc.
8. Or equal.

B. Product Description: Factory fabricated slotted support channels with holes 1-1/2 inches on center, complying with MFMA-4.

2.3 SPRING CLIPS

A. Manufacturers:
1. Allied Tube & Conduit.
2. Cooper B-Line, Inc.; a division of cooper Industries.
3. ERICO International Corporation
4. GS Metals Corp.
5. Thomas & Betts Corporation.
6. Unistrut; Tyco International, Ltd.
7. Wesanco, Inc.
8. Or equal.

B. Product Description: Mounting hole and screw closure.

PART 3 - EXECUTION

3.1 HANGERS AND SUPPORTS APPLICATION

A. Outdoor Locations
   1. Slotted support channels shall be PVC-Coated steel or stainless steel.
   2. Clips, clamps, threaded rods, and fastening hardware shall be stainless steel.

B. Dry Indoor Locations
   1. Slotted support channels shall be galvanized steel.
   2. Clips, clamps, threaded rods, and fastening hardware shall be galvanized steel.

C. Damp or Wet Indoor Locations
   1. Slotted support channels shall be PVC-Coated steel or stainless steel.
   2. Clips, clamps, threaded rods, and fastening hardware shall be stainless steel.

3.2 INSTALLATION - HANGERS AND SUPPORTS

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical system except if requirements in this Section are stricter.

B. Anchors and Fasteners:
   1. Concrete Structural Elements: Provide precast inserts, expansion anchors, powder actuated anchors and preset inserts.
   2. Steel Structural Elements: Provide beam clamps, spring steel clips, steel ramset fasteners, and welded fasteners.
   3. Concrete Surfaces: Provide self-drilling anchors and expansion anchors.
   4. Hollow Masonry, Plaster, and Gypsum Board Partitions: Provide toggle bolts and hollow wall fasteners. Do not mount electrical panels directly to hollow walls – provide slotted support channels attached to wall studs for panel mounting.
   5. Solid Masonry Walls: Provide expansion anchors and preset inserts.
   6. Sheet Metal: Provide sheet metal screws.
   7. Wood Elements: Provide wood screws.

C. Inserts:
   1. Install inserts for placement in concrete forms.
   2. Install inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
   3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
   4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
   5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.

D. Install conduit and raceway support and spacing in accordance with NEC.

E. Do not fasten supports to pipes, ducts, mechanical equipment, or conduit.

F. Install multiple conduit runs on common hangers, sized for 25% spare capacity for future raceways.

G. Slotted support channels supported from threaded hanger rods shall be secured with double nuts.

H. Supports:

1. Fabricate supports from structural steel or formed metal channel. Install hexagon head bolts to present neat appearance with adequate strength and rigidity. Install spring lock washers under nuts.
2. Install surface mounted cabinets and panelboards with minimum of four anchors.
3. Install channel supports to stand cabinets and panelboards 1 inch off wall.
4. Support vertical conduit at every floor.

I. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lbs.

3.3 INSTALLATION - EQUIPMENT BASES AND SUPPORTS

A. Provide housekeeping pads of concrete, minimum 4 inches thick and extending 6 inches beyond supported equipment. Refer to Section 03 30 00, CAST IN PLACE CONCRETE.

B. Anchor equipment to concrete base.
1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

END OF SECTION

SECTION 26 05 33 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes surface raceways, fittings, outlet boxes, pull and junction boxes, and conduit sleeves for electrical systems.

1.2 REFERENCES

A. American National Standards Institute:
   1. ANSI C80.1 - Rigid Steel Conduit, Zinc Coated.
   2. ANSI C80.3 - Specification for Electrical Metallic Tubing, Zinc Coated.
   3. ANSI C80.5 - Aluminum Rigid Conduit - (ARC).

B. National Electrical Manufacturers Association:
   1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
   2. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies.
   3. NEMA OS 1 - Sheet Steel Outlet Boxes, Device Boxes, Covers, and Box Supports.
   4. NEMA OS 2 - Nonmetallic Outlet Boxes, Device Boxes, Covers, and Box Supports.
   5. NEMA RN 1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
   6. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Tubing and Conduit.
   7. NEMA TC 3 - PVC Fittings for Use with Rigid PVC Conduit and Tubing.

1.3 SYSTEM DESCRIPTION

A. Raceway and boxes located as indicated on Drawings, and at other locations required for splices, taps, wire pulling, equipment connections, and compliance with regulatory requirements. Raceway and boxes are shown in approximate locations unless dimensioned. Provide raceway to complete wiring system.

1.4 DESIGN REQUIREMENTS

A. Minimum Raceway Size: 3/4 inch unless otherwise specified.

B. Flexible Conduit Connections: Use maximum of 36 inches of flexible conduit for equipment subject to vibration, noise transmission, or movement.

1.5 SUBMITTALS

A. Product Data: Submit for the following:
   1. Liquidtight flexible metal conduit.
   2. Nonmetallic conduit.
   3. Flexible nonmetallic conduit.
   4. Nonmetallic tubing.
   5. Raceway fittings.
   6. Conduit bodies.
   7. Surface raceway.
   8. Pull and junction boxes.

B. Manufacturer's Installation Instructions: Submit application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include

instructions for storage, handling, protection, examination, preparation, and installation of Product.

1.6 CLOSEOUT SUBMITTALS

A. Project Record Documents:
   1. Record actual routing of all conduits.
   2. Record actual locations and mounting heights of outlet, pull, and junction boxes.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Protect conduit from corrosion and entrance of debris by storing above grade. Provide appropriate covering.

B. Protect PVC conduit from sunlight.

1.8 COORDINATION

A. Coordinate mounting heights, orientation, and locations of outlets mounted above counters, benches, and backsplashes.

PART 2 - PRODUCTS

2.1 METAL CONDUIT

A. Manufacturers:
   1. Allied Tube & Conduit; a part of Atkore International.
   2. EGS/Appleton Electric.
   3. Republic Conduit.
   4. Thomas & Betts Corporation; A Member of the ABB Group.
   5. Western Tube & Conduit Corporation.
   6. Wheatland Tube Company.
   7. Or equal.

B. Rigid Steel Conduit: ANSI C80.1 and UL 6.

C. Rigid Aluminum Conduit: ANSI C80.5.

D. Fittings and Conduit Bodies: NEMA FB 1; material to match conduit.

E. Threaded Joint Compound: UL listed for use in conduit assemblies, to lubricate and protect threaded conduit joints from corrosion and to enhance conductivity.
   1. Eaton STL8 or equal.

2.2 PVC COATED METAL CONDUIT

A. See Section 26 05 33.13, PVC COATED CONDUIT, for requirements.

2.3 LIQUIDTIGHT FLEXIBLE METAL CONDUIT

A. Manufacturers:
   1. AFC Cable Systems: a part of Atkore International.
   2. Adamet Electrical, Inc.
   3. Carlon, a brand of Thomas & Betts Corporation.
   4. EGS/Appleton Electric.

5. Southwire Company.
6. Or equal.

B. Product Description: Interlocked galvanized steel construction with moisture, oil, and sunlight resistant PVC jacket.

C. Fittings: NEMA FB 1.

2.4 NONMETALLIC CONDUIT

A. Manufacturers:
1. Carlon, a brand of Thomas & Betts Corporation.
2. EGS/Appleton Electric.
3. Or equal.

B. Product Description: NEMA TC 2; Schedule 40 or 80 PVC.

C. Fittings and Conduit Bodies: NEMA TC 3.

2.5 OUTLET AND DEVICE BOXES

A. Manufacturers:
1. ABB
2. Allied
3. Emerson
4. Eaton
5. Hubbell
6. Or equal.

B. Sheet Metal Outlet and Device boxes: NEMA OS 1.

C. Nonmetallic Outlet and Device Boxes: NEMA OS2.

D. Cast Outlet and Device Boxes: FEMA FB1, Type FD, material to match conduit type. Furnish gasketed cover.

E. Wall Plates for Finished Areas: As specified in Section 26 27 26, WIRING DEVICES.

F. Wall Plates for Unfinished Areas: Furnish gasketed cover.

2.6 PULL AND JUNCTION BOXES

A. Manufacturers:
1. nVent Hoffman.
2. Rittal.
3. Eaton.
4. Hubbell
5. Or equal.

B. Hinged-Cover Enclosures: Continuous-hinge cover with flush latch, unless otherwise indicated. NEMA 250 rating as indicated in Part 3.

2.7 HAZARDOUS LOCATION CONDUIT SEAL FITTINGS

A. Manufacturers:

1. Eaton.
2. Emerson.
3. Or equal.

B. UL listed seal fitting designed to restrict the passage of gasses, vapors, or flames from one portion of the conduit system to another. Listed for installation in Class I, Division 1 & 2 locations.

C. Material type to match installed conduit material type. Designed for installation in vertical or horizontal positions.

2.8 RACEWAY SLEEVES

A. Provide round galvanized steel or cast-iron conduit raceway sleeves when penetrating conduit through masonry or concrete walls.
1. Steel Wall Sleeves: ASTM A53, Type E, Grade B, Schedule 40, zinc coated, plain ends and integral water-stop.
2. Cast-Iron Wall Sleeves: Cast or fabricated wall pipe, equivalent to ductile-iron pressure pipe, with plain ends and integral water-stop.

2.9 SLEEVE SEALING SYSTEM

A. Description: Modular elastomer sealing system, designed for field assembly, to provide weather-proof seal of annular space between sleeve and conduit.
1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
2. Pressure Plates: Stainless steel. Include two for each sealing element.
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoor Locations
1. Exposed: PVC-Coated Rigid Steel
2. Connection to Vibrating Equipment (Transformers, Motors, etc.): Liquid-tight Flexible Metal Conduit (LFMC)

B. Indoor Locations
1. Exposed Clean and Dry Locations: Galvanized Rigid Steel
2. Exposed Damp or Wet Locations: PVC-Coated Rigid Steel
3. Concealed above ceilings or in walls: Electric Metallic Tubing (EMT) with compression fittings.
4. Connection to Vibrating Equipment (Transformers, Motors, etc.): Liquid-tight Flexible Metal Conduit (LFMC)

C. Underground Locations
1. See Section 26 05 43, UNDERGROUND DUCTS AND BOXES FOR ELECTRICAL SYSTEMS, for underground raceway applications.

3.2 BOX APPLICATION

A. Outdoor Locations
1. Pull or Junction Boxes: NEMA 4X stainless steel

2. Device or Outlet Boxes: NEMA FB1 Type FD PVC-coated cast metal with gasketed covers

B. Indoor Locations
1. Dedicated Locations (Electrical Rooms):
a. Pull or Junction Boxes: NEMA 1
b. Surface Mount Device or Outlet Boxes: NEMA FB1 Type FD cast metal
c. Recessed or Concealed Device or Outlet Boxes: NEMA OS1 sheet metal
2. Dry Non-Dedicated Locations (subject to Dust, Dirt only):
a. Pull or Junction Boxes: NEMA 12
b. Surface Mount Device or Outlet Boxes: NEMA FB1 Type FD cast metal with gasketed covers
3. Damp or Wet Locations:
a. Pull or Junction Boxes: NEMA 4X stainless steel
b. Surface Mount Device or Outlet Boxes: NEMA FB1 Type FD PVC-coated cast metal with gasketed covers

C. Underground Locations
1. See Section 26 05 43, UNDERGROUND DUCTS AND BOXES FOR ELECTRICAL SYSTEMS, for underground box applications.

3.3 EXAMINATION

A. Verify outlet locations and routing and termination locations of raceway prior to rough-in.

3.4 INSTALLATION - GENERAL

A. Ground and bond raceway and boxes in accordance with Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

B. Fasten raceway and box supports to structure and finishes in accordance with Section 26 05 29, HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS.

C. Identify raceway and boxes in accordance with Section 26 05 53, IDENTIFICATION FOR ELECTRICAL SYSTEMS.

D. Arrange raceway and boxes to maintain headroom and present neat appearance. Route raceway parallel and perpendicular to walls.

3.5 INSTALLATION - RACEWAY

A. Raceway routing is shown in approximate locations unless dimensioned. Route to complete wiring system.

B. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

C. Arrange raceway supports to prevent misalignment during wiring installation.

D. Support raceway using coated straps, lay-in adjustable hangers, clevis hangers, and split hangers.

E. Group related raceway; support using conduit rack. Construct rack using channel supports specified in Section 26 05 29, HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS;

provide material type to match provided conduit material type. Provide space on each for 25 percent additional raceways.

F. Do not support raceway with wire or perforated pipe straps. Remove wire used for temporary support. Do not attach raceway to ceiling support wires or other piping systems.

G. Maintain clearance between raceway and piping for maintenance purposes. Maintain 12 inches clearance between raceway and surfaces with temperatures exceeding 104 degrees F.

H. Cut conduit square using saw or pipe cutter; de-burr cut ends.

I. Join nonmetallic conduit using cement as recommended by manufacturer. Wipe nonmetallic conduit dry and clean before joining. Apply full even coat of cement to entire area inserted in fitting. Allow joint to cure for minimum 20 minutes.

J. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

K. Aluminum raceway shall not be installed in contact with concrete or earth.

L. Install weatherproof conduit hubs with grounding bushing and insulated throat, to fasten rigid metal conduit to boxes. Hub material type shall match conduit material type and shall provide a NEMA rating equal to or greater than the NEMA rating of the box.

M. Install insulating bushings and inserts at raceway connections to boxes, corner fittings, or locations subject to vibration.

N. Install no more than equivalent of three 90 degree bends between boxes. Install conduit bodies to make sharp changes in direction, as around beams. Install factory elbows for bends in metal conduit larger than 2-inch size.

O. Avoid moisture traps; install junction box with drain fitting at low points in conduit system.

P. Install suitable pull string or cord in each empty raceway except sleeves and nipples. Leave at least 12 inches of slack at each end of pull wire.

Q. Install suitable caps to protect installed conduit against entrance of dirt and moisture.

R. Cord Fittings:
   1. Where exposed cords or cables emerge from a raceway system, install gasketed weatherproof cord fittings to seal raceways and protect cords from damage. Cord fittings shall include an elastomeric grommet seal designed to be tightened around the cable for a weathertight seal.
   2. Where cord fitting is installed within a hazardous location, provide fitting that is UL listed for the defined hazardous classification.
   3. Cord fitting material shall match the conduit material type.

S. Expansion-Joint Fittings:
   1. Install in each run of exterior aboveground conduit that has straight-run length that exceeds 25 feet.
   2. Provide type and quantity of fittings for each run to accommodate a 125 deg F temperature change.

3. Install each expansion-joint fitting with position, mounting and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.

T. Raceways Embedded in Slabs:
1. Run conduit parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
2. Do not embed conduits larger than 1-1/2" in slabs. Conduits larger than 1-1/2" shall be routed below concrete slabs.
3. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
4. Do not install conduits in such a manner as to compromise the structural integrity of walls, roofs, ceilings, or floor. Where necessary, provide additional supporting members to support conduit runs.
5. Comply with Chapter 6 of ACI 318.
6. Change from nonmetallic conduit to Galvanized Rigid Steel or PVC-Coated Rigid Steel Conduit before rising above the floor.

U. Raceway Seals:
1. Install raceway sealant compound within the interior of raceways at suitable, approved, and accessible locations. Sealants shall be identified for use with the cable insulation, shield, or other components. Install raceway seals at the following points:
   a. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces or boundaries from exterior to interior locations.
   b. Service raceway building entrances.
   c. All spare or unused raceways.
   d. Where otherwise required by NFPA 70.

V. Hazardous Locations:
1. Boundary Seals: Provide hazardous location conduit seal fittings at boundaries to hazardous locations following the requirements of NEC Article 500 and Article 501.
2. When conduit is installed within hazardous locations, provide material that is UL listed for the defined hazardous classification, and install per requirements of NEC Article 500 and Article 501.

W. Conduit Wall or Floor Penetrations:
1. Seal all conduit penetrations through non-fire-rated walls and slabs with a weatherproof sealant meeting the requirements of Specification 07 92 00, JOINT SEALANTS, non-shrink grout meeting the requirements of Specification 03 60 00, GROUT, or sleeve seal system meeting the requirements of this specification.
2. Firestopping: Install conduit in a manner to preserve fire resistance rating of walls. Refer to Specification 07 84 00, FIRESTOPPING.
3. Do not penetrate conduits through wet well walls below the high-level water mark.
4. Coordinate installation of conduit wall sleeves prior to concrete placement.

3.6 INSTALLATION - BOXES

A. Install wall mounted boxes at elevations to accommodate mounting heights as indicated on Drawings.

B. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Coordinate masonry cutting to achieve neat opening.

C. Adjust box location prior to rough-in to accommodate intended purpose.

D. Orient boxes to accommodate wiring devices.

E. Install pull boxes and junction boxes above accessible ceilings and in unfinished areas only.

F. In Accessible Ceiling Areas: Install outlet and junction boxes no more than 6 inches from ceiling access panel or from removable recessed luminaire.

G. Do not install flush mounting box back-to-back in walls; install with minimum 6 inches separation.

H. Secure flush mounting box to interior wall and partition studs. Accurately position to allow for surface finish thickness.

I. Install stamped steel bridges to fasten flush mounting outlet box between studs.

J. Install flush mounting box without damaging wall insulation or reducing its effectiveness.

K. Install adjustable steel channel fasteners for hung ceiling outlet box.

L. Do not fasten boxes to ceiling support wires or other piping systems.

M. Support boxes independently of conduit.

N. Install gang box where more than one device is mounted together. Do not use sectional box.

O. Install gang box with plaster ring for single device outlets.

P. Hazardous Locations:
   1. When boxes are installed within hazardous locations, provide material that is UL listed for the defined hazardous classification, and install per requirements of NEC Article 500 and Article 501.

3.7 ADJUSTING

A. Adjust flush-mounting outlets to make front flush with finished wall material.

B. Install knockout closures in unused openings in boxes.

3.8 CLEANING

A. Clean interior of boxes to remove dust, debris, and other material.

B. Clean exposed surfaces and restore finish.

END OF SECTION

SECTION 26 05 33.13 – PVC COATED CONDUIT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes PVC coated raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

B. Related Sections include the following:
   1. Section 26 05 33 – Raceway and Boxes for Electrical Systems.

1.2 SUBMITTALS

A. Product Data: for surface raceways, wireways and fittings, hinged-cover enclosures, and cabinets.

B. Custom enclosures and cabinets.

C. Source quality-control test reports.

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. Comply with NFPA 70.

C. All the conduit, fittings, and supporting products shall be provided by the same manufacturer to ensure that a five-year product warrantee is achieved.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include:
   1. Perma-Cote
   2. Plasti-Bond
   3. KorKap
   4. Calbond

2.2 MATERIALS

A. PVC coated, Galvanized Rigid Conduit and fittings shall meet all the performance standards specified herein and such performance standards shall require verification by a nationally recognized testing agency including ASTM (American Society for Testing and Materials) and UL (Underwriter Laboratories).

B. The PVC coated galvanized rigid conduit shall be UL Listed. The PVC coating shall have been investigated by UL as providing the primary corrosion protection for the rigid metal conduit. Ferrous fittings for general service locations shall be UL Listed with PVC as the primary corrosion protection. Hazardous location fittings, prior to plastic coating shall be UL listed. All conduits and fittings shall be new, unused material. Applicable UL standards shall include: UL 6

Standard for Safety, Rigid Metal Conduit, UL514B Standard for Safety, Fittings for Conduit and Outlet Boxes.

C. The PVC coated galvanized rigid conduit shall be Electrical Testing Laboratory (ETL) Verified to the Intertek ETL SEMKO High Temperature H2O PVC Coating Adhesion Test Procedure for 200 hours. The PVC coated galvanized rigid conduit shall bear the ETL Verified PVC-001 label to signify compliance to the adhesion performance standard.

D. The conduit shall be hot dip galvanized inside and out with hot galvanized threads.

E. A PVC sleeve extending one pipe diameter or two inches, whichever is less, shall be formed at every female fitting opening except unions. The inside sleeve diameter shall be matched to the outside diameter of the conduit.

F. The PVC coating on the outside of conduit couplings shall have a series of longitudinal ribs 40 mils in thickness to protect the coating from tool damage during installation.

G. Form 8 Condulets, 1/2" through 2" diameters, shall have a v-seal tongue-in-groove gasket to effectively seal against the elements. The design shall be equipped with a positive placement feature to ease and assure proper installation. Certified results confirming seal performance at 15 psig (positive) and 25 in. of mercury (vacuum) for 72 hours shall be available. Form 8 Condulets shall be supplied with plastic encapsulated stainless steel cover screws.

H. A urethane coating shall be uniformly and consistently applied to the interior of all conduit and fittings. This internal coating shall be a nominal 2 mil thickness. Conduit or fittings having areas with thin or no coating shall be unacceptable.

I. The PVC exterior and urethane interior coatings applied to the conduit shall afford sufficient flexibility to permit field bending without cracking or flaking at temperatures above 30°F (-1°C).

J. All male threads on conduit, elbows and nipples shall be protected by application of a urethane coating.

K. All female threads on fittings or conduit couplings shall be protected by application of a urethane coating.

L. Independent certified test results shall be available to confirm coating adhesion under the following conditions:
   1. Conduit and condulet exposure to 150°F (65°C) and 95% relative humidity with a minimum mean time to failure of 30 days (ASTM D1151).
   2. The interior coating bond shall be confirmed using the Standard Method of Adhesion by Tape Test (ASTM D3359).
   3. No trace of the internal coating shall be visible on a white cloth following six wipes over the coating which has been wetted with acetone (ASTM D1308).
   4. The exterior coating bond shall be confirmed using the methods described in Section 3.8, NEMA RN1. After these tests the physical properties of the exterior coating shall exceed the minimum requirements specified in Table 3.1, NEMA RN1.

M. Right angle beam clamps and U bolts shall be specially formed and sized to snugly fit the outside diameter of the coated conduit. All U bolts shall be supplied with plastic encapsulated nuts that cover the exposed portions of the threads.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All clamping, cutting, threading, bending, and assembly instructions listed in the manufacturer's installation guide should be vigorously followed.

B. Installation of the PVC Coated Conduit System shall be performed in accordance with the Manufacturer's Installation Manual. To assure correct installation, the installer shall be certified by Manufacturer to install coated conduit.

C. Installer certification, before installation, is required.

D. Clamps, bolts, angles, pipe straps, struts, rods, nuts and other supporting products for PVC coated conduits shall be PVC coated or stainless steel.

E. The Contractor shall use equipment specifically designed for PVC coated conduit when cutting, clamping, reaming, threading, bending, assembling or performing other installation procedures. PVC coating shall be protected.

F. Where PVC-coated conduit transitions to liquid-tight flexible metal conduit, utilize PVC-coated couplings on both ends of the liquid-tight flexible metal conduit connection.

G. Touch-up compound for PVC coated conduit shall NOT be allowed. All conduits with damaged coatings shall be removed and replaced at no cost to Owner.

END OF SECTION

SECTION 26 05 43 – UNDERGROUND DUCTS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Conduit and accessories for below grade duct banks.
2. Precast concrete boxes.
3. Polymer concrete composite boxes.

B. Related Requirements:
1. Section 26 05 33 – Raceway and Boxes for Electrical Systems.
2. Section 26 05 53 – Identification for Electrical Systems.
3. Section 31 23 16 – Excavation.
4. Section 31 23 16.13 – Trenching for Site Utilities.
5. Section 31 23 23.13 – Fill and Backfill.

1.2 REFERENCE STANDARDS

A. ASTM International:
1. ASTM C857 - Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
2. ASTM C858 - Standard Specification for Underground Precast Concrete Utility Structures.
3. ASTM C891 - Standard Practice for Installation of Underground Precast Concrete Utility Structures.
4. ASTM C1037 - Standard Practice for Inspection of Underground Precast Concrete Utility Structures.

B. National Electrical Manufacturers Association:
1. NEMA FB 1 - Fittings, Cast Metal Boxes and Conduit Bodies for Conduit, Electrical Metallic Tubing (EMT) and Cable.
2. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Tubing and Conduit.
3. NEMA TC 3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
4. NEMA TC 6 and 8 - Polyvinyl Chloride (PVC) Plastic Utilities for Underground Installations.
5. NEMA TC 9 - Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation.
6. NEMA TC 14 - Aboveground Reinforced Thermosetting Resin Conduit and Fittings.

C. UL, Inc.:
1. UL 651A - Type EB and A Rigid PVC Conduit and HDPE Conduit.

1.3 COORDINATION

A. Coordinate Work of this Section with existing underground utilities and structures.

B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions and surface features. Revise locations and elevations from those indicated a required to suit field conditions and to ensure that duct runs drain to manholes and handholes and as approved by Engineer.

1.4 DEFINITIONS

A. The term “manhole” is used throughout to indicate a pre-cast concrete underground box providing access to below grade cables and conductors.

B. The term “handhole” is used throughout to indicate a polymer-concrete composite underground box providing access to below grade cables and conductors.

1.5 SUBMITTALS

A. Section 01 33 00, SUBMITTAL PROCEDURES: Requirements for submittals.

B. Product Data: Submit manufacturer information for metallic conduits, nonmetallic conduits, ducts, manhole accessories, handholes, and manholes.

C. Shop Drawings: Indicate dimensions, reinforcement, size and locations of duct entry provisions, grounding details, and accessory locations for each type and size of manhole or handhole provided.

D. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

E. Manufacturer Instructions: Submit detailed instructions on installation requirements, including storage and handling procedures.

F. Source Quality-Control Submittals: Indicate results of factory tests and inspections.

G. Qualifications Statement:
   1. Submit qualifications for manufacturer.

H. Product Data: For the following:
   1. Accessories for manholes, handholes, boxes.

I. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.
   1. Include plans and sections, drawn to scale, and show bends and locations of fittings.

J. Product Certificates: for concrete and steel used in precast concrete manholes, as required by ASTM C858.

1.6 CLOSEOUT SUBMITTALS

A. Project As-Built Documents:
   1. Record actual routing and elevations of underground conduit and duct.
   2. Record actual locations and sizes of manholes and handholes.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this Section with a minimum of five years documented experience.

1.8 SOURCE QUALITY CONTROL

A. Testing: Provide shop testing of completed assembly.

B. Inspection: Inspect manholes according to ASTM C1037.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.

B. Store products according to manufacturer instructions.

C. Protection:
   1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
   2. Provide additional protection according to manufacturer instructions.

D. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

E. Store manholes and handholes at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.

F. Lift and support precast concrete units only at designated lifting or supporting points.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Interconnected system of conduits, ducts, manholes, and handholes to distribute power, control, and data communications wiring. Conduit and duct routing and manhole/handhole locations are shown in approximate locations on Drawings unless dimensions are indicated. Route and locate for completion of duct bank system.

B. Design Requirements: Minimum below-grade conduit size shall be 1”; raceways designated as 3/4” on drawings shall transition to 1” below grade.

2.2 RIGID STEEL CONDUIT

A. Description:
   1. Rigid Steel Conduit: Comply with ANSI C80.1.
   2. Fittings:
      a. Comply with NEMA FB 1.
      b. Material: Galvanized Steel.

B. PVC COATED RIGID STEEL CONDUIT
   1. Refer to 26 05 33.13, PVC COATED CONDUIT, for requirements.

2.3 PVC CONDUIT

A. Description:
   1. Rigid Plastic Conduit:
      a. Comply with NEMA TC 2.
      b. Material: PVC, Schedule 40.
      c. Fittings and Conduit Bodies: Comply with NEMA TC 3.

2.4 PRECAST CONCRETE MANHOLES

A. Manufacturers:
   1. Hanson Pipe & Precast.

2. Oldcastle Infrastructure Inc.
3. Utility Structures Inc.
4. WCP: Wichita Concrete Pipe
5. Or equal.

B. Description: Precast manhole designed according to ASTM C858, comprising modular, interlocking sections complete with accessories.

C. Box to be provided with dampproof and waterproof coating designed for application on pre-cast concrete.

D. Loading: ASTM C857, Class A-16, H-20 rated.

E. Shape: Square or as indicated on drawings.

F. Nominal Dimensions: 4' x 4' minimum, or as required to accommodate installed conductors and meet minimum dimension requirements per National Electric Code.

G. Inside Depth: As required for application.

H. Base Section:
1. Sump:
a. Size: 4 inches deep by 12 inches in diameter.
b. Furnish cast sleeve and 1 -inch ground rod opening.

I. Top Section: Furnish 39 inch-diameter, grooved opening for frame and cover.

J. Riser Casting:
1. Diameter: 12 inches.
2. Furnish manhole steps cast into frame.

K. Frames and Covers:
1. Comply with ASTM A48/A48M.
2. Material: Class 30B gray cast iron.
3. Diameter: 30 inches.
4. Surfacing: Machine finished with flat bearing surfaces.
5. Furnish cover cast with ELECTRIC in large letters to indicate utility.

L. Duct Entry Provisions: Coordinate knockout locations and size with duct banks per drawings.

M. Cable Pulling Irons:
1. Galvanized rod and hardware.
2. Locate opposite each duct entry.
3. Furnish watertight seal.

N. Cable Rack Inserts:
1. Minimum Load Rating: 800 lb.

O. Cable Rack Mounting Channel:
1. Material: Steel channel.
2. Furnish cable rack arm mounting slots as required.

P. Cable Racks:
1. Material: Steel channel.
2. Furnish fasteners to match mounting channel.

Q. Cable Supports: Porcelain clamps and saddles.

R. Manhole Steps:
1. Description: Polypropylene plastic manhole step with 1/2-inch steel reinforcement.
2. Cast steps at 12 inches O.C., vertically.

S. Sump Covers:
1. Material: Class 30B gray cast iron.
2. Comply with ASTM A48/A48M.

2.5 HANDHOLES

A. Manufacturers:
1. Quazite; brand of Hubbell.
2. Oldcastle Infrastructure Group.
3. Newbasis.
4. Or equal.

B. Description: Polymer concrete composite material, molded of sand and aggregate, bound together with a polymer resin and reinforced with steel or fiberglass. Open bottom unless otherwise indicated.

C. Loading: Tier 22 design loads for driveway, parking lot, and off-roadway applications subject to occasional non-deliberate heavy vehicular traffic.

D. Shape: Square or rectangular.

E. Nominal Dimensions: 17” x 30” minimum, or as required to accommodate installed conductors and meet minimum dimension requirements per National Electric Code.

F. Inside Depth: As required for application.

G. Covers:
1. Description: Polymer concrete cover.
a. Stainless steel fasteners.
b. 0.5 coefficient of friction skid resistant surface.
c. Furnish cover embedded with ELECTRIC to indicate utility.

H. Duct Entry Provisions: Coordinate knockout locations and size with duct banks per drawings.

2.6 ACCESSORIES

A. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation and workable at temperatures as low as 35 degrees F. Capable of withstanding temperature of 300 degrees F without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

B. Cover Hooks: Heavy duty, designed for lifts 60 lb and greater.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify routing and termination locations of duct bank prior to excavation for rough-in.

B. Verify locations of manholes and handholes prior to excavating for installation.

3.2 UNDERGROUND DUCT APPLICATION

A. Rigid non-metallic conduit, NEMA Type EPC-40-PVC, arranged in concrete-encased duct bank, unless otherwise indicated.

3.3 UNDERGROUND BOX APPLICATION

A. Circuits 600 V and Less:
   1. Box sizes up to 4’ x 4’: Polymer concrete handholes or precast concrete manholes.
   2. Box sizes larger than 4’ x 4’: Precast concrete manholes.

B. Circuits Greater than 600V:
   1. Precast concrete manholes.

C. Do not install boxes within driveways without prior written approval from Engineer. When approved, boxes must be AASHTO H-20 rated for deliberate roadway traffic.

D. Do not mix conductors of different voltage types within the same box without prior written approval from Engineer. In general, circuits shall be grouped into separate boxes as follows:
   1. Circuits greater than 600VAC.
   2. 480/277VAC circuits.
   3. 120-240VAC circuits.
   4. 24VDC analog signal and fiber-optic circuits.

E. When different voltage types are approved within a common box, suitable barriers must be provided within the box to separate conductors of different voltages.

F. Cables shall be looped or installed around perimeter of boxes to provide a minimum 3 feet of cable slack for future modifications – cables shall not be pulled tight or “straight through” the box.

3.4 INSTALLATION

A. Duct Banks:
   1. Install duct to locate top of ducts at depths as indicated on Drawings. In no case shall ducts be installed less than 18” below grade without prior written approval from Engineer.
   2. Conduit and Duct Slope:
      a. Minimum 4 inches per 100 feet.
      b. Slope conduit and duct towards manholes/handholes and away from building entrances.
   3. PVC Conduit System:
      a. Join nonmetallic conduit and duct using adhesive as recommended by manufacturer.
      b. Wipe nonmetallic conduit and duct dry and clean before joining.
      c. Apply full even coat of adhesive to entire area inserted in fitting.
      d. Allow joint to cure for minimum 20 minutes.
   4. Conduit Bends:
      a. Install no more than equivalent of three 90-degree bends between pull points.
      b. For conduits containing cables operating at greater than 600VAC, provide long-sweep elbows with a minimum radius of 36” for all bends.
      c. For conduits containing fiber-optic cables, provide long-sweep elbows with a minimum radius of 36” for all bends.

5. Install fittings to accommodate expansion and deflection. Stagger conduit and duct joints vertically at minimum 6” spacing.
6. Terminate conduit and duct at manhole/handhole entries using end bells. Grout end bells into structure walls.
7. Separators and Chairs:
    a. Provide suitable separators and chairs, installed not greater than 5 feet on center.
8. Concrete Encasement:
    a. Band conduits and ducts together before backfilling or placing concrete.
    b. Securely anchor conduit, separators, and chairs to prevent movement during concrete placement.
    c. Place concrete as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.
    d. Use mineral pigment to color concrete red. Pigment shall be thoroughly mixed into concrete for a uniform red color throughout.
    e. Install ducts with a minimum of 3 inches of concrete cover at bottoms, tops, and sides of duct banks.
    f. For duct bank runs under paved areas, install two No. 4 steel reinforcing bars in top of duct bank concrete.
    g. Connect to existing concrete encasement and manhole walls using dowels.
9. Backfill trenches as specified in Section 31 23 16.13, TRENCHING FOR SITE UTILITIES.
10. Duct Markers:
    a. Install detectable underground warning tape above duct banks per requirements of Section 26 05 53, IDENTIFICATION FOR ELECTRICAL SYSTEMS.
11. Duct Cleaning:
    a. Pull test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and re-test.
    b. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
    c. Install suitable caps to protect duct against entrance of dirt and moisture.
12. Pulling cord: Install 100-lbf-test nylon cord in ducts, including spares.
13. Duct Bank Transition:
    a. At building approaches, transition from concrete-encased duct bank to direct-buried PVC installed a minimum of 18” below building slab, without forming a trap in the line. Coordinate entrances to avoid building footings.
    b. Transition to above ground, starting at the vertical 90 degree bend, shall be galvanized rigid conduit at dry indoor locations, PVC-coated steel conduit at exterior or interior wet locations, and PVC-coated steel conduit at chemical room locations.

B. Precast Manholes
1. Excavate for manhole installation as specified in Section 31 23 16, EXCAVATION.
2. Install and seal to comply with ASTM C891, unless otherwise indicated.
3. Install manholes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.
4. Seal around conduit penetrations after fittings are installed.
5. Unless otherwise indicated, support manholes on a level 12” bed of crushed stone or gravel graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
6. Use precast neck and shaft sections to bring manhole cover to finished elevation.
7. Attach cable racks to inserts after manhole installation is complete.
8. Install drains connected to manhole sumps and connect to Site drainage system.
9. Backfill manhole excavation as specified in Section 31 23 23.13, FILL AND BACKFILL.

C. Polymer Concrete Handholes

1. Excavate for handhole installation as specified in Section 31 23 16, EXCAVATION.
2. Install handholes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.
3. Seal around conduit penetrations after fittings are installed.
4. Unless otherwise indicated, support handholes on a level 12” bed of crushed stone or gravel graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
5. Handhole covers: In hard-surface areas, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
6. Backfill handhole excavation as specified in Section 31 23 23.13, FILL AND BACKFILL.

D. Grounding:
1. Ground underground ducts and utility structures according to Section 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

END OF SECTION

SECTION 26 05 53 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Nameplates.
   2. Labels.
   3. Wire markers.
   4. Underground Warning Tape.
   5. Lockout Devices.

1.2 SUBMITTALS

A. Section 01 33 00 – Submittal Procedures.

B. Product Data:
   1. Submit manufacturer's catalog literature for each product required.
   2. Submit electrical identification schedule including list of wording, symbols, letter size, color coding, tag number, location, and function.

C. Samples:
   1. Submit two samples of each type of identification products applicable to project.
   2. Submit two nameplates, 4 x 4 inch in size illustrating materials and engraving quality.

D. Manufacturer's Installation Instructions: Indicate installation instructions, special procedures, and installation.

1.3 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum three years documented experience.

B. Installer: Company specializing in performing Work of this section with minimum three years documented experience.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Accept identification products on site in original containers. Inspect for damage.

B. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.

C. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.5 ENVIRONMENTAL REQUIREMENTS

A. Install labels nameplates only when ambient temperature and humidity conditions for adhesive are within range recommended by manufacturer.

PART 2 - PRODUCTS

2.1 NAMEPLATES

A. Manufacturers:
1. Craftmark Pipe Markers
2. Kolbi Pipe Marker Co.
3. Pipemarker.com; Brimar Industries, Inc.
4. Seton Identification Products: Brady corporation Co.
5. Approved equal.

B. Product Description: Laminated three-layer plastic with engraved white letters on black contrasting background color.

C. Letter Size:
As shown on drawings.

D. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. in. and 1/8 inch thick for larger sized.
1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.2 LABELS

A. Manufacturers:
1. Brady Identification Inc.
2. Seton Identification Products: Brady corporation Co.
3. Approved equal.

B. Comply with NFPA 70 and 29 CFR 1910.145 and NFPA 70E.

C. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door or other access to equipment unless otherwise indicated.

D. Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend and size required for application. ¼ inch grommets in corners for mounting. Nominal size, 10 by 14 inches.

E. Sample warning label and sign shall include, but are not limited to the following legends:
1. Multiple Power source Warning: “DANGER – ELECTRICAL SHOCK HAZARD – EQUIPMENT HAS MULTIPLE POWER SOURCES.”
2. Workspace Clearance Warning: “WARNING - OSHA REGULATION – AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR”
3. WARNING – ARC FLASH AND SHOCK HAZARD –APPROPRIATE PPE REQUIRED.

2.3 WIRE MARKERS

A. Manufacturers:
1. Brady ID.
2. Grafoplast Wire Markers.
3. Ideal Industries, Inc.

4. Approved equal.

B. Description: Cloth tape, split sleeve, or tubing type wire markers.

C. Legend:
1. Power and Lighting Circuits: Branch circuit or feeder number as indicated on Drawings.
2. Control Circuits: Control wire number as indicated on Drawings.

2.4 UNDERGROUND WARNING TAPE

A. Manufacturers:
1. Brady ID.
2. Kolbi Pipe Marker Co.
3. Seton Identification Products: Brady corporation Co.
4. Approved equal.

B. Description: 3 inch wide plastic tape, detectable type, colored red with suitable warning legend describing buried electrical lines.

2.5 LOCKOUT DEVICES

A. Lockout Hasps:
1. Manufacturers:
a. Brady Identification Inc.
b. Seton Identification Products: Brady corporation Co.
c. Approved equal.
2. Anodized aluminum with reinforced nylon hasp with erasable label surface; size minimum 7-1/4 x 3 inches.

PART 3 - EXECUTION

3.1 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

3.2 APPLICATION

A. Outlet Boxes for Receptacles: Identify branch circuit by panel name and circuit number.

B. Power-Circuit Conductor Identification: of secondary conductors No. 1/0 AWG and larger in vaults, pull and junction boxes, manholes, and handholes use color-coding conductor tape. Identify source and circuit number of each set of conductors. For single conductor cables, identify phase in addition to the above.

C. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use color-coding conductor tape. Identify each ungrounded conductor according to source and circuit number.

D. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
1. Identify conductors, cables and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
2. Use system of marker type designations that is uniform and consistent with system used by manufacturer for factory-installed connections.

3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.

E. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: comply with 29 CFR 1910.145 and apply metal-backed, butyrate warning signs. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover or other access.
   1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to the following:
      a. Power transfer switches
      b. Controls with external control power connections.
   2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.

F. Instruction Signs:
   1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
   2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 3/8 inch high letters for emergency instructions at equipment used for power transfer.

G. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
   1. Equipment to Be Labeled:
      a. Panelboards, electrical cabinets and enclosures.
      b. Access doors and panels for concealed electrical items.
      c. Electrical switchgear and switchboards.
      d. Transformers.
      e. Motor-control centers.
      f. Disconnect switches.
      g. Enclosed circuit breakers.
      h. Motor starters.
      i. Push-bottom stations.
      j. Power transfer equipment.
      k. Contactors.
      l. Remote-controlled switches and control devices.
      m. Power-generating units.
      n. Voice and data cable terminal equipment.
      o. Terminals, racks and patch panels for voice and data communications and for signal and control functions.

3.3 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach non-adhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.

F. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for ungrounded service, feeder and branch-circuit conductors.
   1. Color shall be factory applied or, for sizes larger than No. 6 AWG if authorities having jurisdiction permit, field applied.
   2. Colors for 480/277-V, 3 phase Circuits:
      a. Phase A: Brown
      b. Phase B: Orange
      c. Phase C: Yellow
      d. Neutral: Gray
      e. Ground: Green
   3. Colors for 240/208/120-V, 3 phase Circuits:
      a. Phase A: Black
      b. Phase B: Red
      c. Phase C: Blue
      d. Neutral: White
      e. Ground: Green
   4. Colors for 240/120-V, 1 phase Circuits:
      a. L1: Black
      b. L2: Black
      c. N: White
      d. Ground: Green
   5. Cables for systems with a “high-leg” shall be provided with orange color-coding tape on the high leg conductor.
   6. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

G. Underground Warning Tape Installation:
   1. Install underground warning tape along length of each underground conduit, raceway, or cable 12 inches below finished grade, directly above buried conduit, raceway, or cable.

END OF SECTION

SECTION 26 05 93 - ELECTRIC MOTORS

PART 1 - GENERAL

1.1 SUMMARY

A. This section describes materials, installation and testing of induction motors and applies to motors which are generally provided as part of equipment specified in other sections. The Supplier/Manufacturer shall provide motors, accessories, and appurtenances complete and operable in accordance with the individual driven equipment specifications.

1.2 DEFINITIONS

A. ODP: Open Drip Proof.

B. TEFC: Totally Enclosed Fan Cooled.

1.3 SUBMITTALS

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

B. Complete motor data shall be submitted by Supplier, including:
1. Machine name and specification number of driven machine.
2. Motor manufacturer.
3. Motor type or model and dimensional drawing, including weight.
4. Horsepower nominal.
5. Guaranteed minimum full load efficiency. Also, nominal efficiencies at 1/2 and 3/4 load.
6. Full load speed.
7. Full load current at rated horsepower for application voltage.
8. Service factor, minimum 1.15.
9. Voltage, phase and frequency rating.
10. Winding insulation class.
11. Temperature rise class.
12. Frame size.
13. Enclosure.
14. NEMA design.
15. Thermal protection or over temperature protection.
16. Wiring diagram for devices such as temperature switches, space heaters and motor leak detection as applicable.
17. Bearing data, including recommendation of lubricants.
18. Inverter duty motor. Include minimum speed at which motors may be operated.
19. Power factor at 1/2, 3/4 and full load.
20. Complete nameplate data, rating and characteristics.
21. Mounting arrangement, size and location of conduit entries, including lugs.
22. Factory test results for each motor.

1.4 QUALITY ASSURANCE

A. Provide routine (short commercial) test data complying with NEMA MG 1-12.51 and MG 1-23.46.

B. Test thermally protected motors in accordance with NEMA MG 1 winding temperature and trip current tests.

C. Comply with NEMA MG 1.

1.5 COORDINATION

A. Furnish reviewed shop drawings from motor controller manufacturer for coordination and sizing of the controller.

B. Coordinate supplied motor connection box with conduits sizes indicated in the drawings.

C. Coordinate motor leads and lugs with wire sizes indicated in the drawings.

PART 2 - PRODUCTS

2.1 MOTOR REQUIREMENTS

A. All motors shall be squirrel cage, a-c induction type motors. Motor driven by variable frequency drives shall be inverter duty rated. In no case shall starting torque or breakdown torque be less than the value specified in ANSI/NEMA MG 1. In all cases, motor shall be suitable for the indicated starting method.

B. Where motors are controlled by variable frequency drives, the critical vibration speed of the motor/load combination shall either not fall within the operating range of the drive or such frequencies shall be blocked with the drive critical speed avoidance circuit.

C. Stator winding shall be copper.

D. The maximum motor loading shall not exceed its nameplate horsepower rating (exclusive of service factor) under any operating condition.

E. Motors shall be sized to start and accelerate the design loading and operate the full range of driven equipment without exceeding any of the specified design requirements. Motors that fail to meet these requirements shall be replaced at no additional cost to the Owner.

F. The three phase motors shall be provided with Class F insulation, rated to operate at a maximum ambient temperature of 40 degrees C and at the altitudes where the motors will be installed and operated without exceeding Class B temperature rise limits stated in ANSI/NEMA MG1-12, 42. Motor shall be provided with insulation systems to withstand 1600 volt spikes, with dV/dt as defined in NEMA MG 1-31.

G. Motors shall have a minimum service factor of 1.15.

H. Motors shall have enclosures suitable for the installed location. Such motors shall be UL listed and stamped.
   1. Interior Dry and Clean Locations: ODP or TEFC.
   2. Interior Damp or Wet Locations: TEFC.
   3. Outdoor Locations: TEFC.
   4. Hazardous Locations: Motors shall be listed for operation in the installed hazardous location as defined by the NEC and NFPA.

I. Motors located outdoors or in non-conditioned spaces shall have 120-volt AC space heaters. Space heater size and quantity shall be suitable to maintain minimum recommended temperatures for the installed location.

J. Motors shall be provided with vibration switches where indicated on the equipment data sheets or contract drawings. Vibration switches shall be Metrix 440 or equal, with independent adjustable alarm and shutdown mechanical relay outputs, unless indicated otherwise. Manufacturer shall be responsible for providing recommended trip settings based on the application.

K. Where driven by a variable frequency drive, provide a shaft grounding ring meeting the following requirements. Grounding ring shall be factory installed.
   1. Aluminum frame and internal components.
   2. Conductive microfiber brushes.
   3. Maintenance free design.
   4. Aegis Bearing Protection Ring or equal.

L. Unless otherwise specified, motor shall have no-load sound power levels not to exceed the values specified in NEMA MG 1-12.53.3.

M. Premium Efficiency Motors:
   1. Motors with a nameplate rating of 1 horsepower and larger shall be premium efficiency type motors as determined by the testing set forth in ANSI/IEEE 112 – Standard Test Procedure for Polyphase Induction Motors and Generators, Method B. Motor shall be stamped with the efficiency on the nameplate with the caption “NEMA Nominal Efficiency.”
   2. Efficiency index, nominal efficiency and minimum efficiency shall be defined in accordance with ANSI/NEMA MG1-12.59 – Efficiency Levels of Energy Efficient Polyphase Squirrel-Cage Induction Motors. All three values are required to be indicated in the submittal.

2.2 MOTOR BEARINGS

A. All motors greater than 2 horsepower shall have bearings designed for 17,500 hours (belted) or 100,000 hours (coupled) L-10 life.

B. Horizontal motors over 2 horsepower shall be shielded open-type bearing installed with labyrinth sealed end bells with pipe plugs. Bearings shall be re-greasable and have provisions for purging old grease.

2.3 MOTOR THERMAL PROTECTION

A. Motors shall be provided with winding thermostats where indicated on the equipment data sheets or contract drawings, in accordance with NEMA MG-1. Thermostats shall be snap action, bi-metallic, temperature actuated type switches and shall be provided with a normally closed contact. Thermostats shall be pre-calibrated by the manufacturer and shall be series connected.

B. All single phase motors shall have integral thermal overload protection or shall be current limited. The motor nameplate shall be stamped indicating integral thermal protection is provided.

C. Motors shall be provided with winding and bearing RTDs where indicated on the equipment data sheets or contract drawings. RTDs shall be PT100 platinum type complying with IEC 60751.

2.4 ACCESSORIES

A. All motors 3 horsepower and larger shall have split-type conduit boxes with a gasketed moisture seal between the conduit box and motor frame. Provide quantity and size of conduit knockouts to match the installation requirements.

B. All motors weighing 250 pounds or greater shall have suitable lifting eyes for installation and removal.

C. Motor grounding lugs shall be provided and shall be suitable for terminating ground wires.

D. All motors shall be fitted with permanent stainless-steel nameplates indelibly stamped or engraved with NEMA Standard motor data.

E. Provide 120VAC space heaters, winding thermostats, or RTDs as identified in the equipment data sheets or when indicated on contract drawings.

PART 3 - EXECUTION

3.1 STORAGE

A. The Supplier shall coordinate the storage location and delivery to the storage location with the Owner.

B. Protect motors from exposure to elements for which they are not designed. Install and energize temporary electrical service to motors with electrical heaters.

C. Store motors in an air-conditioned, ventilated, or protected environment similar to or better than the destination environment.

3.2 INSTALLATION

A. Contractor shall perform motor installation in accordance with the motor manufacturer's written recommendations and the written requirements of the manufacturer of the driven equipment.

B. Connections, switches, controls, disconnects and other items shall be provided by the Supplier in accordance with the plans and specifications for each motor.

C. The Supplier shall coordinate conduit sizes indicated in the drawings with the supplied motor connection box. The Supplier shall be responsible for providing larger connection boxes as may be required.

3.3 FIELD TESTING

A. The Contractor shall perform all field testing as facilitated in conjunction with oversight by the Supplier and in accordance with both the Manufacturer's recommendations and the requirements specified herein.

B. Perform insulation resistance tests in accordance with NEMA MG-1. Test voltage shall be 1000 VAC plus twice the rated voltage of motor.

C. Inspect the physical and mechanical conditions of each motor installation including any deviations from the nameplate, drawings, specifications, and manufacturer's written guidelines. Verify expected rated voltage, phase, and frequency for each motor installation. Confirm the presence of and correct application of lubrications for each motor along with proper securing and torque settings for bolted installations of each motor.

D. Check for proper phase and ground connections for each motor are connected. For multi-voltage motors, verify that motors are connected properly for the supplied voltage.

E. Verify that space heaters, where provided, are functional.

F. Test the motor for proper rotation prior to connection to the driven equipment. Measure and record running current and evaluate the current relative to the load conditions and nameplate full-load amps.

G. Simulate operating conditions for each motor to demonstrate proper operation of interlocks and control features.

H. Record operating current in each phase for each motor ½ horsepower and larger. Motors exceeding motor nameplates values shall be repaired or replaced.

I. For motors 50 horsepower and larger or when a discernible abnormal vibration is detectible, a vibration test shall be completed. Vibration shall not exceed 0.25 in./sec. For horizontal motors, the N-S and E-W vibrations shall be measured at the top and bottom of the front and rear bearing housing. For vertical motors, the N-S and E-W vibrations shall be measured at the upper and lower bearing housing.

J. All testing shall be witnessed by the Engineer and Owner.
   1. Motor and Motor Protection Tests for motors – In addition to other testing start and stop each motor a minimum of 3 times and perform a run test for vibration, heat, and to document motor protection. The Contractor shall document the settings of the motor overcurrent protection, overload relay and similar data on the provided form – MOTOR TEST REPORT.
   2. The Contractor shall develop non-conforming material reports for each failure and repair or report failures.
   3. The Contractor shall replace defective parts, correct malfunctioning units, make all repairs and retest to demonstrate compliance. The Contractor shall document action taken on appropriate non-conforming material report.

3.4 MOTOR TEST REPORT

A. The following form is provided for the motor certification specified herein. Master blank forms are available on request.

END OF SECTION

MOTOR TEST REPORT

Each electric motor shall be tested for proper operation. Follow manufacturer's testing recommendations and procedures.

1. Name and Horsepower of Motor Tested:_____

2. Overcurrent Protection:_____

3. Overload Protection: _____

4. Visual Inspection Checklist:

   - ❑ Momentarily Bump Motor Shaft for Proper Rotation
   - ❑ Motor Frame Bolts
   - ❑ Shaft Coupling
   - ❑ Lubricants
   - ❑ Other Comments:

5. Megger motor from wire in motor control center or control panel and record results. Do not perform megger testing with wiring connected to variable frequency drive, soft start, or other electronic controller.

   ϕA-ϕB_____ ϕB-ϕC_____ ϕC-ϕA_____

   ϕA-G_____ ϕB-G_____ ϕC-G_____

6. Record full load voltage and current:

   Vab_____ Van_____ Ia_____

   Vbc_____ Vbn_____ Ib_____

   Vca_____ Vcn_____ Ic_____

7. Motor Nameplate FLA:_____

   Running Amps:_____

   P.F. _____

8. Comments:

Signature Required: _____

Company: _____

Date: _____

SECTION 26 24 19 – MOTOR CONTROL CENTERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Motor control centers.

1.2 REFERENCE STANDARDS

A. Institute of Electrical and Electronics Engineers:
   1. IEEE C62.41 - Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.

B. National Electrical Manufacturers Association:
   1. NEMA FU 1 - Low Voltage Cartridge Fuses.
   2. NEMA ICS 2 - Industrial Control and Systems: Controllers, Contactors, and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC.
   3. NEMA ICS 2.3 - Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers.
   4. NEMA ICS 3 - Industrial Control and Systems: Factory Built Assemblies.
   5. NEMA ICS 5 - Industrial Control and Systems: Control Circuit and Pilot Devices.
   6. NEMA ICS 7 - Industrial Control and Systems: Adjustable Speed Drives.
   7. NEMA ICS 7.1 - Safety Standards for Construction and Guide for Selection, Installation, and Operation of Adjustable Speed Drive Systems.
   8. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

C. International Electrical Testing Association:
   1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

D. Underwriters Laboratories Inc.:
   1. UL 198E - Class R Fuses.
   2. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
   3. UL 508 - Industrial Control Panels.
   4. UL 845 - Motor Control Centers.

1.3 SUBMITTALS

A. Section 01 33 00, SUBMITTAL PROCEDURES: Submittal procedures.

B. Product Data: Submit electrical characteristics including voltage, frame size and trip ratings, fault current withstand ratings, and time-current curves of equipment and components. For each type of controller and each type of motor-control center. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings and finishes.

C. Shop Drawings: Indicate front and side views of enclosures with overall dimensions shown; conduit entrance locations and requirements; nameplate legends; size and number of bus bars for each phase, neutral, and ground; electrical characteristics including voltage, frame size and trip ratings, withstand ratings, and time and current curves of equipment and components.

D. Coordination Drawings: floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around motor-control centers where pipe and ducts are prohibited. Show motor-control center layout and relationships between electrical components and adjacent structural and mechanical elements. Show compliance with NFPA 70, Article 240.24 height limitation of overcurrent device operating handles. Show support locations, type of support and weight on each support. Indicate field measurements.

E. Qualification Data: for manufacturer and testing agency.

F. Field quality-control test reports.

G. Operation and Maintenance Data: for motor-control centers, all installed devices and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01, include the following:
   1. Routine maintenance requirements for motor-control centers and all installed components.
   2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

H. Load-Current and Overload-Relay heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

I. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

J. Test and Evaluation Reports: Indicate field test and inspection procedures and test results.

K. Source Quality Control Submittals: Indicate results of factory tests and inspections.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 250 miles of Project site, a service center capable of providing training, parts and emergency maintenance and repairs.

B. Source Limitations: Obtain motor-control centers and controllers of a single type through one source from a single manufacturer.

C. 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.

D. Comply with NFPA 70.

E. Field Quality Control Submittals: Indicated results of Contractor furnished tests and inspections.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Submit replacement parts list for controllers.

B. Project Record Documents: Record actual locations, configurations, and ratings of motor control centers and major components.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum five years' experience.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver in 60-inch maximum width shipping splits, individually wrapped for protection, and mounted on shipping skids.

B. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, water, construction debris, and traffic.

C. Handle in accordance with NEMA ICS 2.3. Lift only with lugs provided. Handle carefully to avoid damage to motor control center components, enclosure, and finish. Comply with NECA 402, "Recommended Practice for Installing and Maintaining Motor Control Centers."

1.8 AMBIENT CONDITIONS

A. Conform to NEMA ICS 2 service conditions during and after installation of motor control centers.

1.9 COORDINATION

A. Coordinate layout and installation of motor-control centers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

C. Coordinate features of motor-control centers, installed units, and accessory devices with pilot devices and control circuits to which they connect.

D. Coordinate features, accessories, and functions of each motor-control center, each controller, and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

1.10 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Spare fuses: Furnish one spare for every five installed, but no fewer than one set of three of each type and rating.
   2. Indicating Lights: Two of each type installed.

PART 2 - PRODUCTS

2.1 MOTOR CONTROL CENTER

A. Manufacturers:
   1. Square D; by Schneider Electric.
   2. ABB.
   3. Allen-Bradley.
   4. Siemens.

B. Description: NEMA ICS 3, Class I, Type B motor control center.

1. Main Overcurrent Protection: Molded case circuit breaker.

C. Enclosures: Flush- or surface-mounting cabinets as indicated. Standard, 20” depth.
   1. Compartments: Modular; individual doors with concealed hinges and quick-captive screw fasteners. Interlocks on combination controller units requiring disconnecting means in off position before door can be opened or closed, except by operating a permissive release device.
   2. Interchangeability: Compartments constructed to allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in motor-control center; same size compartments to permit interchangeability and ready rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.
   3. Final installation height of disconnect devices, accounting for pad height under the motor control center, shall be in compliance with NFPA 70, Article 240.24.
   4. Wiring spaces: Wiring channel in each vertical section for vertical and horizontal wiring to each unit compartment; supports to hold wiring in place.

D. NEMA enclosure type to meet environmental conditions at the installed location.
   1. Interior Dedicated Locations (Electrical Rooms): Type 1
   2. Interior Dry Locations (Non-Dedicated Spaces subject to Dust, Dirt only): Type 12.

E. Operation:
   1. Voltage Rating: As indicated on contract drawings.
   2. Integrated Equipment Short Circuit Rating: As indicated on contract drawings. If no rating listed, provide 42kAIC minimum.

F. Materials:
   1. Horizontal Bus: Copper, with continuous current ratings as indicated on drawings.
      a. Material: Plated hard-drawn copper, 98 percent conductivity. Include copper ground bus entire length of control center.
   2. Vertical Bus: Copper.

G. Ampacity Ratings: As indicated for horizontal main buses.

H. Neutral Buses: Full size or as available relative to the main ampacity.

I. Equipment Ground Bus: Non-insulated, horizontal configuration; adequate for equipment ground conductors; bonded to enclosure.

J. Horizontal Bus Arrangement: Main phase, neutral and ground buses extended with same capacity the entire length of motor-control center, with provision for future extension at both ends by bolt holes and captive bus splice sections or equivalent.

K. Short-Circuit Withstand Rating: Same as short-circuit current rating of section.

L. Fabrication
   1. Configuration: Units front mounting only, accessible from front only.

M. Finishes
   1. Manufacturer's standard gray enamel.

2.2 FUNCTIONAL FEATURES

A. Description: Modular arrangement of controllers, control devices, overcurrent protective devices, transformers, panelboards, instruments, indicating panels, blank panels, and other items mounted in compartments of motor-control center.

B. Controller Units: Combination controller units of types and with features, ratings and circuit assignments indicated:
   1. Install units up to and including Size 3 on drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.
   2. Provide units with short-circuit current ratings equal to or greater than short-circuit current rating of motor-control center sections.
   3. Equip units in Type B and Type C motor-control centers with pull-apart terminal strips or drawout terminal boards for external control connections.
   4. Controller Disconnecting Means: Factory-assembled combination disconnect and controller.
      a. Circuit-Breaker Disconnecting Means: NEMA AB1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

C. Overcurrent Protective Devices: Individual feeder-tap units through 225-A rating shall have drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions. Installed height, including that of the concrete base, of operating handles of overcurrent protective devices shall not exceed the height limitation of NFPA 70, Article 240.24.

D. Surge Protective Devices: Connect to motor-control center bus.

E. Spaces and Blank Units: Compartments fully bused and equipped with guide rails or equivalent, ready for insertion of drawout units.

F. Spare Units: Type, sizes, and ratings indicated; installed in compartments indicated “spare.”

G. Key Interlocking: Where indicated on drawings, provide a key interlocking system for indicated circuit breakers to prevent simultaneous energization of multiple sources.

2.3 FULL-VOLTAGE NON-REVERSING CONTROLLERS

A. Description: NEMA ICS 2, AC general-purpose Class A solid-state controller for induction motors rated in horsepower.

B. Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means.
   1. MCP Disconnecting Means:
      a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
      b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
      c. Auxiliary NO/NC contact that operates to indicate “ON” or “OFF”.

C. Overloads: Solid state type, electronic design with a 5:1 adjustment range, current based measurement protection, thermal memory, integrated I/O points, and enhanced phase loss protection.

D. Operation:
1. Control Voltage: 120 volts, 60 Hertz.
a. Control Circuit: 120 V; obtained from integral control power transformer with a control power transformer of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.

E. Materials:
1. Overload Relay: NEMA ICS 2.
2. Product Options and Features:
a. Auxiliary Contacts: NEMA ICS 2, 2 each field convertible contacts in addition to seal-in contact.
b. Cover Mounted Pilot Devices: NEMA ICS 5, heavy duty oiltight type.
c. Pilot Device Contacts: NEMA ICS 5, Form Z, rated A150.
d. Indicating Lights: LED type.
e. Selector Switches: Rotary type.
f. Relays: NEMA ICS 5.
g. Control Power Transformers: 120 volt secondary, 100% spare capacity minimum. Furnish fused primary and secondary, and bond unfused leg of secondary to enclosure.

F. Motor controller buckets shall include control features as indicated on the contract documents, which may include but not limited to the following:
1. Motor control selector switch
2. Remote start input
3. Stop pushbutton (normally closed)
4. Start pushbutton (normally open)
5. Running indicator light
6. Overload reset pushbutton
7. Dry status contacts for motor running and overload
8. Other indication and control devices as indicated on the contract drawings

2.4 FULL-VOLTAGE NON-REVERSING CONTROLLERS

A. Description: NEMA ICS 2, AC general-purpose Class A solid-state controller for induction motors rated in horsepower.

B. Operation:
1. Control Voltage: 120 volts, 60 Hertz.

C. Materials:
1. Overload Relay: NEMA ICS 2.
2. Product Options and Features:
a. Auxiliary Contacts: NEMA ICS 2, 2 each field convertible contacts in addition to seal-in contact.
b. Cover Mounted Pilot Devices: NEMA ICS 5, heavy duty oiltight type.
c. Pilot Device Contacts: NEMA ICS 5, Form Z, rated A150.
d. Indicating Lights: LED type.
e. Selector Switches: Rotary type.
f. Relays: NEMA ICS 5.
g. Control Power Transformers: 120 volt secondary, 100% spare capacity minimum. Furnish fused primary and secondary, and bond unfused leg of secondary to enclosure.

2.5 VARIABLE FREQUENCY CONTROLLER

A. Description: Where drives are indicated on the contract drawings as an integral part of the motor control center lineup, furnish pulse-width-modulated, 6 pulse variable frequency controller; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase, induction motor by adjusting output voltage and frequency.
   1. Provide unit suitable for operation of standard and premium-efficiency motor as defined by NEMA MG 1.
   2. Control Circuit: 120 V; obtained from integral control power transformer with a control power transformer of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.

B. Design and Rating: Match load type such as fans, blowers, and pumps.

C. VFC shall meet or exceed the latest version of IEEE Standard 519 with regard to harmonics generated by the non-linear loads. Factory certification of IEEE 519 compliance shall be submitted to the engineer prior to shipment.

D. Line Reactor: Each variable frequency drive must be equipped with an input reactor or DC choke offering no less than 4.5% effective impedance at rated motor amps (the fundamental current). They must be harmonic compensated and be UL-506 and UL-508 approved. The continuous current rating of the reactor must be equal to or greater than the rms input current rating of the drive. Reactors must be copper wound with a UL class H (180 C) insulation system. They must be suitable for an ambient temperature of 45 C and a have a maximum temperature rise of 115 C. Their watts loss must be less than 1% of the rated load. Box lug type terminals must be provided on all reactors rated from 2 amps thru 400 amps. Higher current reactors may be supplied with copper tab type terminals.

E. Output Filter:
   1. For motor lead lengths 150-500 feet, provide dv/dt output filter, TCI V1k or equal.
   2. For motor lead lengths greater than 500 feet, provide motor sine wave filter, TCI MotorShield or equal.

F. Operation:
   1. Ratings:
      a. Rated Input Voltage: 480 volts, three phase, 60 Hertz.
      b. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range.
      c. Motor Nameplate Voltage: 460 volts, three phase, 60 Hertz.
      d. Displacement Power Factor: Between 1.0 and 0.95, lagging, over entire range of operating speed and load.
      e. Operating Ambient: 0 degrees C to 40 degrees C for conditioned spaces. 0 degrees C to 50 degrees C for non-conditioned spaces.

G. Unit Operating Requirements:
   1. Input AC Voltage Tolerance: Plus 10 and minus 15 percent of VFC input voltage rating.
   2. Input AC Voltage Unbalance: Not exceeding 5 percent.
   3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
   4. Minimum Efficiency: 97 percent at 60 Hz, full load.
   5. Minimum Displacement Primary-Side Power Factor: 95 percent under any load or speed condition.
   6. Minimum Short-Circuit Current (Withstand) Rating: Equal to or greater than short circuit rating of motor control center assembly.
   7. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.5 times the base load current for three seconds.
   8. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.

9. Speed Regulation: Plus or minus 5 percent.
10. Stop Modes: Programmable; includes ramp, coast, and fast.

H. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
1. Signal: Electrical, 4 to 20 mA DC.

I. Self-Protection and Reliability Features:
1. Input transient protection by means of surge suppressors to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
3. Under- and overvoltage trips.
4. Inverter overcurrent trips.
5. VFC and Motor Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor overload alarm and trip; settings selectable via the keypad; NRTL approved.
6. Critical frequency rejection, with three selectable and adjustable deadbands.
7. Instantaneous line-to-line and line-to-ground overcurrent trips.
8. Loss-of-phase protection.
9. Reverse-phase protection.
10. Short-circuit protection.
11. Motor overtemperature fault.

J. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

K. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

L. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

M. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

N. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

O. Integral disconnecting Means: NEMA AB1, instantaneous-trip circuit breaker with lockable handle.

P. Variable frequency controllers shall include control features as indicated on the contract documents, including but not limited to the following:
1. Manufacturer's standard front-accessible, LCD display and keypad
2. Three position selector switch
3. Remote start input
4. Manual speed potentiometer
5. VFD Running indicator light

6. VFD Fault indicator light
7. Reset pushbutton
8. Dry status contacts for motor running, VFD fault, and mode selection
9. 4-20 mA speed command input
10. 4-20 mA speed feedback
11. Other indication and control devices as indicated on the plans.
12. Communication: Provide Ethernet/IP communication support.

2.6 FUSIBLE SWITCH ASSEMBLIES

A. Description: NEMA KS 1, Type HD, load interrupter knife switch. Handle lockable in OFF position.

B. Materials:
1. Fuse clips: Designed to accommodate NEMA FU 1, Class R fuses.

2.7 MOLDED CASE CIRCUIT BREAKER

A. Description: UL 489, molded-case circuit breaker: Standard frame sizes, trip ratings and number of poles.
1. Lugs: Mechanical Compression style, suitable for number, size, trip ratings and material of conductors.
2. Application Listing: Appropriate for application: Type SWD for switching fluorescent lighting loads; type HACR for heating, air-conditioning, and refrigerating equipment.
3. Interrupting capacity to match the rating of the motor control center assembly.

B. Thermal Magnetic Trip Circuit Breaker: Circuits breakers indicated on drawings as “TM”, or 250 amperes and smaller not designated with adjustable electronic trip features, shall be thermal magnetic type with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Thermal magnetic breakers larger than 150 ampere frame size shall have changeable trip units with adjustable magnetic trip settings.

C. Solid State Electronic Trip Circuit Breaker: Circuit breakers indicated on drawings with long-time (L), short-time (S), instantaneous (I), or ground fault (G) trip features, or any circuit breaker larger than 250 ampere frame size, shall be electronic trip type with the features identified on drawings. If no trip features are identified on the drawings, provide LSI as standard for electronic trip breakers less than 800 ampere frame size, and provide LSIG for breakers 800 amperes and larger.

D. Arc Reduction Maintenance Mode: Provide arc reduction maintenance mode (ARMS) feature for all circuit breakers rated 1200 amperes and larger, or where indicated on drawings.

2.8 TRANSFORMER AND PANELBOARD

A. Where indicated on drawings, provide step-down transformer and panelboard mounted integral to the motor control center.

B. Transformer shall be provided with a primary circuit breaker disconnect sized for the transformer kVA rating. Transformer size and secondary voltage shall be as indicated on the drawings. Transformer temperature rise shall not exceed 150 deg C.

C. Panelboard ampacity and voltage ratings shall be as indicated on the drawings. Panelboards and circuit breakers shall be rated for 10kAIC minimum.

D. Provide panelboard with main circuit breaker rating to match bus ampacity.

E. Panelboard busses shall be copper.

F. Provide panel spaces as indicated on drawings, or thirty (30) spaces, whichever is greater. Provide circuit breaker quantities and ratings as indicated on drawings. If not indicated, fill all spaces with 20A single pole breakers.

2.9 ELECTRONIC METERING UNIT

A. Include microprocessor-based power meter factory-installed integral to each motor control center, whether or not indicated on the contract drawings.

B. Electronic Metering Unit: Digital, multi-function, programmable, meter; UL listed and CE marked.
   1. Input: Accept input from 5 amp secondary current transformers and 120 volt secondary potential transformers.
   2. Voltage Monitoring Range: Up to 600 volts, phase to phase.
   3. Configuration: Capable of connection to three phase, four wire wye system and three phase, three wire, delta system.
   4. Monitor: Three phase real time amps, volts, power, energy, power factor, and frequency.
   5. PT and CT Ratios: User programmable.
   6. Display: 3-line LED to display volts, amps, and power simultaneously; selectable to indicate instantaneous, average, maximum, and minimum measurements for all phases.
   7. Mounting: Flush or semi-flush in motor control center instrument compartment face.

C. Meter Measurement Capability: Continuously meter electrical loads with plus or minus 1 percent accuracy.
   1. True RMS Measurements:
      a. Voltage phase to neutral.
      b. Voltage phase to phase.
      c. Current per phase.
      d. Neutral current.
      e. Real power
      f. Reactive power.
      g. Apparent power.
   2. Other Measurements: Power factor and frequency.

D. Unit to have ethernet port for connection to external monitoring system.

2.10 SURGE PROTECTION DEVICES

A. Include surge protective devices factory-installed integral to each motor control center, whether or not indicated on the contract drawings, meeting the following requirements:
   1. Comply with UL 1449, Type 2.
   2. Provide SPD in dedicated bucket and connect through circuit breaker for disconnection.
   3. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 160 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
   4. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V, three-phase, four-wire circuits shall not exceed the following:
      a. Line to Neutral: 1200 V.
      b. Line to Ground: 1200 V.
      c. Line to Line: 2000 V.
   5. SCCR: Equal or exceed the short circuit current rating of the motor control center.
   6. Nominal Rating: 20 kA.

2.11 ACCESSORIES

A. Control Relays: Auxiliary and adjustable time-delay relays.

B. Elapsed Time Meters: Heavy duty, LED type, with digital readout in hours.

C. Current-Sensing, Phase-Failure Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage; with adjustable response delay.

2.12 SOURCE QUALITY CONTROL

A. Shop inspect and perform standard productions tests for each controller in accordance with manufacturer's standards.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify surfaces are suitable for motor control center installation.

B. Examine areas and surfaces to receive motor-control centers for compliance with requirements, installation tolerances and other conditions affecting performance.
   1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Select features of each controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, controller, and load; and configuration of pilot device and control circuit affecting controller functions.

B. Select horsepower rating of controllers to suit motor controlled.

3.3 INSTALLATION

A. Install motor control centers on minimum 4” tall concrete housekeeping pads under the provision of Section 03 30 00. Anchor each motor control center assembly according to manufacturer’s written instructions.

B. Install in accordance with NEMA ICS 2.3 and NEMA 7.1.

C. Tighten accessible bus connections and mechanical fasteners after placing motor control center.

D. Install fuses in fusible switches.

E. Select and install heater elements in motor controllers to match installed motor characteristics.

F. Install engraved plastic nameplates in accordance with Section 26 05 53.

G. Neatly type label inside each motor controller door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, voltage rating, and phase rating. Place label in clear plastic holder. Indicate method of identifying phase conductors.

H. Ground and bond motor control centers in accordance with Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

3.4 FIELD QUALITY CONTROL

A. Inspect and test in accordance with NETA ATS.

B. Perform inspections and tests listed in NETA ATS, Section 7.16.

C. Inspect and test variable frequency controllers according to NEMA ICS 7.1.

D. Prepare for acceptance tests as follows:
1. Test insulation resistance for each motor-control center element, bus, component, connecting supply, feeder and control circuit.
2. Test continuity of each circuit.

E. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components and equipment.
2. To assist in field testing of equipment including pretesting and adjusting of solid-state controllers.
3. Report results in writing.

F. Perform the following field test and inspections and prepare test reports:
1. Perform each electrical test and visual and mechanical inspection tests, stated in NETA ATS "Motor Control Centers." Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.5 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate and maintain components of motor-control centers including solid-state controllers and variable frequency controllers.

END OF SECTION

SECTION 26 27 26 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes wall switches; wall dimmers; receptacles; multioutlet assembly; and device plates and decorative box covers.

B. Related Sections:
   1. Section 26 05 33 – Raceway and Boxes for Electrical Systems.

1.2 REFERENCES

A. National Electrical Manufacturers Association:
   1. NEMA WD 1 - General Requirements for Wiring Devices.
   2. NEMA WD 6 - Wiring Devices-Dimensional Requirements.

1.3 SUBMITTALS

A. Section 01 33 00, SUBMITTAL PROCEDURES: Submittal procedures.

B. Product Data: Submit manufacturer's catalog information showing dimensions, colors, and configurations.

C. Samples: Submit two samples of each wiring device and wall plate illustrating materials, construction, color, and finish.

1.4 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.

B. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as type are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.

C. 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.

D. Comply with NFPA 70.

1.5 EXTRA MATERIALS

A. Furnish two of each style, size, and finish wall plate.

PART 2 - PRODUCTS

2.1 GENERAL

A. Wiring devices shall be specification grade, with special devices as noted on the drawings. Should the drawings indicate a device other than those listed herein without reference to catalog number, such device shall be of the same grade and manufacturer as specified below.

Furnish a matching cap for all special purpose devices that do not have the common 120V NEMA 5-15R or 5-20R configuration.

B. All lighting switches and duplex receptacles installed shall be by the same manufacturer and shall be identical in appearance, unless noted otherwise.

2.2 WALL SWITCHES

A. Manufacturers:
1. Arrow-Hart
2. Bryant
3. General Electric
4. Hubbell, Inc.
5. Leviton Manufacturing Co., Inc.
6. Pass & Seymour, Lagrand North America, Inc.
7. Or equal.

B. Product Description: All switches and associated materials shall bear a UL 20 and comply with NEMA WD 1. Provide all necessary wiring and accessories as required for complete installation.

C. All single-pole, double-pole, three-way, and four-way switches as indicated.

D. Flush and Surface Mounted, Tumbler, Self-Grounding, Heavy-Duty Switches:
1. “Specification” grade, Fed. Spec. W-S-896.
2. White toggle and “Specification” grade white thermoplastic wall plate with matching screws in finished areas.
3. Gray toggle in all other areas with 302 stainless steel wall plates.
4. With grounding lug.

E. Ratings:
1. Voltage: 120 120-277 volts, AC.
2. Current: 20 amperes.

F. Weatherproof, Self-Grounding, Heavy-Duty Switches:
1. Flush or surface mounted as indicated.
2. “Specification” grade, Fed. Spec. W-S-896
3. Lever-type, cast aluminum, gasketed cover plate.
   a. Crouse-Hinds DS185 or equal.
4. Locations: All exterior or interior wet locations, or as indicated on drawings.

G. Dimmers
1. Solid State Dimmer for LED dimmable driver: Captive linear-slide dimmer for a traditional cover plate opening.
2. Output 0-10V for control of dimmable LED drivers.
3. Provide power supply as required.
4. For indoor use only.
5. Finish shall match wall switches.
6. UL Listed.

H. Occupancy Sensors:
1. Adjustable occupancy sensor settings:
   a. Time delay.
   b. Walk-through mode.
   c. Sensitivity.
   d. Occupancy mode (auto-on/auto-off).

2. Occupancy Sensor shall use dual technology (Passive Infrared and Ultrasonic).
3. Ceiling or wall-mount as indicated.
4. Output 0-10V for control of dimmable LED drivers.
5. Provide power supply as required.
6. For indoor use only.
7. Finish shall match wall switches.
8. UL Listed.

2.3 RECEPTACLES

A. Manufacturers:
1. Arrow-Hart.
2. Bryant.
3. General Electric.
4. Hubbell, Inc.
5. Leviton Manufacturing Co., Inc.
6. Pass & Seymour, Lagrand North America, Inc.
7. Or equal.

B. Product Description: All receptables shall be heavy-duty type and shall bear a UL 498 label and comply with NEMA WD 1 and WD 6 as applicable. Provide all necessary wiring and accessories as required for complete installation.

C. Flush Mounted and Surface Mounted Receptacles.
1. Duplex, arc-resistant, back and side-wired, 3-wire grounding type. NEMA reference 5-20R. “Specification” grade type 5362, Fed. Spec. W-C-596 compliant.
2. Receptacle and wall plates shall be as follows:
   a. Flush mounted white receptacle and “Specification” grade white thermoplastic wall plate with matching screws in finished areas.
   b. Receptacles in all other areas shall be gray with 302 stainless steel wall plates.
   c. Receptacles fed from UPS circuits in finished areas shall be red with “Specification” grade red thermoplastic wall plates with matching screws.
   d. Receptacles fed from UPS circuits in other areas shall be red with 302 stainless steel wall plates.
   e. Locations as indicated.
   f. When indicated provide GFCI type as specified.

D. Ground Fault Circuit Interrupter (GFCI) Receptacles:
1. Flush or Surface mounted as indicated.
2. NEMA reference 5-20R. Rated 20A at 125-Vac, Fed. Spec. W-C-596.
3. Back and side wired terminals with feed-through design. Terminal installation unless indicated otherwise.
4. UL Standard 943 Class A, Group 1.
5. Leakage current sensitivity: 5mA ± 1mA.
   a. Opens circuit within 25 milliseconds of reaching 5 mA.
6. Duplex, arc resistant and pre-wired.
7. Cover plate materials and colors shall match standard receptacles as specified this section.
8. All exterior or interior wet locations, or as indicated on drawings.

E. Weatherproof Receptacles:
1. Flush or Surface mounted as indicated.
2. Rated 20A at 125-Vac, Fed. Spec. W-C-596. NEMA reference 5-20R.
3. GFCI receptacle as specified in this Section when indicated.
4. Provide a gray receptacle with a cast aluminum weather-proof cover.

a. Provide while-in-use cover for outdoor locations.
b. Provide hinged self-closing, gasketed type covers for indoor locations.

5. All exterior or interior wet locations, or as indicated on drawings.

F. Floor Receptacles:
1. Receptacles shall be compatible with the recessed box assembly. Provide 20-ampere, 125V, 2-pole, 3-wire, grounding, gray duplex receptacles, NEMA configuration 5-20R.
2. Recessed boxes shall include duplex receptacles and network keystone jacks as indicated.

G. Poke-Through Floor Devices: Factory-fabricated poke-through assembly devices with modular, flush or above-floor service outlets (as required), multi-channeled thru-floor service fitting (or flush carpet flange) of die cast, satin finished aluminum with 20-ampere, 125-Vac, 2-pole, 3-wire, grounding gray duplex NEMA 5-20R receptacle and modular communication/data service outlet with separation barrier between power and low-voltage section. Provide integral assembly UL listed as a total unit, with fire rating of 1, 2, or 4 hours as required to be consistent with that of floor penetrated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify outlet boxes are installed at proper height.

B. Verify wall openings are neatly cut and completely covered by wall plates.

C. Verify branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.

3.2 Coordination with Other Trades:

A. Take steps to ensure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.

B. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables. Clean all debris from outlet boxes.

C. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.

D. Install wiring devices after all wall preparation, including painting is complete.

3.3 Conductors:

A. Do not strip insulation from conductors until just before they are spliced or terminated on devices.

B. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.

C. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.

D. Existing conductors:
   1. Cut back and pigtail or replace all damaged conductors.
   2. Straighten conductors that remain and remove corrosion and foreign matter.
   3. Pigtailing existing conductors is permitted provided the outlet box is large enough.

3.4 INSTALLATION

A. Install devices plumb and level.

B. Install switches with OFF position down.

C. Install wall dimmers to achieve full rating specified and indicated after derating for ganging as instructed by manufacturer.

D. Do not share neutral conductor on load side of dimmers.

E. Device Installation:
   1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
   2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
   3. Do not remove surface protection such as plastic film and smudge covers until the last possible moment.
   4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
   5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
   6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
   7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
   8. Tighten unused terminal screws on the device.
   9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

F. Connect wiring device grounding terminal to outlet box with bonding jumper and branch circuit equipment grounding conductor.

G. Install wall plates on flush mounted switches, receptacles, and blank outlets.

H. Install decorative plates on switch, receptacle, and blank outlets in finished areas.

I. Connect wiring devices by wrapping solid conductor around screw terminal. Install stranded conductor for branch circuits 10 AWG and smaller. When stranded conductors are used in lieu of solid, use crimp on fork terminals for device terminations. Do not place bare stranded conductors directly under device screws.

J. Use jumbo size plates for outlets installed in masonry walls.

K. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface mounted outlets.

3.5 INTERFACE WITH OTHER PRODUCTS

A. Coordinate locations of outlet boxes to obtain mounting heights as specified and as indicated on drawings.

B. Install wall switch 48 inches above finished floor.

C. Install convenience receptacle 24 inches above finished floor.

D. Install convenience receptacle 6 inches above counter and back splash of counter.

E. Install dimmer 48 inches above finished floor.

3.6 FIELD QUALITY CONTROL

A. Inspect each wiring device for defects.

B. Operate each wall switch with circuit energized and verify proper operation.

C. Verify each receptacle device is energized.

D. Test each receptacle device for proper polarity.

E. Test each GFCI receptacle device for proper operation.

F. Perform tests and inspections and prepare test reports.
   1. Test Instruments: Use instruments that comply with UL 1436.
   2. Test Instrument for Convenience Receptacles: digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

G. Tests for Convenience Receptacles:
   1. Line voltage: Acceptable range is 110 to 125V.
   2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
   3. Ground Impedance: Values of up to 2 ohms are acceptable.
   4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
   5. Using the test plug, verify that the device and its outlet box are securely mounted.
   6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

H. Test straight blade for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz.

3.7 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

3.8 CLEANING

A. Clean exposed surfaces to remove splatters and restore finish.

END OF SECTION

SECTION 26 28 13 - FUSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Fuses.

1.2 REFERENCE STANDARDS

A. National Electrical Manufacturers Association:
   1. NEMA FU 1 - Low Voltage Cartridge Fuses.

1.3 SUBMITTALS

A. Section 01 33 00, SUBMITTAL PROCEDURES: Submittal procedures.

B. Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:
   1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
      a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
      b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
   2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.

C. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals.
   1. Ambient temperature adjustment information.
   2. Current-limitation curves for fuses with current-limiting characteristics

D. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

1.4 QUALITY ASSURANCE

A. Qualifications:
   1. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.

B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

C. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency and marked for intended location and application.

D. Comply with NEMA FU 1 for cartridge fuses.

E. Comply with NFPA 70.

1.5 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers:
   1. Cooper Bussmann; Eaton.
   2. Edison Fuse, Inc.
   3. Ferraz Shawmut, Inc.
   4. Littelfuse Inc.

2.2 DESIGN REQUIREMENTS

A. Select fuses to provide appropriate levels of short circuit and overcurrent protection for the following components: wire, cable, bus structures, and other equipment. Design system to maintain component damage within acceptable levels during faults.

B. Select fuses to coordinate with time current characteristics of other overcurrent protective elements, including other fuses, circuit breakers, and protective relays. Design system to maintain operation of device closest to fault operates.

2.3 FUSES

A. Dimensions and Performance: NEMA FU 1, Class as specified or as indicated on Drawings.
   1. Feeders: Class RK1, RK5, or L, fast acting
   2. Motor Branch Circuits: Class RK1 or RK5, time delay
   3. Control Circuits: Class CC fast acting.

B. Voltage: Rating suitable for circuit phase-to-phase voltage.

PART 3 - EXECUTION

3.1 DEMOLITION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install fuse with label oriented so manufacturer, type, and size are easily read.

B. Install labels complying with requirements for identification specified in Section 26 05 53, IDENTIFICATION FOR ELECTRICAL SYSTEMS, and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION

SECTION 26 28 16.16 - ENCLOSED SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Fusible switches.
   2. Nonfusible switches.

B. Related Requirements:
   1. Section 26 05 29 – Hangers and Supports for Electrical Systems.
   2. Section 26 05 53 – Identification for Electrical Systems.
   3. Section 26 28 13 – Fuses.

1.2 REFERENCE STANDARDS

A. National Electrical Manufacturers Association:
   1. NEMA FU 1 - Low Voltage Cartridge Fuses.
   2. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

B. International Electrical Testing Association:
   1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

1.3 SUBMITTALS

A. Section 01 33 00, SUBMITTAL PROCEDURES: Submittal procedures.

B. Product Data: Submit switch ratings and enclosure dimensions.

C. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
   1. Enclosure types and details for all types indicated, including NEMA 250, Type 1.
   2. Current and voltage ratings.
   3. Short-circuit current ratings (interrupting and withstand, as appropriate).
   4. Include evidence of Nationally Recognized Testing Laboratory listing for series rating of installed devices.
   5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

D. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
   1. Wiring Diagrams: for power, signal, and control wiring.

E. Qualification Data: For qualified testing agency.

F. Field quality-control reports.
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

G. Operation and Maintenance Data: For enclosed switches to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01, include the following:
   1. Manufacturer's written instructions for testing and adjusting enclosed switches.

1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of enclosed switches and ratings of installed fuses.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

1.7 COORDINATION

A. Coordinate layout and installation of switches and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCH ASSEMBLIES

A. Manufacturers:
   1. Eaton.
   2. Square D.
   3. ABB.
   4. Siemens.

B. Description: NEMA KS 1, Type HD, enclosed load interrupter knife switch. Handle lockable in OFF position. UL98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:
   1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
   2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
   3. Fuse clips: Designed to accommodate NEMA FU 1 fuses.
   4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
   5. Lugs: Mechanical type, suitable for number, size and conductor material.

D. Operation:
   1. Switch Ratings
      a. Switch Rating: Horsepower rated for AC or DC as indicated on Drawings.

E. Service Entrance: Switches identified for use as service equipment are to be labeled for this application. Furnish solid neutral assembly and equipment ground bar.

F. Furnish switches with entirely copper current carrying parts.

2.2 NONFUSIBLE SWITCH ASSEMBLIES

A. Manufacturers:
   1. Eaton.
   2. Square D.
   3. ABB.
   4. Siemens.

B. Description: NEMA KS 1, Type HD enclosed load interrupter knife switch. Handle lockable in OFF position. UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:
   1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
   2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.

D. Operation:
   1. Switch Ratings
      a. Switch Rating: Horsepower rated for AC or DC as indicated on Drawings.

E. Furnish switches with entirely copper current carrying parts.

2.3 ENCLOSURES

A. NEMA enclosure type to meet environmental conditions at the installed location.
   1. Interior Dedicated Locations (Electrical Rooms): Type 1
   2. Interior Dry Locations (Non-Dedicated Spaces subject to Dust, Dirt only): Type 12
   3. Interior Wet Locations (Wash-Down or Corrosive): Type 4X Stainless Steel
   4. Exterior Locations: Type 4X Stainless Steel
   5. Hazardous Locations: Type 7/8 Explosion Proof

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install individual wall-mounted enclosed devices with tops at uniform height unless otherwise indicated.

B. Install enclosed switches plumb. Provide supports in accordance with Section 26 05 29, HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS.

C. Height: 5 feet to operating handle. Receive Engineer or Owner approval for other mounting heights. In no instance shall the operating handle be greater than 6’7” above the floor or working platform.

D. Install fuses for fusible disconnect switches. Refer to Section 26 28 13, FUSES, for product requirements.

E. Install engraved plastic nameplates in accordance with Section 26 05 53, IDENTIFICATION FOR ELECTRICAL SYSTEMS. Engrave nameplates with the equipment served and the panel and circuit number supplying the switch.

F. Apply adhesive tag on inside door of each fused switch indicating NEMA fuse class and size installed.

3.3 FIELD QUALITY CONTROL

A. Perform inspections and tests listed in NETA.

B. Acceptance Testing Preparation:
1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:
1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed switches will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies enclosed switches. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3.4 CLEANING

A. Clean existing enclosed switches to remain or to be reinstalled.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

END OF SECTION

DIVISION 31

EARTHWORK

SECTION 31 11 00 – SITE PREPARATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Definitions for site preparation.
   2. Execution of site preparation work.

1.2 DEFINITIONS

A. Interfering or Objectionable Material: Trash, rubbish, and junk; vegetation and other organic matter, whether alive, dead, or decaying; topsoil.

B. Clearing: Removal of interfering or objectionable material lying on or protruding above ground surface.

C. Grubbing: Removal of vegetation and other organic matter including stumps, buried logs, and roots greater than 2 inches caliper to a depth of 12 inches below subgrade.

D. Scalping: Removal of sod without removing more than upper 3 inches of topsoil.

E. Stripping: Removal of topsoil remaining after applicable scalping is completed.

F. Project Limits: Areas, as shown or specified, within which Work is to be performed.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Drawings clearly showing clearing, grubbing, and stripping limits.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements: Obtain all permits required for site preparation work prior to proceeding with the work, including clearing, tree removal, and burning (if allowed). Verify and comply with applicable regulations regarding those governing noise, dust, nuisance, drainage and runoff, fire protection, and disposal.

B. Obtain Engineer's approval of staked clearing, grubbing, and stripping limits, prior to commencing clearing, grubbing, and stripping.

1.5 SCHEDULING AND SEQUENCING

A. Clearing and Grubbing: Perform clearing and grubbing in advance of grading operations.

B. Prepare site only after adequate erosion and sediment controls are in place. Limit areas exposed uncontrolled to erosion during installation of temporary erosion and sediment controls to maximum of 5 acres.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

A. Examine site and verify existing conditions for beginning work.

B. Clear, grub, and strip areas for waste disposal, borrow, or site improvements within limits shown or specified.

C. Do not injure or deface vegetation that is not designated for removal. Protect existing improvements from damage by site preparation work. Install fence at drip line of trees to remain as indicated on the Drawings.

3.2 LIMITS

A. As follows, but NOT to extend beyond Project limits.
   1. Excavation, including trenches, 5 feet beyond top of cut slopes or shored walls.
   2. Fill:
      a. Clearing and Grubbing: 5 feet beyond toe of permanent fill.
      b. Stripping and Scalping: 2 feet beyond toe of permanent fill.
   3. Structures: 15 feet outside of new structures.
   4. Roadways: Clearing, grubbing, scalping, and stripping 15 feet from centerline.
   5. Other Areas: As shown.

B. Remove rubbish, trash, and junk from entire area within Project limits.

3.3 CLEARING

A. Clear areas where construction is to be performed and other areas as indicated on the Drawings or specified of fences, lumber, walls, stumps, brush, roots, weeds, trees, shrubs, rubbish, and other objectionable material of any kind resting on or protruding through the surface of the ground which, if left in place would interfere with proper performance or completion of the Work, would impair its subsequent use, or form obstructions therein.

B. Do not incorporate organic material from clearing and grubbing operations in fills and backfills.

C. Preserve and protect trees and other vegetation designated on the Drawings or directed by the Engineer to remain.

D. Contractors Construction Facilities: Fill or remove pits, fill, and other earthwork required for erection of facilities, upon completion of the Work, and level to meet existing contours of adjacent ground.

3.4 GRUBBING

A. Grub and remove all stumps, roots and root systems and other obstructions in excess of 1-inch in diameter to a depth of not less than 18-inches below finished grade.

B. Refill all grubbing holes and depressions excavated below the original ground surface with suitable materials and compact to a density conforming to the surrounding ground surface and undisturbed soil areas.

3.5 SCALPING

A. Do not remove sod until after clearing and grubbing is completed and resulting debris is removed.

B. Scalp areas within limits shown or specified.

3.6 STRIPPING

A. Strip topsoil material containing sod, grass, or other vegetation from all areas to be occupied by structures and all areas to be excavated or filled to minimum depths shown or specified.

B. Topsoil material shall be free from brush, trash, large stones and other extraneous material. Avoid mixing topsoil with subsoil.

C. Stockpile and protect topsoil until it is to be used in loaming and seeding operations. Dispose of surplus topsoil after all Work is completed.

3.7 TOPSOIL

A. Natural, friable, sandy loam, obtained from well-drained areas, free from objects larger than 1-1/2 inches maximum dimension, and free of subsoil, roots, grass, other foreign matter, hazardous or toxic substances, and deleterious material that may be harmful to plant growth or may hinder grading, planting, or maintenance.

3.8 DISPOSAL

A. Clearing and Grubbing Debris:
   1. Dispose of debris
   2. Burning of debris shall NOT be allowed.
   3. Woody debris may be chipped. Chips may be sold to Contractor's benefit or used for landscaping as mulch or uniformly mixed with topsoil, provided that resulting mix will be fertile and NOT support combustion. Maximum dimensions of chipped material used shall be 1/4-inch by 2 inch. Dispose of chips that are unsaleable or unsuitable for landscaping or other uses with unchipped debris.
   4. Limit disposal of clearing and grubbing debris to locations that are approved by federal, state, and local authorities, and that will NOT be visible from Project.

B. Scalpings: As specified for clearing and grubbing debris.

C. Strippings:
   1. Dispose of strippings that are unsuitable for topsoil or that exceed quantity required for topsoil
   2. Stockpile topsoil in sufficient quantity to meet Project needs. Dispose of excess strippings as specified for clearing and grubbing.

END OF SECTION

SECTION 31 23 16 – EXCAVATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Work and materials associated with excavation.

B. Related sections:
1. Section 01 50 00 – Temporary Facilities and Controls
2. Section 02 41 00 – Demolition
3. Section 31 11 00 – Site Preparation
4. Section 31 23 19 – Dewatering
5. Section 31 50 00 – Excavation Support Systems

1.2 SUBMITTALS

A. Shop Drawings:
1. Excavation Plan, Detailing:
a. Methods and sequencing of excavation.
b. Proposed locations of stockpiled excavated material.
c. Proposed and spoil disposal sites.
d. Numbers, types, and sizes of equipment proposed to perform excavations.

1.3 QUALITY ASSURANCE

A. Provide adequate survey control to avoid unauthorized overexcavation.

1.4 WEATHER LIMITATIONS

A. Material excavated when frozen or when air temperature is less than 32 degrees Fahrenheit shall not be used as fill or backfill until material completely thaws.

B. Material excavated during inclement weather shall NOT be used as fill or backfill until after material drains and dries sufficiently for proper compaction.

1.5 SEQUENCING AND SCHEDULING

A. Demolition: Complete applicable Work specified in Section 02 41 00, DEMOLITION, prior to excavating.

B. Clearing, Grubbing, and Stripping: Complete applicable Work specified in Section 31 11 00, SITE PREPARATION, prior to excavating.

C. Dewatering: Conform to applicable requirements of Section 31 23 19, DEWATERING, prior to initiating excavation.

D. Excavation Support: Install and maintain, as specified in Section 31 50 00, EXCAVATION SUPPORT SYSTEMS, and as necessary to support sides of excavations and prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed Work.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

A. Excavate to lines, grades, and dimensions shown and as necessary to accomplish Work. Excavate to within tolerance of plus or minus 0.1-foot except where dimensions or grades are shown or specified as maximum or minimum. Allow for forms, working space, granular base, topsoil, and similar items, wherever applicable. Trim to neat lines where concrete is to be deposited against earth.

B. Do not over excavate without written authorization of Engineer.

C. Remove or protect obstructions as shown and as specified in Section 01 50 00, TEMPORARY FACILITIES AND CONTROLS.

3.2 UNCLASSIFIED EXCAVATION

A. All material excavated, regardless of its nature or composition, shall be classified as Unclassified Excavation. Excavation shall include the removal of all soil, rock, weather rock, rocks of all types, boulders, conduits, pipe, and all other obstacles encountered and shown to be removed within the limits of excavation shown on the Drawings or specified herein. The cost of excavation shall be included in the Lump Sum Bid Price. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.

3.3 EXCAVATION

A. All excavations shall be made in the dry and in such a manner and to such widths as will give ample room for properly constructing and inspecting the structures and/or piping they are to contain and for such excavation support, pumping and drainage as may be required. Excavation shall be made in accordance with the grades and details shown on the Drawings and as specified herein.

B. Excavation slopes shall be flat enough to avoid slides that will cause disturbance of the subgrade or damage of adjacent areas. Excavation requirements and slops shall be as indicated in the Drawings. The Contractor shall intercept and collect surface runoff both at the top and bottom of cut slopes. The intersection of slopes with natural ground surfaces, including the beginning and ending of cut slopes, shall be uniformly rounded as sown on the Drawings or as may be indicated by the Engineer. Concurrent with the excavation of cuts, the Contractor shall construct intercepting berm ditches or each berms along and on top of the cut slopes at locations shown on the Drawings or designed by the Engineer. All slopes shall be finished to reasonably uniform surfaces acceptable for seeding and mulching operations. No rock or boulders shall be left in place which protrude more than 1 foot within the typical section cut slope lines and all other objectionable vegetation shall be removed from slopes.

C. All cuts shall be brought to the grade and cross section shown on the Drawings, or established by the Engineer, prior to final inspection and acceptance by the Engineer.

D. Slides and overbreaks which occur due to negligence, carelessness or improper construction techniques on the part of the Contractor shall be removed and disposed of by the Contractor as indicated by the Engineer at no additional cost to the Owner. If grading operations are suspended for any reason whatsoever, partially completed cut and fill slopes shall be brought to the required slop and the work of seeding and mulching or other required erosion and sedimentation control operations shall be performed.

3.4 EMBANKMENT

A. The Contractor shall perform the construction of embankments in such a manner that cut and fill slopes will be completed to final slopes and grade in a continuous operation. The operation of removing excavation material from any cut and the placement of embankment in any fill shall be a continuous operation to completion unless otherwise permitted by Engineer.

B. Surfaces upon which embankments are to be constructed shall be stripped of topsoil, organic material, rubbish and other extraneous materials. After stripping and prior to placing embankment material, the Contractor shall compact the top 12 inches of in place soil.

C. Any soft or unsuitable materials revealed before or during the in-place compaction shall be removed as instructed by the Engineer and replaced with select fill.

D. Ground surfaces on which embankment is to be placed shall be scarified or stepped in a manner which will permit bonding of the embankment with the existing surface. The embankment soils shall be deposited and spread in successive, uniform, approximately horizontal layers not exceeding 8 inches in compacted depth for the full width of the cross section and shall be kept approximately level by the use of effective spreading equipment. Hauling shall be distributed over the full width of the embankment and in no case will deep ruts be allows to form during the construction of the embankment. The embankment shall be properly drained at all times. Each layer of the embankment shall be thoroughly compacted.

E. The embankment or fill material in the layers shall be of the proper moisture content before rolling to obtain the prescribed compaction. Wetting or drying of the material and manipulation when necessary to secure a uniform moisture content throughout the layer shall be required. Should the material be too wet to permit proper compaction or rolling, all work on all portions of the embankment thus affected shall be delayed until the material has dried to the required moisture content. Samples of all embankment materials for testing, both before and after placement and compaction, will be taken at frequent intervals. From these tests, corrections, adjustments, and modifications of methods, materials, and moisture content will be made to construct the embankment.

F. Where embankments are to be placed and compacted on hillsides, or when new embankment is to be compacted against embankments, or when embankment is built in part widths, the slops that are steeper than 4:1 shall be loosened or plowed to a minimum depth of 6 inches or, if in the opinion of the Engineer the nature of the ground is such that greater precautions should be taken to bind the fill to the original ground, then benches shall be cut in the existing ground as instructed by the Engineer.

G. When rock and other embankment material are excavated at approximately the same time, the rock shall be incorporated into the outer portions of the embankments and the other material which meets the requirements for select fill shall be incorporated into the formation of the embankments. Stones or fragmentary rock larger than 4 inches in their greatest dimension shall not be allowed within the top 6 inches of the final grade. Stones, fragmentary rock, or boulders larger than 12 inches in their greatest dimension shall not be allowed in any portions of embankments and shall be disposed of by the Contractor. When rock fragments or stone are used in embankments, the material shall be brought up in layers as specified or directed and every effort shall be made to fill the voids with finer material to form a dense, compact mass which meets the densities specified for embankment compaction.

3.5 STOCKPILING EXCAVATED MATERIAL

A. Stockpile excavated material that is suitable for use as fill or backfill until material is needed.

B. Post signs indicating proposed use of material stockpiled. Signs shall be readable from all directions of approach to each stockpile. Signs should be clearly worded and readable by equipment operators from their normal seated position.

C. Confine stockpiles to within easements, rights-of-way, and approved work areas. Do not obstruct roads or streets.

D. Do not stockpile excavated material adjacent to trenches and other excavations unless excavation side slopes and excavation support systems are designed, constructed, and maintained for stockpile loads.

E. Do not stockpile excavated materials near or over existing facilities, adjacent property, or completed Work, if weight of stockpiled material could induce excessive settlement.

3.6 REMOVAL AND DISPOSAL OF EXCESS AND UNSUITABLE MATERIALS

A. The Contractor shall remove and dispose of all excavated materials, which are unsuitable or exceed quantity needed for fill or backfill, off-site. Contractor shall submit to the Engineer for review all required permits and a list of disposal sites for the unsuitable or excess materials. If the disposal site is located on private property, the submittal shall also include written permission from the owner.

B. All unsuitable materials shall be disposed of in locations and under conditions that comply with federal, state and local laws and regulations.

C. The Contractor shall obtain an off-site disposal area prior to beginning excavation operations.

3.7 EXCAVATION SAFETY

A. The Contractor shall furnish, place, and maintain such excavation support systems which may be required to support sides of excavation or to protect structures, pipes, and utilities from possible damage and to provide safe working conditions. The Contractor shall be exclusively responsible for maintaining structure integrity without overstressing and damaging existing structures, pipes, and utilities resulting from the Contractor's desires to temporarily place, move, or remove loads on or adjacent to existing structures, pipes, and utilities. If the Engineer is of the opinion that at any point, sufficient or proper supports have not been provided, additional supports will be required at the expense of the Contractor. The Contractor shall be responsible for the adequacy of all supports used and for all damage resulting from failure of support system or from placing, maintaining and removing it.

B. The excavation support systems shall conform to all applicable federal, state, and local regulations and meet additional requirements as specified in Section 31 50 00, EXCAVATION SUPPORT SYSTEMS.

3.8 SUBGRADE PREPARATION

A. The excavation for all structures and facilities shall be in dewatered, firm, undisturbed earth. If, in the Engineer's opinion, the subgrade has been disturbed, corrective measures may include:
   1. Scarification and recompaction to 95 percent relative compaction or,
   2. Overexcavation and replacement with compacted granular fill.

B. If the source of disturbance is determined to be the result of the actions, or inactions of the Contractor, (for example, inadequate dewatering, disturbance by excavating or hauling equipment) the cost of additional subgrade preparation shall be at the Contractor's expense.

END OF SECTION

SECTION 31 23 16.13 - TRENCHING FOR SITE UTILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
   1. Backfilling and compacting for utilities outside the building to utility main connections.

B. Related sections:
   1. Section 01 33 00 – Submittal Procedures.
   2. Section 31 23 16 – Excavation.
   3. Section 31 23 23.13 – Fill and Backfill.
   4. Section 31 23 23.16 – Trench Backfill.

1.2 DEFINITIONS

A. Subgrade Elevations: 4 inches below finish grade elevations indicated on drawings, unless otherwise indicated.

B. Finish Grade Elevations: 4 inches above subgrade elevations indicated on drawings, unless otherwise indicated.

1.3 SUBMITTALS

A. See Section 01 33 00, SUBMITTAL PROCEDURES, for submittal procedures.

B. Compaction Density Test Reports.

1.4 PROJECT CONDITIONS

A. Provide sufficient quantities of fill to meet project schedule and requirements. When necessary, store materials on site in advance of need.

B. Verify that survey bench marks and intended elevations for the work are as indicated.

PART 2 - PRODUCTS

2.1 FILL MATERIALS

A. As specified in Section 31 23 23.16, TRENCH BACKFILL.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Identify required lines, levels, contours, and datum locations.

B. Locate, identify, and protect utilities that remain and protect from damage.

C. Notify utility company to remove and relocate utilities.

3.2 TRENCHING

A. Notify Owner's Representative of unexpected subsurface conditions and discontinue affected Work in areas until notified to resume work.

B. Slope banks of excavations deeper than 4 feet to angle of repose or less until shored.

C. Do not interfere with 45 degree bearing splay of foundations.

D. Cut trenches wide enough to allow inspection of installed utilities.

E. Hand trim excavations. Remove loose matter.

F. Remove excavated material that is unsuitable for re-use from site.

G. Remove excess excavated material from site.

3.3 PREPARATION FOR UTILITY PLACEMENT

A. Cut out soft areas of subgrade not capable of compaction in place. Backfill with general fill.

B. Compact subgrade to density equal to or greater than requirements for subsequent fill material.

C. Until ready to backfill, maintain excavations and prevent loose soil from falling into excavation.

3.4 BACKFILLING

A. Backfill to contours and elevations indicated using unfrozen materials.

B. Employ a placement method that does not disturb or damage other work.

C. Systematically fill to allow maximum lime for natural settlement. Do not fill over porous, wet, frozen or spongy subgrade surfaces.

D. Maintain optimum moisture content of fill materials to attain required compaction density.

E. Slope grade away from building minimum 2 inches in 10 ft. unless noted otherwise. Make gradual grade changes. Blend slope into level areas.

F. Correct areas that are over-excavated.
   1. Thrust bearing surfaces: Fill with concrete.
   2. Other areas: Use general fill, flush to required elevation, compacted to minimum 98 percent of maximum dry density.

G. Compaction Density Unless Otherwise Specified or Indicated.
   1. Under paving, slabs-on-grade, and similar construction: 98 percent of maximum dry density.
   2. All other locations: 95 percent of maximum dry density.

H. Reshape and re-compact fills subjected to vehicular traffic.

3.5 BEDDING AND FILL AT SPECIFIC LOCATIONS

A. At Pipe Culverts:
   1. Bedding: use general fill.

2. Cover with general fill.
3. Fill up to subgrade elevation.
4. Compact in maximum 8 inch lifts to 95 percent of maximum dry density.

3.6 TOLERANCES

A. Top Surface of General Backfilling: Plus or minus 1 inch from required elevations.

3.7 FIELD QUALITY CONTROL

A. Perform compaction density testing on compacted fill in accordance with ASTM D1556, ASTM D2167, ASTM D6938, or ASTM D3017.

B. Evaluate results in relation to compaction curve determined by testing uncompacted material in accordance with ASTM D1557 (“Modified Proctor”).

C. If tests indicate work does not meet specified requirements, remove work, replace and retest.

D. Frequency of Tests; One test per every other lift per 200 lineal feet of trench.

3.8 CLEAN-UP

A. Leave unused materials in a neat compact stockpile.

B. Remove unused stockpiled material, leave area in a clean and neat condition. Grade stockpile areas to prevent standing surface water.

C. Leave borrow areas in a clean and neat condition. Grade to prevent standing surface water.

END OF SECTION

SECTION 31 23 19 – DEWATERING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Work required to dewater excavations.

B. Related sections:
   1. Section 01 50 00 – Temporary Facilities and Controls.

1.2 WATER CONTROL PLAN

A. As a minimum, include:
   1. Descriptions of proposed groundwater and surface water control facilities including, but NOT limited to, equipment; methods; standby equipment and power supply, pollution control facilities, discharge locations to be utilized, and provisions for immediate temporary water supply as required by this section.
   2. Drawings showing locations, dimensions, and relationships of elements of dewatering system.

B. If system is modified during installation or operation revise or amend and resubmit Water Control Plan.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

A. Remove and control surface and subsurface water during periods when necessary to properly accomplish Work.

3.2 SURFACE WATER CONTROL

A. See Section 01 50 00, TEMPORARY FACILITIES AND CONTROLS.

B. Remove surface runoff controls when no longer needed.

3.3 DEWATERING SYSTEMS

A. Provide, operate, and maintain dewatering systems of sufficient size and capacity to permit excavation and subsequent construction in dry and to lower and maintain groundwater level a minimum of 2 feet below the lowest point of excavation. Continuously maintain excavations free of water, regardless of source, and until backfilled to final grade.

B. Design and Operate Dewatering Systems:
   1. To prevent loss of ground as water is removed.
   2. To avoid inducing settlement or damage to existing facilities, completed Work, or adjacent property.
   3. To relieve artesian pressures and resultant uplift of excavation bottom.
   4. Prevent softening, loosening or otherwise disturbing the excavation subgrade.

C. Provide sufficient redundancy in each system to keep excavation free of water in event of component failure.

D. Provide supplemental ditches and sumps only as necessary to collect water from local seeps.

3.4 DISPOSAL OF WATER

A. Obtain discharge permit for water disposal from authorities having jurisdiction.

B. Treat water collected by dewatering operations, as required by regulatory agencies, prior to discharge.

C. Discharge water as required by discharge permit and in manner that will NOT cause erosion or flooding, or otherwise damage existing facilities, completed Work, or adjacent property.

D. The discharge of ground water into treatment facilities shall NOT be permitted unless specifically authorized by the Owner. Remove solids from treatment facilities and perform other maintenance of treatment facilities as necessary to maintain their efficiency. If Owner allows groundwater discharge into facilities.

3.5 PROTECTION OF PROPERTY

A. Make assessment of potential for dewatering induced settlement. Provide and operate devices or systems, including but NOT limited to reinjection wells, infiltration trenches and cutoff walls, necessary to prevent damage to existing facilities, completed Work, and adjacent property.

B. Securely support existing facilities, completed Work, and adjacent property vulnerable to settlement due to dewatering operations. Support shall include, but NOT be limited to, sheeting bracing, underpinning, or compaction grouting.

3.6 REMEDIATION OF GROUNDWATER AFTER DEPLETION

A. If dewatering reduces quantity or quality of water produced by existing wells, temporarily supply water to affected well Owners from other sources. Furnish water of a quality and quantity equal to or exceeding the quality and quantity available to the well Owner prior to beginning Work or as satisfactory to each well Owner.

END OF SECTION

SECTION 31 23 23.13 – FILL AND BACKFILL

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Work and materials required for fill and backfill for all excavations other than trench type excavations.

B. Related sections:
1. Section 01 40 00 – Quality Requirements.
2. Section 02 41 00 – Demolition.
3. Section 03 30 00 – Cast-In-Place Concrete.
4. Section 31 11 00 – Site Preparation.
5. Section 31 23 16 – Excavation.
6. Section 31 23 23.16 – Trench Backfill.

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this section:
1. ASTM International:
a. C117 – Standard Test Method for Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing.
b. C136 – Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
c. D75 – Standard Practice for Sampling Aggregates.
d. D698 – Standard Test Methods for Laboratory Characteristics of Soil Using Modified Effort (12,400 ft-lbf/ft^3).
e. D1556 – Standard Test Method for Density of Soil in Place by the Sand Cone Method.
f. D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3).
g. D6938 – Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
h. D4253 – Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
i. D4254 – Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.

1.3 DEFINITIONS

A. Relative Compaction:
1. Ratio, in percent, of as-compacted field dry density to laboratory maximum dry density as determined in accordance with ASTM D698.
2. Apply corrections for oversize material to either as-compacted field dry density or maximum dry density, as determined by Engineer.

B. Optimum Moisture Content:
1. Determined in accordance with ASTM D698 specified to maximum dry density for relative compaction.
2. Determine field moisture content on basis of fraction passing 3/4-inch sieve.

C. Relative Density: Calculated in accordance with ASTM D4254 based on maximum index density determined in accordance with ASTM D4253 and minimum index density determined in accordance with ASTM D4254.

D. Prepared Ground Surface: Ground surface after completion of required demolition, clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and preparation.

E. Completed Course: A course or layer that is ready for next layer or next phase of Work.

F. Lift: Loose (uncompacted) layer of material.

G. Geosynthetics: Geotextiles, geogrids, or geomembranes.

H. Well-Graded:
   1. A mixture of particle sizes with no specific concentration or lack thereof of one or more sizes.
   2. Does NOT define numerical value that shall be placed on coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters.
   3. Used to define material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids.

I. Influence Area: Area within planes sloped downward and outward at 60-degree angle from horizontal measured from:
   1. 1-foot outside outermost edge at base of foundations or slabs.
   2. 1-foot outside outermost edge at surface of roadways or shoulder.
   3. 0.5-foot outside exterior at spring line of pipes or culverts.

J. Borrow Material: Material from required excavations or from designated borrow areas on or near site.

K. Selected Backfill Material/Select Fill: Materials available onsite that Engineer determines to be suitable for specific use.

L. Imported Material: Materials obtained from sources suitable for specified use.

M. Structural Fill: Fill materials as required under structures, pavements, and other facilities.

N. Embankment Material: Fill materials required to raise existing grade in areas other than under structures.

O. Standard Specification: The latest edition, including supplements of the Alabama Options: Alabama Department of Transportation (ALDOT) Standard Specifications for Highway Construction.

1.4 SUBMITTALS

A. Quality requirements Submittals:
   1. Catalog and manufacturer's data sheets for compaction equipment.
   2. Certified test results from independent testing agency.

1.5 QUALITY ASSURANCE

A. Notify Engineer when:
   1. Structure is ready for backfilling, and whenever backfilling operations are resumed after a period of inactivity.
   2. Soft or loose subgrade materials are encountered wherever embankment or site fill is to be placed.
   3. Fill material appears to be deviating from Specifications.

1.6 SEQUENCING AND SCHEDULING

A. Prior to placing fill or backfill, complete applicable Work specified in:
   1. Section 02 41 00, DEMOLITION.
   2. Section 31 11 00, SITE PREPARATION.
   3. Section 31 23 16, EXCAVATION

B. Backfill against concrete structures only after concrete has attained compressive strength, specified in Section 03 30 00, CAST-IN-PLACE CONCRETE. Obtain acceptance of concrete work and attained strength prior to placing backfill.

C. Backfill around water-holding structures only after completion of satisfactory leakage tests as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

D. Do not place granular base, subbase, or surfacing until after subgrade has been prepared.

PART 2 - PRODUCTS

2.1 SOURCE QUALITY REQUIREMENTS

A. Gradation Tests: It shall be the Contractor’s responsibility to conduct testing as necessary to locate acceptable sources of imported material.

2.2 SELECT FILL

A. Excavated material from required excavations, free from rocks larger than 3 inches, from roots and other organic matter, ashes, cinders, trash, debris, and other deleterious materials.

2.3 GRANULAR FILL

A. Crushed Stone material shall conform with the requirements of the applicable sections of the ALDOT Standard Specifications and shall consist of clean, hard and durable particles or fragments, free from dirt, vegetation or objectionable materials. Two classes of crushed stone may be referred to as follows:
   1. Class I – ALDOT No. 78 Aggregate
   2. Class II – Dense Graded Aggregate (DGA)

2.4 WATER FOR MOISTURE CONDITIONING

A. Free of hazardous or toxic contaminates, or contaminants deleterious to proper compaction.

2.5 FOUNDATION STABILIZATION ROCK

A. Crushed rock or pit run rock.

B. Uniformly graded from coarse to fine.

C. Free from excessive dirt and other organic material.

D. Maximum 2-1/2 inches particle size.

PART 3 - EXECUTION

3.1 GENERAL

A. Keep placement surfaces free of water, debris, and foreign material during placement and compaction of fill and backfill materials.

B. Place and spread fill and backfill materials in horizontal lifts of uniform thickness, in a manner that avoids segregation, and compact each lift to specified densities prior to placing succeeding lifts. Slope lifts only where necessary to conform to final grades or as necessary to keep placement surfaces drained of water.

C. During filling and backfilling, keep level of fill and backfill around each structure and buried tank even.

D. Do not place fill or backfill, if fill or backfill material is frozen, or if surface upon which fill or backfill is to be placed is frozen.

E. If pipe, conduit, duct bank, or cable is to be laid within fill or backfill:
   1. Fill or backfill to an elevation 2 feet above top of item to be laid.
   2. Excavate trench for installation of item.
   3. Install bedding, if applicable, as specified in Section 31 23 23.16, TRENCH BACKFILL.
   4. Install item.
   5. Backfill envelope zone and remaining trench, as specified in Section 31 23 23.16, TRENCH BACKFILL, before resuming filling or backfilling specified in this section.

F. Tolerances:
   1. Final Lines and Grades: Within a tolerance of 0.1-foot unless dimensions or grades are shown or specified otherwise.
   2. Grade to establish and maintain slopes and drainage as shown. Reverse slopes are NOT permitted.

G. Settlement: Correct and repair any subsequent damage to structures, pavements, curbs, slabs, piping, and other facilities, caused by settlement of fill or backfill material.

H. Fill and backfill materials shall be conditioned to a water content that is within 2 percentage points (plus or minus) of the optimum required for compaction as determined by ASTM D698.

3.2 BACKFILL UNDER AND AROUND STRUCTURES

A. Under Facilities: Within influence area beneath structures, slabs, pavements, curbs, piping, conduits, duct banks, and other facilities, backfill with granular fill, unless otherwise shown. Place granular fill in lifts of 6-inch maximum thickness and compact each lift to minimum of 95 percent relative compaction as determined in accordance with ASTM D698, Method C.

B. Subsurface Drainage: Backfill with granular drain material, where shown. Place granular drain material in lifts of 6-inch maximum thickness and compact each lift to minimum of 90 percent relative density.

C. Other Areas: Backfill with select fill to lines and grades shown, with proper allowance for topsoil thickness where shown. Place in lifts of 6-inch maximum thickness and compact each lift to minimum 95 percent relative compaction as determined in accordance with ASTM D698, Method C.

3.3 FILL

A. Outside Influence Areas Beneath Structures, Tanks, Pavements, Curbs, Slabs, Piping, and Other Facilities: Unless otherwise shown, place select fill as follows:
   1. Allow for 6-inch thickness of topsoil where required.
   2. Maximum 9-inch thick lifts.
   3. Place and compact fill across full width of embankment.
   4. Compact to minimum 95 percent relative compaction as determined in accordance with ASTM D698, Method C.
   5. Dress completed embankment with allowance for topsoil, crest surfacing, and slope protection, where applicable.

3.4 SITE TESTING

A. Gradation:
   1. One sample from each 400 tons of finished product or more often as determined by Engineer, if variation in gradation is occurring, or if material appears to depart from Specifications.
   2. If test results indicate material does NOT meet Specification requirements, terminate material placement until corrective measures are taken.
   3. Remove material placed in Work that does NOT meet Specification requirements.

B. In-Place Density Tests: In accordance with ASTM. During placement of materials, test as follows:
   1. One test per every other lift per 200 lineal feet of roadway or trench.
   2. A minimum of two tests on granular fill beneath structures.
   3. A minimum of two test per 300 cubic yards during backfilling of walls.

C. Testing shall be the Contractor’s responsibility and conducted by persons experienced in such work.

3.5 GRANULAR BASE, SUBBASE, AND SURFACING

A. The coarse aggregate for base courses shall be all material retained on the No. 8 {2.36 mm} sieve.

3.6 REPLACING OVEREXCAVATED MATERIAL

A. Replace excavation carried below grade lines shown or established by Engineer as follows:
   1. Beneath Footings: Concrete of strength equal to that of respective footing.
   2. Beneath Fill or Backfill: Same material as specified for overlying fill or backfill.
   3. Beneath Slabs-On-Grade: Granular fill.
   4. Trenches:
      a. Unauthorized Overexcavation: Either trench stabilization material or granular pipe base material, as specified in Section 31 23 23.16, TRENCH BACKFILL.
      b. Authorized Overexcavation: Trench stabilization material, as specified in Section 31 23 23.16, TRENCH BACKFILL.
   5. Permanent Cut Slopes (Where Overlying Area is NOT to Receive Fill or Backfill):
      a. Flat to Moderate Steep Slopes (3:1, Horizontal Run: Vertical Rise or Flatter): Select Fill.
      b. Steep Slopes (Steeper than 3:1):
         1) Correct overexcavation by transitioning between areas and designed slope adjoining areas, provided such cutting does NOT extend offsite or outside easements and right-of-ways, or adversely impacts existing facilities, adjacent property, or completed Work.

2) Backfilling over-excavated areas is prohibited unless, in opinion, backfill will remain stable, and over-excavated material is replaced as compacted select fill.

END OF SECTION

SECTION 31 23 23.16 - TRENCH BACKFILL

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): 253.1, Safety Color Code.
   2. American Public Works Association (APWA): Uniform Color Code for Temporary Marking of Underground Utility Locations.
   3. American Society for Testing and Materials (ASTM):
      a. ASTM D448, Standard Classification for Sizes of Aggregate for Road and Bridge Construction.
      b. ASTM C94, Specification for Ready-Mixed Concrete.
      c. ASTM C117, Standard Test Method for Materials Finer than 75 micrometer (No. 200) Sieve in Mineral Aggregates by Washing.
      d. ASTM C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
      e. ASTM C150, Standard Specification for Portland Cement.
      f. ASTM C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
      g. ASTM D422, Standard Test Method for Particle-Size Analysis of Soils.
      h. ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil using Standard Effort (12,400 ft-lbf/cubic ft).
      i. ASTM D1140, Standard Test Methods for Amount of Material in Soils Finer than the No. 200 (75 micrometer) Sieve.
      j. ASTM D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil using Modified Effort (56,000 ft-lbf).
      k. ASTM D3776, Standard Test Methods for Mass per Unit Area (Weight) of Fabric.
      l. ASTM D3786, Standard Test Method for Bursting Strength of Textile Fabrics: Diaphragm Bursting Strength Tester Method.
      m. ASTM D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
      n. ASTM D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
      o. ASTM D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
      p. ASTM D4533, Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
      q. ASTM D4832, Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.
      r. ASTM D4991, Standard Test Method for Leakage Testing of Empty Rigid Containers by Vacuum Method.
      s. ASTM D5034, Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test).

1.2 DEFINITIONS

A. Base Rock: Granular material upon which manhole bases and other structures are placed.

B. Bedding Material: Granular material upon which pipes, conduits, cables, or duct banks are placed.

C. Imported Material: Material obtained by the Contractor from source(s) offsite.

D. Lift: Loose (uncompacted) layer of material.

E. Pipe Zone: Backfill zone that includes full trench width and extends from prepared trench bottom to an upper limit above top outside surface of pipe, conduit, cable or duct bank.

F. Prepared Trench Bottom: Graded trench bottom after stabilization and installation of bedding material.

G. Relative Compaction: The ratio, in percent, of the as-compacted field dry density to the laboratory maximum dry density as determined by ASTM D698. Corrections for oversize material may be applied to either the as-compacted field dry density or the maximum dry density, as determined by the Engineer.

H. Relative Density: As defined by ASTM D4253 and ASTM D4254.

I. Selected Backfill Material: Material available that the Engineer determines to be suitable for a specific use.

J. Well-Graded: A mixture of particle sizes that has no specific concentration or lack thereof of one or more sizes producing a material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids. Well-Graded does not define any numerical value that must be placed on the coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters.

1.3 SUBMITTALS

A. Shop Drawings: Manufacturer's descriptive literature for marking tapes.

B. Samples:
1. Trench stabilization material.
2. Bedding and pipe zone material.
3. Granular drain.
4. Granular backfill.
5. Earth backfill.
6. Sand(s).
7. Geotextile.

C. Quality Control Submittals: Catalog and manufacturer's data sheets for compaction equipment.

D. Certified Gradation Analysis: Submit not less than 30 days prior to delivery for imported materials or anticipated use for excavated materials, except for trench stabilization material that will be submitted prior to material delivery to site.

E. Controlled Low Strength Material: Certified mix design and test results. Include material types and weight per cubic yard for each component of mix.

PART 2 - PRODUCTS

2.1 MARKING TAPE

A. Plastic:
1. Inert polyethylene, impervious to known alkalis, acids, chemical reagents, and solvents likely to be encountered in soil.
2. Thickness: Minimum 4 mils.
3. Width: 12 inches.

4. Identifying Lettering: Minimum 1-inch high, permanent black lettering imprinted continuously over entire length.
5. Manufacturers and Products:
   a. Reef Industries; Terra Tape.
   b. Allen; Markline.

B. Metallic:
1. Solid aluminum foil, visible on unprinted side, encased in a protective high visibility, inert polyethylene plastic jacket.
2. Thickness: Minimum 5 mils.
3. Width: 12 inches.
4. Identifying Lettering: Minimum 1-inch high, permanent black lettering imprinted continuously over entire length.
5. Joining Clips: Tin or nickel-coated, furnished by tape manufacturer.
6. Manufacturers and Products:
   a. Reef Industries; Terra Tape Sentry Line.
   b. Allen; Detectatape.

C. Color: In accordance with APWA Uniform Color Code for Temporary Marking of Underground Facilities.

Color[a]	Facility
Red	Electric power lines, cables, conduit, and lightning cables
Orange	Communicating alarm or signal lines, cables, or conduit
Yellow	Gas, oil, steam, petroleum, or gaseous materials
Green	Sewers and drain lines
Blue	Water, irrigation, and slurry lines
[a]As specified in ANSI Z53.1, Safety Color Code.	

2.2 TRACER WIRE

A. Open trench tracer wire shall be copper-clad steel 12-AWG high strength, high carbon with minimum 450 lb. break load. Directional Drill or bored installations shall have minimum 1,150 lb. break load.

B. Wire shall have min 30 mil HDPE insulation thickness, color coded based on APWA color code from Item 2.1.

C. Connectors
1. Mainline wires shall be connected in intersections, mainline tees, and crosses. At tees, the three wires shall be tied together using a single 3-way lockable connector. At crosses, the four wires shall be joined using a 4-way connector. Use of two 3-way connectors with a short jumper wire is acceptable as an alternative.
2. Direct bury connectors shall include 3-way lockable connectors and mainline to lateral lug connectors specifically manufactured for use in underground trace wire installation. Connectors shall be dielectric silicon filled to seal out moisture and shall be installed to prevent any uninsulated wire exposure.
3. Non-locking friction fit, twist on, or taped connectors are prohibited.

D. Termination/ Access

1. All trace wire termination points shall utilize an approved trace wire access box (above ground access box or in-ground access box) specifically manufactured for this purpose. In-ground access boxes must be traffic-rated.
2. At grade boxes shall be appropriately identified with “WATER”, “SEWER”, “ELECTRIC”, “GAS”, OR “COMMUNICATIONS” as applicable cast into the cap, and color coded.
3. A minimum of 2 feet of excess/ slack wire is required in all trace wire access boxes after meeting final elevation.
4. All trace wire access boxes shall include a manually interruptible conductive/ connective link between the terminal(s) for the trace wire connection and the terminal for the grounding anode wire connection.
5. Grounding anode wire shall be connected to the identified (or bottom) terminal on all access boxes.
6. All two-terminal access points must include external direct connection points to both the tracer wire and ground rod from top of lid.
7. All at-grade access points shall include an encapsulated magnet molded into the top of the tube to allow for detection by a ferrous metal detector.
8. All at-grade access points shall be supplied with anti-corrosion wax/gel to protect wires.
9. Manufacturers: Copperhead Industries, Valvco, TriView Ultimate by Rhino Marking, approved equal.

2.3 TRENCH STABILIZATION MATERIAL

A. Clean, hard, durable 3-inch minus crushed rock gravel, or pit run, free from clay balls, other organic materials, or debris.

B. Uniformly graded from coarse to fine, less than 8 percent by weight passing the 1/4-inch sieve.

2.4 BEDDING MATERIAL AND PIPE ZONE MATERIAL

A. Unfrozen, friable, and no clay balls, roots, or other organic material.

B. Clean or gravelly sand with less than 5 percent passing No. 200 sieve, as determined in accordance with ASTM D1140, or gravel or crushed rock within maximum particle size and other requirements as follows unless otherwise specified.
1. Duct Banks: 3/4-inch maximum particle size.
2. PVC Irrigation System Piping, and Ductile Iron Pipe with Polyethylene Wrap: 3/8-inch maximum particle size.
3. Pipe Under 18 Inches Diameter: 3/4-inch maximum particle size, except 1/4-inch for stainless steel pipe, copper pipe, tubing, and plastic pipe under 3 inches diameter.
4. Pipe Greater than 18 Inches Diameter: 1-1/2-inch maximum particle size for ductile iron pipe, concrete pipe, welded steel pipe, and pretensioned or prestressed concrete cylinder pipe. 3/4-inch maximum particle size for PVC, FRP, or HDPE Pipe.
5. Perforated Pipe: Granular drain material.
6. Conduit and Direct-Buried Cable:
    a. Sand, clean or clean to silty, less than 12 percent passing the No. 200 sieve.
    b. Individual Particles: Free of sharp edges.
    c. Maximum Size Particle: Pass a No. 4 sieve.
    d. If more than 5 percent passes No. 200 sieve, the fraction that passes No. 40 sieve shall be nonplastic as determined in accordance with ASTM D4318.

2.5 EARTH FILL

A. As specified in Section 31 23 23.13, FILL AND BACKFILL.

2.6 CONTROLLED LOW STRENGTH FILL

A. Select and proportion ingredients to obtain compressive strength between 50 and 150 psi at 28 days in accordance with ASTM D4832.

B. Materials:
   1. Cement: ASTM C150, Type I or II.
   2. Aggregate: ASTM C33, Size 7.
   3. Fly Ash (if used): ASTM C618, Class C.
   4. Water: Clean, potable, containing less than 500 ppm of chlorides.

2.7 CONCRETE BACKFILL

A. Provide as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

2.8 TOPSOIL

A. Topsoil removed and stockpiled from onsite excavation.

2.9 SOURCE QUALITY CONTROL

A. Perform gradation analysis in accordance with ASTM C136 for:
   1. Earth backfill, including specified class(es).
   2. Trench stabilization material.
   3. Bedding and pipe zone material.

B. Certify Laboratory Performance of Mix Designs:
   1. Controlled low strength fill.
   2. Concrete.

PART 3 - EXECUTION

3.1 TRENCH PREPARATION

A. Water Control: Conform to Section 31 23 19, DEWATERING.
   1. Promptly remove and dispose of water entering trench as necessary to grade trench bottom and to compact backfill and install manholes, pipe, conduit, direct-buried cable, or duct bank. Do not place concrete, lay pipe, conduit, direct-buried cable, or duct bank in water.
   2. Remove water in a manner that minimizes soil erosion from trench sides and bottom.
   3. Provide continuous water control until trench backfill is complete.

B. Remove foreign material and backfill contaminated with foreign material that falls into trench.

3.2 TRENCH BOTTOM

A. Firm Subgrade: Grade with hand tools, remove loose and disturbed material, and trim off high areas and ridges left by excavating bucket teeth. Allow space for bedding material if shown or specified.

B. Soft Subgrade: If it is encountered that it may require removal to prevent pipe settlement, notify Engineer. Engineer will determine the depth of overexcavation, if any, required.

3.3 TRENCH STABILIZATION MATERIAL INSTALLATION

A. Rebuild trench bottom with trench stabilization material.

B. Place material over full width of trench in 6-inch lifts to required grade, providing allowance for bedding thickness.

C. Compact each lift so as to provide a firm, unyielding support for the bedding material prior to placing succeeding lifts.

3.4 BEDDING

A. Furnish imported bedding material where, in the opinion of the Engineer, excavated material unsuitable for bedding or insufficient in quantity.

B. Place over the full width of the prepared trench bottom in two equal lifts when the required depth exceeds 8 inches.

C. Hand grade and compact each lift to provide a firm, unyielding surface.

D. Minimum Thickness:
   1. Pipe, 15-inch and Smaller: 4 inches.
   2. Pipe, 18-inch to 36 inch: 6 inches.
   3. Pipe, 42-inch and Larger: 12 inches.
   4. Conduit: 3 inches.
   5. Direct-Buried Cable: 3 inches.
   6. Duct Banks: 3 inches.

E. Check grade and correct irregularities in bedding material. Loosen top 1 to 2 inches of compacted bedding material with a rake or by other means to provide a cushion before laying each section of pipe, conduit, direct-buried cable, or duct bank.

F. Install to form continuous and uniform support except at bell holes, if applicable, or minor disturbances resulting from removal of lifting tackle.

G. Bell or Coupling Holes: Excavate in bedding at each joint to permit proper assembly and inspection of joint and to provide uniform bearing along barrel of pipe or conduit.

3.5 BACKFILL PIPE ZONE

A. Upper limit of pipe zone shall not be less than following:
   1. Pipe: 12 inches above top of pipe, unless shown otherwise.
   2. Conduit: 3 inches above top of conduit, unless shown otherwise.
   3. Direct-Buried Cable: 3 inches above top of cable, unless shown otherwise.
   4. Duct Bank: 3 inches above top of duct bank, unless shown otherwise.

B. Restrain pipe, conduit, cables, and duct banks as necessary to prevent their movement during backfill operations.

C. Place material simultaneously in lifts on both sides of pipe and, if applicable, between pipes, conduit, cables, and duct banks installed in same trench.
   1. Pipes 10 Inches and Smaller Diameter: First lift less than or equal to pipe-diameter.
   2. Pipes Over 10 Inches Diameter: Maximum 6-inch lifts.

D. Thoroughly tamp each lift, including area under haunches, with handheld tamping bars supplemented by "walking in" and slicing material under haunches with a shovel to ensure that voids are completely filled before placing each succeeding lift.

E. After the full depth of the pipe zone material has been placed as specified, compact the material by a minimum of three passes with a vibratory plate compactor only over the area between the sides of the pipe and the trench walls.

F. Do not use power-driven impact compactors to compact pipe zone material.

3.6 TRACER WIRE INSTALLATION

A. Install in a manner that allows proper access for connection of line tracing equipment, proper locating of wire without loss or deterioration of low frequency (512 Hz) signal, and without distortion of signal caused by more than one wire installed in close proximity.

B. Place tracer wire directly above the initial backfill within the trench, centered above the utility.

C. Install as one continuous wire, except where using approved connectors. No looping or coiling of wire is allowed.

D. Damaged wires will not be allowed and taping or spray coating is not allowed.

E. Mainline tracer wire shall not be connected to existing conductive pipes. Treat as a mainline dead-end ground using an approved waterproof connector to a ground rod driven into virgin soil beneath and in line with the utility.

F. Tracer wire shall be property grounded. At all mainline dead-ends, wire shall go to ground using an approved connection to a 1.5-lb, drive-in, magnesium ground rod.

G. Ground rod wire shall be connected to the appropriate location on the access terminal.

3.7 MARKING TAPE INSTALLATION

A. Continuously install marking tape along centerline of all buried piping, at depth of 2 feet. Coordinate with piping installation drawings.
   1. Metallic Marking Tape: Install with nonmetallic piping
   2. Plastic Marking Tape: Install with metallic piping.

3.8 BACKFILL ABOVE PIPE ZONE

A. General:
   1. Process excavated material to meet specified gradation requirements.
   2. Adjust moisture content as necessary to obtain specified compaction.
   3. Do not allow backfill to free fall into the trench or allow heavy, sharp pieces of material to be placed as backfill until after at least 2 feet of backfill has been provided over the top of pipe.
   4. Do not use power driven impact type compactors for compaction until at least 4 feet of backfill is placed over top of pipe.
   5. Backfill to grade with proper allowances for topsoil, crushed rock surfacing, and pavement thicknesses, wherever applicable.
   6. Backfill around structures with same class backfill as specified for adjacent trench unless otherwise shown or specified.

B. Select Excavated Backfill:

1. Place in lifts not exceeding 9-inch thickness.
2. Mechanically compact each lift to a minimum of 95 percent relative compaction prior to placing succeeding lifts.

C. Excavated Backfill: Backfill trench above the pipe zone with granular backfill in lifts not exceeding 8 inches. Compact each lift to a minimum of 95 percent relative compaction prior to placing succeeding lifts.

D. Concrete Backfill:
1. Place above bedding.
2. Minimum Concrete Thickness: 6 inches on top and sides of pipe.
3. Do not allow dirt or foreign material to become mixed with concrete during placement.
4. Allow sufficient time for concrete to reach initial set before additional backfill material is placed in trench.
5. Prevent flotation of pipe.
6. Begin and end concrete backfill within 4 inches of a pipe joint on each end.
7. Do not encase pipe joints except within the limits of the concrete backfill.

E. Controlled Low Strength Fill:
1. Discharge from truck mounted drum type mixer into trench.
2. Place in lifts as necessary to prevent uplift (flotation) of new and existing facilities.

3.9 REPLACEMENT OF TOPSOIL

A. Replace topsoil in top 6 inches of backfilled trench.

B. Maintain the finished grade of topsoil even with adjacent area and grade as necessary to restore drainage.

3.10 MAINTENANCE OF TRENCH BACKFILL

A. After each section of trench is backfilled, maintain the surface of the backfilled trench even with the adjacent ground surface until final surface restoration is completed.

B. Gravel Surfacing Rock: Add gravel surfacing rock where applicable and as necessary to keep the surface of the backfilled trench even with the adjacent ground surface, and grade and compact as necessary to keep the surface of backfilled trenches smooth, free from ruts and potholes, and suitable for normal traffic flow.

C. Topsoil: Add topsoil where applicable and as necessary to maintain the surface of the backfilled trench level with the adjacent ground surface.

D. Asphaltic Pavement: Replace settled areas or fill with asphalt.

E. Other Areas: Add excavated material where applicable and keep the surface of the backfilled trench level with the adjacent ground surface.

3.11 SETTLEMENT OF BACKFILL

A. Settlement of trench backfill, or of fill or facilities constructed over trench backfill, will be considered a result of defective compaction of trench backfill.

END OF SECTION

SECTION 31 50 00 – EXCAVATION SUPPORT SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Work required to install and remove excavation support systems.

B. Related Sections:
   1. Section 01 40 00 – Quality Requirements.
   2. Section 31 23 23.13 – FILL AND BACKFILL

1.2 SUBMITTALS

A. Shop Drawings:
   1. Excavation support plan.
   2. Movement monitoring plan.

B. Quality requirements Submittals: Movement measurement and data and reduced results indicating movement trends.

1.3 QUALITY ASSURANCE

A. Provide surveys to monitor movements of critical facilities.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

A. The Contractor shall design, furnish, place, and maintain such excavation support systems which may be required to support sides of excavation or to protect structures, pipes, and utilities from possible damage and to provide safe working conditions. The Contractor shall be exclusively responsible for maintaining structure integrity without overstressing and damaging existing structures, pipes, and utilities resulting from the Contractor's desires to temporarily place, move, or remove loads on or adjacent to existing structures, pipes, and utilities. If the Engineer is of the opinion that at any point, sufficient or proper supports have not been provided, additional supports will be required at the expense of the Contractor. The Contractor shall be responsible for the adequacy of all supports used and for all damage resulting from failure of support system or from placing, maintaining and removing it.

B. The excavation support systems shall conform to all applicable federal, state, and local regulations. Selection of and design of any proposed excavation support system is exclusively the responsibility of the Contractor. Contractor shall submit drawings and calculations of proposed system(s) sealed by a Professional Engineer currently registered in the state of the Work.

C. Minimum areas for sharing, sheeting and bracing are shown on the Drawings. It will be the Contractor's responsibility to determine if areas will require excavation slope retention to protect existing structures and facilities from damage resulting from the Contractor's excavation or excavation methods.

D. The Contractor shall exercise caution in the installation and removal of supports to ensure no excessive or unusual loadings or vibrations are transmitted to any new or existing structure. The

Contractor shall promptly repair, at his expense, any and all damage that can be reasonably attributed to installation or removal of excavation support systems.

E. All pre-construction condition assessments and documentation of adjacent structures on-site and off-site shall be performed by the Contractor. If any sign of distress such as cracking or movement occurs in any adjacent structure, utility or roadway during installation of supports, subsequent excavation, service period of supports, subsequent backfill and construction, or removal of supports, Engineer shall be notified immediately. Contractor shall be exclusively responsible for repair of any damage to any roadway, structure, utility, pipes, etc. both on-site and off-site, as a result of excavation.

3.2 EXCAVATION SUPPORT PLAN

A. Prepare Excavation Support Plan Addressing Following Topics:
   1. Details of shoring, bracing, sloping, or other provisions for worker protection of existing structures or facilities.
   2. Design assumptions and calculations.
   3. Methods and sequencing of installing excavation support.
   4. Proposed locations of stockpiled excavated material.
   5. Minimum lateral distance from the crest of slopes for vehicles and stockpiled excavated materials.

3.3 MOVEMENT MONITORING PLAN

A. Prepare Movement Monitoring Plan Addressing Following Topics:
   1. Survey control.
   2. Locations of monitoring points (at least one every 50 feet).
   3. Plots of data trends.
   4. Interval between surveys (not to exceed 5 working days).

B. Movement monitoring shall be done on every existing structure that is adjacent to the Contractor’s excavations.

C. Results of movement monitoring shall be delivered for the Engineer at least once a week.

3.4 REMOVAL OF EXCAVATION SUPPORT

A. DO NOT begin to remove excavation support until it can be removed without damage to existing facilities, completed Work, or adjacent property.

B. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and earth and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils and rock or damaging structures, pavements, facilities, and utilities. Maintain soil wall support as excavation is backfilled.

C. Fill voids immediately with approved backfill compacted to density specified in Section 31 23 23.13, FILL AND BACKFILL.

END OF SECTION

DIVISION 40

PROCESS INTEGRATION

SECTION 40 05 00 – PIPING SYSTEMS TESTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes test requirements for piping systems.

B. Related Sections:
   1. Section 01 50 00 – Temporary Facilities and Controls.
   2. Section 40 23 39 – Process Piping, General.

1.2 REFERENCES

A. National Fuel Gas Code (NFGC):
   1. ANSI Z 223.1 or NFPA 54.

B. ASME:
   1. B31.8 – Gas Transmission and Distribution Piping Systems.
   2. B31.1 – Power Piping.
   3. B31.3 – Process Piping.

1.3 TESTING REQUIREMENTS

A. General Requirements:
   1. Testing requirements are stipulated in Laws and Regulations; are included in the Process Piping Schedule in Section 40 23 39, PROCESS PIPING, GENERAL; are specified in the specifications covering the various types of piping; and are specified herein.
   2. Requirements in Laws and Regulations supersede other requirements of Contract Documents, except where requirements of Contract Documents are more stringent, including higher test pressures, longer test times, and lower leakage allowances.
   3. Test plumbing piping in accordance with Laws and Regulations, the plumbing code, as specified in UL requirements.
   4. Test Natural Gas or Digester Gas Piping:
      a. For less than 125 pounds per square inch gauge working pressure, test in accordance with mechanical code, as specified the National Fuel Gas Code, whichever is more stringent.
      b. For 125 pounds per square inch gauge or greater working pressure, test per ASME B31.3 or ASME B31.8, whichever is more stringent.
   5. When testing with water, the specified test pressure is considered to be the pressure at the highest point of the piping section under test. Lower test pressure as necessary to prevent testing the lowest point above a safe test pressure.

B. Furnish necessary personnel, materials, and equipment, including bulkheads, restraints, anchors, temporary connections, pumps, water, pressure gauges, and other means and facilities required to perform tests.

C. Water for Testing, Cleaning, and Disinfecting:
   1. Water for testing, cleaning, and disinfecting shall be provided as specified in Section 01 50 00, TEMPORARY FACILITIES AND CONTROLS.

D. Pipes to be Tested: Test only those portions of pipes that have been installed as part of this Contract. Test new pipe sections prior to making final connections to existing piping. Furnish and install test plugs, bulkheads, and restraints required to isolate new pipe sections. Do not use existing valves as test plug or bulkhead.

E. Unsuccessful Tests:
   1. Where tests are not successful, correct defects or remove defective piping and appurtenances and install piping and appurtenances that comply with the specified requirements.
   2. Repeat testing until tests are successful.

F. Test Completion: Drain and leave piping clean after successful testing.

G. Test Water Disposal: Dispose of testing water at the facility in accordance with requirements of federal, state, county, and city regulations governing disposal of waste in the location of the Project and disposal site.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 00, SUBMITTAL PROCEDURES.

B. Schedule and Notification of Tests:
   1. Submit a list of scheduled piping tests by noon of the working day preceding the date of the scheduled tests.
   2. Notification of Readiness to Test: Immediately before testing, notify Engineer in writing of readiness, not just intention, to test piping. Have personnel, materials, and equipment specified in place before submitting notification of readiness.

1.5 SEQUENCE

A. Clean piping before pressure or leak tests.

B. Test gravity piping underground, including sanitary sewers, for visible leaks before backfilling and compacting.

C. Underground pressure piping may be tested before or after backfilling when not indicated or specified otherwise.

D. Backfill and compact trench or provide blocking that prevents pipe movement before testing underground piping with a maximum leakage allowance.

E. Test underground piping before encasing piping in concrete or covering piping with slab, structure, or permanent improvement.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 TESTING, ALIGNMENT, GRADE, AND DEFLECTION

A. Alignment and Grade:
   1. Visually inspect the interior of gravity piping with artificial light, reflected light, or laser beam.
   2. Consider inspection complete when no broken or collapsed piping, no open or poorly made joints, no grade changes that affect the piping capacity, or no other defects are observed.

B. Deflection Test:
   1. Pull a mandrel through the clean piping section under test.
   2. Perform the test not sooner than 30 days after installation and not later than 60 days after installation.

3. Use a 9-rod mandrel with a contact length of not less than the nominal diameter of the pipe within one percent plus or minus.
4. Consider test complete when the mandrel can be pulled through the piping with reasonable effort by one person, without the aid of mechanical equipment.

3.2 AIR TESTING METHOD FOR PRESSURE PIPING

A. Air test piping, indicated with “AM” in the Process Piping Schedule, with air or another nonflammable or inert gas.

B. Test gas, air, liquefied petroleum gas, liquid chlorine, and chlorine gas piping by the air test method:
1. Test chlorine piping with dry air or nitrogen having a dew point of minus 40 degrees Fahrenheit or less. Supply temporary air dryers as necessary.

C. Test at pressure as specified in Process Piping Schedule in Section 40 23 39, PROCESS PIPING – GENERAL:
1. Provide temporary pressure relief valve for piping under test. Set at the lesser of 110 percent of the test pressure or 50 pounds per square inch gauge over the test pressure.
2. Air method test pressures shall not exceed 110 percent of the piping maximum allowable working pressure calculated in accordance with the most stringent of ASME B31.1. AS<E B31.3, ASE B31.8, or the pipe manufacturer’s stated maximum working pressure.
3. Gradually increase test pressure to an initial test pressure equal to the lesser of one-half the test pressure or 25 pounds per square inch gauge.
4. Perform initial check of joints and fittings for leakage.
5. Gradually increase test pressure in steps no larger than the initial pressure. Check for leakage at each step increase until test pressure is reached.
6. At each step in the pressure, examine and test piping being air tested for leaks with soap solution.
7. Consider examination complete when piping section under test holds the test pressure for 15 minutes without losses.

3.3 TESTING GRAVITY FLOW PIPING

A. Test Gravity Flow Piping indicated with “G” in the Process Piping Schedule, as follows:
1. Unless specified otherwise, subject gravity flow piping to the following tests:
   a. Alignment and grade.
   b. For plastic piping, test for deflection.
   c. Visible leaks and pressure with maximum leakage allowance, except for storm drains and culverts.
2. Inspect piping for visible leaks before backfilling. Provide temporary restraints when needed to prevent movement of piping. Pressure test piping with maximum leakage allowance after backfilling.
3. With the lower end plugged, fill piping slowly with water while allowing air to escape from high points. Keep piping full under a slight head for the water at least 24 hours.
   a. Examine piping for visible leaks. Consider examination complete when no visible leaks are observed.
   b. Maintain piping with water or allow a new water absorption period of 24 hours for the performance of the pressure test with maximum leakage allowance.
   c. After successful completion of the test for visible leaks, and after the piping has been restrained and backfilled, subject piping to the test pressure for minimum of four hours while accurately measuring the volume of water added to maintain the test pressure.
   d. Consider the test complete when leakage is equal to or less than the following maximum leakage allowances:

1) For Concrete Piping with Rubber Gasket Joints: 80 gallons per day per inch of diameter per mile of piping under test.
   a) Advise manufacturer of concrete piping with rubber gasket joints of more stringent than normal maximum leakage allowance.
2) For Vitrified Clay and Other Piping: 500 gallons per day per inch of diameter per mile of piping under test.

3.4 TESTING HIGH-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure in the Process Piping Schedule is 20 pounds per square inch gauge or greater, by the high head pressure test method, indicated “HH” in the Process Piping Schedule.

B. General:
1. Test connections, hydrants, valves, blowoffs, and closure pieces with the piping.
2. Do not use installed valves for shutoff when the specified test pressure exceeds the valve’s maximum allowable seat differential pressure. Provide blinds or other means to isolate test sections.
3. Do note include valves, equipment or piping specialties in test sections if test pressure exceeds the valve, equipment or piping specialty safe test pressure allowed by the item’s manufacturer.
4. During the performance of the tests, test pressure shall not vary more than plus or minus 5 pounds per square inch gauge with respect to the specified test pressure.
5. Select the limits of testing to sections of piping. Select sections that have the same piping material and test pressure.
6. When test results indicate failure of selected sections, limit tests to piping:
   a. Between valves.
   b. Between a valve and the end of the piping.
   c. Less than 500-feet long.
7. Test piping for a minimum of 2 hours for visible leaks test and minimum of 2 hours for the pressure test with maximum leakage allowance.

C. Testing Procedures:
1. Fill piping section under test slowly with water while venting air. Use potable water for all potable waterlines and where noted on the Process Piping Schedule.
2. Before pressurizing for the test, retain water in piping under slight pressure for a water absorption period of minimum 24 hours.
3. Raise pressure to the specified test pressure and inspect piping visually for leaks. Consider visible leakage testing complete when no visible leaks are observed.

D. Pressure Test with Maximum Leakage Allowance:
1. Leakage allowance is zero for piping systems using flanged, National Pipe Thread threaded and welded joints.
2. Pressure test piping after completion of visible leaks test.
3. For piping systems using joint designs other than flanged threaded or welded joints, accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period.
   a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage and no damage to piping and appurtenances has occurred.
   b. Successful completion of the pressure test with maximum leakage allowance shall have been achieved when the observed leakage during the test period is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.
   c. Successful completion of the pressure test with maximum leakage allowance shall have been achieved with the observed leakage during the test period is equal or

less than the allowable leakage and no damage to piping and appurtenances has occurred.

d. When leakage is allowed, calculate the allowable leakage by the following formula:

$L = S \times D \times (P^{0.5}) \times (148{,}000^{-1})$

Wherein the terms shall mean:
L = Allowable leakage in gallons per hour
S = Length of the test section in feet
D = Nominal diameter of the piping in inches
P = Average observed test pressure in pounds per square inches, guage, at the lowest point of the test section, corrected for elevation of the pressure gauge.
X = Multiplication symbol.

3.5 TESTING LOW-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure is less than 20 pounds per square inch gauge, by the low head pressure test method, indicated "LH" in the Process Piping Schedule.

B. General:
1. Test pressures shall be as scheduled in Section 40 23 39, PROCESS PIPING - GENERAL.
2. During the performance of the tests, test pressure shall not vary more than plus or minus 2 pounds per square inch gauge with respect to the specified test pressure.
3. Test connections, blowoffs, vents, closure pieces, and joints into structures, including existing bell rings and other appurtenances, with the piping.
4. Test piping for a minimum of 2 hours for visible leaks test and minimum of 2 hours for the pressure test with maximum leakage allowance.

C. Visible Leaks Test:
1. Subject piping under test to the specified pressure measured at the lowest end.
2. Fill piping section under test slowly with water while venting air. Use potable water for all potable waterlines and where noted on the Process Piping Schedule.
3. Before pressurizing for the tests, retain water in piping under slight pressure for the water absorption period of minimum 24 hours.
4. Raise pressure to the specified test pressure and inspect piping visually for leaks. Consider testing complete when no visible leaks are observed.

D. Pressure Test with Maximum Leakage Allowance:
1. Pressure test piping after completion of visible leaks test.
2. Accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period.
   a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage of 80 gallons per inch of nominal diameter, per mile of piping section under test after 24 hours and no damage to piping and appurtenances has occurred.
   b. Successful completion of the leakage test shall have been achieved when the observed leakage is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.

E. Optional Joint Test:
1. When joint testing is allowed by note in the Process Piping Schedule, the procedure shall be as follows:
   a. Joint testing shall be allowed only for low head pressure piping.
   b. Joint testing may be performed with water or air.
   c. Joint test piping after completion of backfill and compaction to the top of the trench.
   d. Joint Testing with Water:

1) Measure test pressure at the invert of the pipe. Apply pressure of 4-feet plus the inside diameter of the pipe in water column within 0.20 feet in water column.
2) Maintain test pressure for one minute.
3) Base the allowable leakage per joint on 80 gallons per inch nominal diameter, per mile of piping, per 24 hours equally distributed to the actual number of joints per mile for the type of piping.
4) Consider the pressure test to be complete when makeup water added is less than the allowable leakage.
5) Successful completion of the joint test with water shall have been achieved when the observed leakage is equal or less than the allowable leakage.

e. Joint Testing with Air:
1) Apply test pressure of 3 pounds per square inch gauge with a maximum variation of plus 0.20 and minus 0.00 pounds per square inch.
2) Maintain test pressure for 2 minutes.
3) Consider the pressure test to be complete when the test pressure does not drop below 2.7 pounds per square inch for the duration of the test.

END OF SECTION

SECTION 40 05 06 – PROCESS PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
1. Pipe penetrations.
2. Restrained joints.
3. Flexible metal hose connections.
4. Expansion joints.
5. Expansion loops.
6. Sleeve-type couplings.
7. Unrestrained flanged coupling adapters.
8. Restrained flanged coupling adapters.
9. Restrained dismantling joints.
10. Service saddles.
11. Insulating flanges, couplings, and unions.
12. Strainers.
13. Spray nozzles.
14. Quick couplings.
15. Quick disconnect cam operating couplings for chemical service.
16. Chemical injection quills.

B. Related sections:
1. Section 01 33 00 – Submittal Procedures.
2. Section 01 60 00 – Product Requirements.
3. Section 09 90 00 – Painting and Protective Coatings.
4. Section 40 23 39 – Process Piping, General.

1.2 DEFINITIONS

A. Firestopping (Through-Penetration Protection System): The sealing or stuffing material or assembly placed in spaces between and penetrations through building materials to arrest movement of fire, smoke, heat, and hot gases through fire-rated construction.

B. FM: Factory Mutual Insurance Company; FM Global is the communicative name of the company.

C. WH: Warnock Hersey; indicates compliance to relevant building codes, association criteria, and product safety and performance standards.

1.3 REFERENCES

A. American Water Works Association:
1. AWWA C219 - Bolted, Sleeve-Type Couplings for Plain-End Pipe.

B. American Welding Society:
1. AWS D1.1 - Structural Welding Code - Steel.

C. ASME International:
1. ASME A13.1 - Scheme for the Identification of Piping Systems.
2. ASME B31.3 - Process Piping.
3. ASME B31.9 - Building Services Piping.

4. ASME Boiler and Pressure Vessel Code (BPVC), Section IX - Welding, Brazing, and Fusing Qualifications.

D. ASTM International:
1. ASTM D2000 - Standard Classification System for Rubber Products in Automotive Applications.
2. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
3. ASTM E119 - Standard Test Methods for Fire Tests of Building Construction and Materials.
4. ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems.
5. ASTM E1966 - Standard Test Method for Fire-Resistive Joint Systems.

E. Expansion Joint Manufacturers Association, Inc.:
1. EJMA Standards.

F. NSF International:
1. NSF 61 - Drinking Water System Components - Health Effects.
2. NSF 372 - Drinking Water System Components - Lead Content.

G. UL:
1. UL 263 - Fire Tests of Building Construction and Materials.
2. UL 1479 - Fire Tests of Through-Penetration Firestops.
3. UL 2079 - Tests for Fire Resistance of Building Joint Systems.

1.4 COORDINATION

A. Coordinate Work of this Section with installation of valves and equipment.

1.5 SUBMITTALS

A. General: Administrative, shop drawings, samples, quality control, and contract closeout submittals shall conform to the requirements of Section 01 33 00, SUBMITTAL PROCEDURES.

B. In addition to the requirements of Section 01 33 00, SUBMITTAL PROCEDURES, submit the following additional specific information:
1. Product Data:
a. Submit manufacturer catalog information for each specified product.
b. Firestopping: Submit data on product characteristics, performance, and limitation criteria.
c. Flexible Pipe Connectors: Indicate maximum temperature and pressure rating, face-to-face length, live length, hose wall thickness, hose convolutions per foot and per assembly, fundamental frequency of assembly, braid structure, and total number of wires in braid.
d. Expansion Joints: Indicate maximum temperature, pressure rating, and expansion compensation.
2. Shop Drawings:
a. Identification:
1) Submit list of wording, symbols, letter size, and color coding for pipe identification.
2) Comply with ASME A13.1.
b. Indicate restrained joint details and materials.
c. Submit layout drawings showing piece numbers and location, indicating restrained joint locations.

d. Indicate layout of piping systems, including flexible connectors, expansion joints and compensators, loops, offsets, and swing joints.

3. Firestopping Schedule: Submit schedule of opening locations and sizes, penetrating items, and required listed design numbers to seal openings for maintenance of fire-resistance rating of adjacent assembly.
4. Quality Control Submittals:
   a. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
   b. Welder Certificates: Certify welders and welding procedures employed on Work, verifying ASME qualification within previous 12 months.
   c. Delegated Design Submittals: Submit signed and sealed Shop Drawings with design calculations and assumptions for:
      1) Flexible connectors.
      2) Expansion joints.
      3) Pipe Restraints:
         a) Determine restrained lengths and submit joint restraint details.
         b) Use joint restraint devices specifically designed for applications as described in manufacturer data.
      4) Firestopping Engineering Judgments: For conditions not covered by UL- or WH-listed designs, submit judgments by licensed professional engineer suitable for presentation to authority having jurisdiction to accept as meeting fire-protection code requirements.
   d. Manufacturer Instructions: Submit special procedures and setting dimensions.
   e. Source Quality-Control Submittals: Indicate results of shop tests and inspections.
   f. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.
   g. Qualifications Statements:
      1) Submit qualifications for manufacturer, installer, and licensed professional.
      2) Submit manufacturer's approval of installer.
      3) Welders: Qualify procedures and personnel according to ASME BPVC-IX.

1.6 QUALITY ASSURANCE

A. Materials in Contact with Potable Water: Certified to NSF Standards 61 and 372.

B. Perform Work according to ASME B31.9 for installation of piping systems and according to ASME BPVC-IX for welding materials and procedures.

C. Perform Work according to ASME B31.3, ASME B31.9, and Local Building Codes for installation of piping systems.

D. Through-Penetration Firestopping of Fire-Rated Assemblies:
   1. Comply with UL 1479 or ASTM E814.
   2. Minimum Positive Pressure Differential: 0.1-inch WG to achieve fire F-ratings and temperature T-ratings as indicated on Drawings, but not less than one hour.
   3. Wall Penetrations: Fire F-ratings as indicated on Drawings, but not less than one hour.
   4. Fire-rated firestopping may not be required for non-rated floors and roofs. Coordinate with following non-fire-rated assemblies.
   5. Floor and Roof Penetrations:
      a. Fire F-ratings and Temperature T-ratings: As indicated on Drawings, but not less than one hour.
      b. Floor Penetrations within Wall Cavities: T-rating is not required.

E. Through-Penetration Firestopping of Non-fire-rated Floor and Roof Assemblies:
   1. Materials to resist free passage of flame and products of combustion.

2. Noncombustible Penetrating Items: Noncombustible materials for penetrating items connecting maximum of three stories.
3. Penetrating Items: Materials approved by authorities having jurisdiction for penetrating items connecting maximum of two stories.

F. Fire-Resistive Joints in Fire-Rated Floor, Roof, and Wall Assemblies:
1. Comply with ASTM E1966 or UL 2079.
2. Rating: As indicated on Drawings for assembly in which joint is installed.

G. Fire-Resistive Joints between Floor Slabs and Exterior Walls:
1. Comply with ASTM E119.
2. Minimum Positive Pressure Differential: 0.1-inch WG to achieve fire-resistance rating as indicated on Drawings for floor assembly.

H. Surface-Burning Characteristics: Maximum 25/450 flame-spread/smoke-developed index when tested according to ASTM E84.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years' experience.

B. Installer: Company specializing in performing Work of this Section with minimum three years' experience and approved by manufacturer.

C. Welders: ASME qualified within previous 12 months for employed weld types.

D. Licensed Professional: Professional engineer experienced in design of specified Work and licensed in State of Alabama.

1.8 EXISTING CONDITIONS

A. Contractor shall take field measurements to verify accuracy of information shown on Drawings. Indicate field measurements and/or deviations to Engineer on Shop Drawings.

1.9 WARRANTY

A. Provide warranty for a period of 12 months after the final acceptance of the items specified herein by the Owner and Engineer. The warranty shall stipulate that the items furnished are suitable for the purpose intended and free from defects of material and workmanship for the duration of the warranty. In the event the items fail to perform as specified, the Manufacturer will promptly repair or replace the defective items without additional cost to the Owner.

PART 2 - PRODUCTS

2.1 PIPE PENETRATIONS

A. Performance and Design Criteria:
1. Firestopping Materials: Per manufacturer’s recommendation.
2. Firestop interruptions to fire-rated assemblies, materials, and components.
3. Firestopping: Provide certificate of compliance from authority having jurisdiction, indicating approval of materials used.

B. Flashing:
1. Metal Flashing:

a. Material: Galvanized steel.
b. Thickness: 26 gage.

2. Metal Counterflashing:
   a. Material: Galvanized steel.
   b. Thickness: 22 gage.
3. Lead Flashing:
   a. Material: Sheet lead.
   b. Weight:
      1) Waterproofing: 5 psf.
      2) Soundproofing: 1 psf.
4. Flexible Flashing Materials:
   a. Material: Compatible with service conditions.
   b. Thickness: 47 mils.
5. Caps:
   a. Material: Steel.
   b. Minimum Thickness: 22 gage, and 16 gage at fire-resistive elements.

C. Sleeves:
1. Sleeves for Pipes through Non-fire-rated Floors:
   a. Material: Galvanized steel.
   b. Thickness: 18 gage.
2. Sleeves for Pipes through Non-fire-rated Beams, Walls, Footings, and Potentially Wet Floors:
   a. Steel pipe.
   b. 18 gage galvanized steel.
3. Sleeves for pipes through water bearing structures and where mechanical seals are specified:
   a. Steel pipe.
   b. 3/16-inch minimum galvanized steel.
   c. Seep Ring:
      1) 3/16-inch minimum thickness center steel flange for water stoppage on sleeves in exterior or water-bearing walls.
      2) Outside Diameter: 3-inches greater than pipe sleeve outside diameter.
      3) Continuously fillet weld on each side all around.
   d. Factory Finish:
      1) Galvanizing:
         a) Hot-dip applied, meeting requirements of ASTM A153.
         b) Electroplated zinc or cadmium plating is unacceptable.
      2) Shop Lining and Coating: Factory prepare, prime, and finish coat in accordance with Section 09 90 00, PAINTING AND PROTECTIVE COATINGS.
4. Insulated and Encased Pipe Sleeve:
   a. Manufacturer: Pipe Shields, Inc.; Models WFB, WFB-CS and -CW Series, as applicable.
5. Sealant:
   a. Type: Acrylic.

D. Mechanical Sleeve Seals:
1. Manufacturers:
   a. Advance Products & Systems, Inc.
   b. Fernco Inc.
   c. Flexicraft Industries.
   d. GPT; an EnPro Industries Company
   e. Substitutions: As specified in Section 01 60 00, PRODUCT REQUIREMENTS.
2. Description:

a. Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between object and sleeve.
b. Connection: Bolts and pressure plates causing rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.
c. Assemble interconnected rubber links with ASTM A276, Type 316 stainless steel bolts, nuts, and pressure plates.
d. Size: According to Manufacturer's instructions for the size of pipes shown to provide a watertight seal between pipe and wall sleeve opening, and to withstand a hydrostatic head of 40-feet of water.

E. Wall Pipes:
1. Ductile Iron Wall Pipe:
a. For penetrations through concrete walls, floors, slabs, or roofs that are to be watertight.
b. Diameter and Ends: Same as connecting ductile iron pipe.
c. Thickness: Equal to or greater than remainder of pipe in line.
d. Fittings: In accordance with applicable Pipe Data Sheet.
e. Thrust Collars:
1) Provide for all wall pipes.
2) Rated for thrust load developed at 250 psi.
3) Safety Factor: 2, minimum.
4) Material and Construction:
a) Ductile iron or cast iron, cast integral with wall pipe wherever possible.
b) Fabricate welded attachment of ductile iron thrust collar to pipe where casting impossible. Perform in pipe manufacturer's shop by qualified welders. Electric arc welds of ductile iron with NI-55 or FC-55 nickel-iron-carbon weld rod. Continuously weld on each side all around.
f. Manufacturers: American Cast Iron Pipe Co.; U.S. Pipe and Foundry Co.
g. Coating After Fabrication: Prepare and coat wall pipe in accordance with and as specified in Section 09 90 00, PAINTING AND PROTECTIVE COATINGS.
2. Steel or Stainless-Steel Wall Pipe:
a. Same material and thickness as connecting pipe, except 1/4-inch minimum thickness.
b. Lining: Same as connecting pipe.
c. Thrust Collar: Unless otherwise shown, 3-inches greater than outside diameter of wall pipe. Continuously fillet weld on each side all around.
d. Coating After Fabrication: Prepare and coat wall pipe in accordance with and as specified in Section 09 90 00, PAINTING AND PROTECTIVE COATINGS.
e. Restraint: Provide lugs for use with thrust ties as specified.

2.2 RESTRAINED JOINTS

A. As specified in Section 40 23 39, PROCESS PIPING, GENERAL.

2.3 FLEXIBLE METAL HOSE CONNECTIONS

A. Manufacturers:
1. Flexicraft Industries.
2. Flex-Weld, Inc.
3. Hyspan Precision Products, Inc.
4. Senior Flexonics.
5. Substitutions: As specified in Section 01 60 00, PRODUCT REQUIREMENTS.

B. Steel Piping:
1. Inner Hose: Stainless steel.

2. Exterior Sleeve: Single-braided stainless steel.
3. Pressure Rating: 200 psig WOG at 250 degrees Fahrenheit.
4. Joints: Flanged, Threaded, or Threaded with union as specified for pipe joints.
5. Size: 1/4 to 16-inch.
6. Maximum Offset: 1-inch on each side of installed center line.

C. Copper Piping:
1. Inner Hose: Bronze.
2. Exterior Sleeve: Braided bronze.
3. Pressure Rating: 125 psig WSP at 450 degrees Fahrenheit.
4. Joints: Flanged Threaded with union Soldered As specified for pipe joints.
5. Size: 1/4 to 4-inch.
6. Maximum Offset: 1-inch on each side of installed center line.

2.4 EXPANSION JOINTS

A. Manufacturers:
1. Flexicraft Industries.
2. Flex-Weld, Inc.
3. Hyspan Precision Products, Inc.
4. Mason Industries.
5. Metraflex Company.
6. U.S. Bellows, Inc.
7. Senior Flexonics.
8. Victaulic.
9. Red Valve.
10. General Rubber.
11. Mercer.
12. Substitutions: As specified in Section 01 60 00 – PRODUCT REQUIREMENTS.

B. Performance and Design Criteria:
1. Bellow Design: According to Section C of EJMA Standards.

C. Stainless-Steel Bellows
1. 3-inch and smaller:
   a. Pressure Rating: 125 psig WSP at 400 degrees Fahrenheit.
   b. Maximum Compression: 1-3/4 inches.
   c. Maximum Extension: 1/4 inch.
   d. Joint: Flanged or Welded as specified for pipe joints.
2. External Ring-Controlled Stainless-Steel Bellows Type, 4-inch and larger:
   a. Pressure Rating: 125 psig WSP at 400 degrees Fahrenheit.
   b. Maximum Compression: 1 1/4-inch.
   c. Maximum Extension: 3/8-inch.
   d. Maximum Offset: 5/16-inch.
   e. Joint: Flanged, grooved, or welded as specified for pipe joints.
   f. Accessories: Internal flow liner.
   g. Application: Steel piping 3-inches and larger.

D. Single-Sphere Flexible Compensators:
1. Body: EPDM.
2. Working Pressure:
   a. 2-inch through 12-inch: 150 psig.
   b. 14 inch through 36-inch: 110 psig
3. Maximum Temperature: 250 degrees Fahrenheit.
4. Maximum Compression: 1 1/8-inches or greater.
5. Maximum Elongation: 3/4-inch or greater.

6. Maximum Offset: 3/4-inch or greater.
7. Joint: Tapped steel flanges.
8. Size: 2-inch to 36-inches
9. Accessories: Control rods.
10. Application: Steel or Ductile Iron piping 2-inches and larger.

E. Double-Sphere Flexible Compensators:
1. Body: EPDM.
2. Working Pressure:
   a. 2-inch through 12-inch: 150 psig.
   b. 14-inch through 20-inch: 110 psig
3. Maximum Temperature: 220 degrees Fahrenheit.
4. Maximum Compression: 2-inches or greater.
5. Maximum Elongation: 1/4-inch or greater.
6. Maximum Offset: 3/4-inch or greater.
7. Maximum Angular Movement: 30 degrees.
8. Joint: Tapped steel flanges.
9. Accessories: Control rods.
10. Application: Steel and Ductile Iron piping 2-inches and larger.

F. Two-Ply Bronze Bellows Type:
1. Description: Bronze with anti-torque device, limit stops, and internal guides.
2. Pressure Rating: 125 psig WSP at 400 degrees Fahrenheit.
3. Maximum Compression: 1 3/4-inches.
4. Maximum Extension: 1/4-inch.
5. Application: Copper Piping.

G. Low-Pressure Compensators with Two-Ply Bronze Bellows:
1. Working Pressure: 80 psig.
2. Maximum Temperature: 400 degrees Fahrenheit.
3. Maximum Compression: 1/2-inch.
4. Maximum Extension: 5/32-inch.
5. Joint: Soldered.
6. Application: Copper or steel piping 2-inches and smaller.

2.5 EXPANSION LOOPS

A. Provide expansion loops as indicated on Drawings.

2.6 SLEEVE-TYPE FLEXIBLE COUPLINGS

A. Manufacturers:
1. Romac.
2. Smith-Blair.
3. JCM Industries.
4. Ford Meter Box Company.
5. Substitutions: As specified in Section 01 60 00, PRODUCT REQUIREMENTS.

B. Description:
1. Comply with AWWA C219.
2. Middle Ring:
   a. ≥12-inch diameter: Steel
   b. <12-inch diameter: Ductile iron.
3. Followers:
   a. ≥12-inch diameter: Steel
   b. <12-inch diameter: Ductile iron.

4. Gaskets:
    a. Material: Buna-N, or EPDM, or SBR, Compatible with service conditions and NSF 61 certified.
    b. Comply with ASTM D2000 and AWWA C219.
5. Bolts: 304 Stainless Steel.

C. Finishes:
1. Buried Couplings: Fusion bonded epoxy.
2. Exposed: Match connecting pipe.

2.7 UNRESTRAINED FLANGED COUPLING ADAPTERS

A. Provide flange coupling adapters with anchor lugs or anchor wedge restraints.

B. Manufacturers and Products:
1. Steel Pipe:
    a. Smith-Blair, Series 913 (3-inches & Larger)
    b. Dresser Industries, Inc., Style 128-W (2 – 24-inches)
    c. Romac, FC400 (12 – 96-inch)
2. Ductile Iron Pipe:
    a. Smith-Blair, Series 912 (3 – 12-inches)
    b. Dresser Industries, Inc., Style 128-W (3 – 12-inches)
    c. Romac, FCA501 (3 – 16-inches)
    d. EBAA Iron Series 1000 E-Z Flange Adapter

C. Pressure Rating:
1. When properly installed on a pipe that is within the coupling manufacturer's tolerances, Flanged Coupling Adapters can work at pressures up to the maximum rating of the flange. Flanges are rated for a maximum working pressure of 300 psi.

2.8 RESTRAINED FLANGED COUPLING ADAPTERS

A. Provide flange coupling adapters with anchor lugs or anchor wedge restraints.

B. Manufacturers and Products:
1. Steel Pipe:
    a. Smith-Blair, Model 911 (3 – 12-inches)
    b. Romac, RFCA (3 – 24-inches)
2. Ductile Iron Pipe:
    a. Smith-Blair, Model 911 (3 – 48-inches)
    b. Romac, RFCA (3 – 24-inches)

C. Pressure Rating:
1. When properly installed on a pipe that is within the coupling manufacturer's tolerances, Flanged Coupling Adapters can work at pressures up to the maximum rating of the flange. Flanges are rated for a maximum working pressure of 275 psi.

2.9 RESTRAINED DISMANTLING JOINTS

A. Manufacturers and Products:
1. Steel or Ductile Iron Pipe:
    a. Smith-Blair, Series 975 (3-inches and Larger)
    b. Dresser Industries, Inc., Style 131 (2 – 24-inches)
    c. Romac, DJ400 (3 – 72-inches)

B. Pressure Rating:
   1. Capable of withstanding a maximum working pressure of 300 psi.

2.10 SERVICE SADDLES

A. Double-Strap Iron:
   1. Pressure Rating: Capable of withstanding a maximum of 300 psi internal pressure without leakage or over stressing.
   2. Run Diameter: Compatible with the outside diameter of the pipe on which the saddle is installed.
   3. Taps: Iron pipe threads.
   4. Materials:
      a. Body: Malleable or ductile iron.
      b. Straps: Galvanized steel.
      c. Hex Nuts and Washers: Steel.
      d. Seal: Rubber.
   5. Manufacturers and Products:
      a. Smith-Blair, Series 313 (1.25 – 24-inches) or 366 (19.25 – 43.15-inches O.D. range)
      b. Dresser, Style 91 (2 – 12-inches)

B. Nylon-Coated Iron:
   1. Pressure Rating: Capable of withstanding a maximum of 300 psi internal pressure without leakage or over stressing.
   2. Run Diameter: Compatible with the outside diameter of the pipe on which the saddle is installed.
   3. Materials:
      a. Body: Nylon-coated iron.
      b. Seal: Buna-N.
      c. Clamps and Nuts: Stainless steel.
   4. Manufacturer and Product:
      a. Smith-Blair, Style 315 (1 – 14 inches) or 317 (1.25 – 24 inches)

2.11 INSULATING FLANGES, COUPLINGS, AND UNIONS

A. Materials:
   1. In accordance with the applicable piping material specified in the Pipe Data Sheets.
   2. Galvanically compatible with piping.

B. Connection:
   1. 2-inches and Smaller: Screwed or solder-joint.
   2. 2 1/2-inches and Larger: Flanged, complete with bolt insulators, dielectric gasket, bolts, and nuts.

C. Working Pressure Rating: Suitable for specified system working pressure.

D. Manufacturers and Products:
   1. Dielectric Flanges and Unions:
      a. Epco Sales, Inc.
      b. Capitol Insulation Unions.
   2. Insulating Couplings:
      a. Dresser – Style 39.
      b. R. H. Baker – Series 216.

2.12 STRAINERS

A. Strainers for Process Water Service, 4-inches and Smaller:
   1. Type: Bronze Body, Y-Pattern, 200 psi non-shock rated, with screwed gasketed bronze cap.
   2. Screen: Heavy gauge Type 304 stainless steel or Monel, 20-mesh
   3. Manufacturers:
      a. Armstrong International, Inc. – F Series
      b. Mueller Steam Specialty – Series 351M

B. Strainers for CPVC, Plastic Piping Systems, 4-inches and Smaller:
   1. Type: Y-pattern CPVC body, 150 psi non-shock rated, with screwed CPVC cap; and PTFE Teflon seals as recommended by manufacturer for service.
   2. End Connections: Screwed or solvent weld, 2-inch and smaller. Class 150 ANSI flanged, 1-1/2-inch and larger.
   3. Screen: Heavy-gauge CPVC, 1/32-inch mesh, minimum 2 to 1 screen area to pipe size ratio.
   4. Manufacturers and Products:
      a. Hayward Flow Control.
      b. Or pre-approved equal.

2.13 SPRAY NOZZLES
   1. Scum Spray Nozzle Type 1:
      a. Spray Pattern: Even
      b. Spray Angle: 140 degrees Fahrenheit at 60 psi
      c. Material: 316 stainless steel
      d. Deflection Angle: 75 degrees Fahrenheit
      e. Capacity: 8 gpm at 40 psi
      f. Size: 1/2-inch NPT
      g. Provide nozzle with adjustable ball fitting: Spray System Company Series 36275
      h. Manufacturer and Product:
         1) Spraying System Co. – Nozzle Type K
         2) Or pre-approved equal.
   2. Scum Spray Nozzle Type 2:
      a. Spray Pattern: Solid narrow angle cone-shaped spray pattern with round impact area
      b. Spray Angle: 15 degrees Fahrenheit at 40 psi
      c. Material: 316 stainless steel
      d. Capacity: 3 gpm at 40 psi
      e. Size: 1/4-inch NPT
      f. Provide nozzle with adjustable ball fitting: Spray System Company Series 36275
      g. Manufacturer and Product:
         1) Spraying System Co. – Nozzle Type G-15
         2) Or pre-approved equal.
   3. Scum Spray Nozzle Type 3:
      a. Spray Pattern: Deflected flat spray pattern at low pressure
      b. Spray Angle: 105 degrees Fahrenheit at 10 psi
      c. Counterweight lever which when lifted, allows the solid stream flow to purge nozzle.
      d. Material: Brass with elastomeric seat
      e. Capacity: 3.5 gpm at 10 psi
      f. Size: 1/4-inch NPT
      g. Provide nozzle with adjustable ball fitting: Spray System Company Series 36275
      h. Manufacturer and Product:
         1) Spraying System Co. – 22561 Foam Control Spray Nozzles
         2) Or pre-approved equal.

2.14 QUICK COUPLINGS

A. Provide female NPT by male quick-connect hose adaptors. All adapters and couplers shall satisfy dimensional requirements of MIL-C-27487E and shall be cast iron and sized shown on the Drawings.

B. Manufacturers and Products:
   1. Swagelok – QM Series

2.15 QUICK DISCONNECT CAM OPERATING COUPLINGS FOR CHEMICAL SERVICE

A. Type: Twin cam arm actuated, male and female, locking, for chemical loading and transfer.

B. Material: Glass-filled polypropylene and PVDF with Teflon gaskets and as recommended for the service by Manufacturer.

C. End Connections: NPT threaded or flanged to match piping connections.

D. Hose shanks for chemical installations.

E. Plugs and Caps: Female dust cap for each male end, male dust plug for each female end.

F. Pressure Rating: 125 psi, minimum at 70 degrees Fahrenheit.

G. Manufacturers:
   1. OPW – Kamlok (3/4 – 4 inch)
   2. Ryan Herco – 1300 Series
   3. Goodall – Basic Eight

2.16 CHEMICAL INJECTION QUILLS

A. Retractable injection quill, service rated for 250 psi, including stainless steel check valve, ball valve, solution tube adaptor, packing nut, restraint system, and limit chains, and 300 Series O-ring gaskets.

B. Manufacturer and Products: SAF-T-FLO; or pre-approved equal.

2.17 VENT CAPS

A. Type: Mushroom-style vent cap.

B. Material: Schedule 40 PVC housing and cap. Polypropylene screen.

C. Screen Size: 17 x 17 mesh for sizes 2-inch and smaller. 10 x 10 mesh for sizes 3-inch through 6-inch.

D. Open Area: Minimum 40%.

E. End Connections: NPT treaded.

F. Coatings: As specified in Section 09 90 00, PAINTING AND PROTECTIVE COATINGS.

G. Manufacturer and Products:
   1. Gizmo (1/16 – 8 inch)
   2. Or pre-approved equal.

2.18 INSULATION

A. As indicated on Drawings or pipe schedule.

2.19 FINISHES

A. Prepare piping appurtenances for field finishes as specified in Section 09 90 00, PAINTING AND PROTECTIVE COATINGS.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that field dimensions are as indicated on Drawings.

B. Inspect existing flanges for nonstandard bolt hole configurations or design and verify that new pipe and flanges mate properly.

C. Verify that openings are ready to receive sleeves and firestopping.

D. Verify that pipe plain ends to receive sleeve-type couplings are smooth and round for 12 inches from pipe ends.

E. Verify that pipe outside diameter conforms to sleeve manufacturer's requirements.

3.2 PREPARATION

A. Cleaning: Thoroughly clean end connections before installation.

B. Close pipe and equipment openings with caps or plugs during installation.

C. Surface Preparation: Clean surfaces to remove foreign substances.

3.3 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Comply with Section 01 60 00, PRODUCT REQUIREMENTS.

B. No shipment shall be made until the Contractor has an approved shop drawing submittal.

C. Delivery of Materials: Products shall be delivered in original, unbroken packages, containers, or bundles bearing the name of the manufacturer.

D. Storage: Products shall be carefully stored in a manner that will prevent damage and in an area that is protected from the elements.

E. 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 at all times.

3.4 INSTALLATION

A. Install in accordance with manufacturer’s written instructions and approved submittals.

B. Coating: Finish piping appurtenances as specified in Section 09 90 00, PAINTING AND PROTECTIVE COATINGS.

C. Pipe Penetrations:
   1. Flashing:
      a. Provide flexible flashing and metal counterflashing where piping penetrates weatherproofed or waterproofed walls, floors, and roofs.
      b. Flash floor drains with topping over finished areas with lead, 10-inches clear on sides, with minimum 36-by-36-inch sheet size.
      c. Fasten flashing to drain clamp device.
   2. Sleeves:
      a. Exterior Watertight Entries: Seal with mechanical sleeve seals.
      b. Set sleeves in position in forms and provide reinforcement around sleeves.
      c. Size sleeves large enough to allow for movement due to expansion and contraction and provide for continuous insulation wrapping.
      d. Extend sleeves through floors 1 inch above finished floor level and calk sleeves.
      e. Where piping penetrates floor, ceiling, or wall, close off space between pipe and adjacent Work with firestopping insulation and calk airtight.
      f. Provide close-fitting metal collar or escutcheon covers at both sides of penetration.
      g. Install stainless-steel escutcheons at finished surfaces.

D. Firestopping:
   1. Materials: Per manufacturer's recommendation.
   2. Placement:
      a. Place foamed material in layers to ensure homogenous density, filling cavities and spaces.
      b. Place sealant to completely seal junctions with adjacent dissimilar materials.
   3. Fire-Rated Surfaces:
      a. Seal opening at floor wall partition ceiling and roof.
      b. Install sleeve through opening and extend beyond minimum of 1-inch on both sides of building element.
      c. Size sleeve, allowing minimum of 1-inch void between sleeve and building element.
      d. Pack voids with backing material.
      e. Seal ends of sleeve with UL-listed, fire-resistive silicone compound to meet fire rating of structure penetrated.
   4. Non-rated Surfaces:
      a. Seal opening through non-fire-rated wall partition floor ceiling and roof.
      b. Install sleeve through opening and extend beyond minimum of 1-inch on both sides of building element.
      c. Size sleeve to allow minimum of 1-inch void between sleeve and building element.
      d. Install type of firestopping material recommended by manufacturer.
      e. Occupied Spaces:
         1) Install escutcheons floor plates or ceiling plates where conduit penetrates non-fire-rated surfaces in occupied spaces.
         2) Occupied spaces include rooms with finished ceilings and rooms where penetration occurs below finished ceiling.
      f. Exterior Wall Openings below Grade: Assemble rubber links of mechanical sealing device to size of piping and tighten in place according to manufacturer instructions.
      g. Interior Partitions:
         1) Seal pipe penetrations at clean rooms, laboratories, computer rooms, telecommunication rooms, and data rooms.
         2) Apply sealant to both sides of penetration to completely fill annular space between sleeve and conduit.

E. Flexible Connections: Install flexible couplings at connections to equipment and where indicated on Drawings or as required by equipment or piping manufacturer.

F. Expansion Joints:

1. Install flexible couplings and expansion joints at connections to equipment and where indicated on Drawings or as required by equipment or piping manufacturer.
2. If expansion joint is supplied with internal sleeve, indicate flow direction on outside of joint.

G. Air Release and Vacuum Breakers: Provide vacuum breakers as indicated on Drawings.

H. Backflow Preventers:
1. Install with nameplate and test cock accessible.
2. Install according to local code requirements.
3. Do not install in vertical position.

3.5 PIPING FLEXIBILITY PROVISIONS

A. General:
1. Install thrust protection.
2. Install flexible couplings to facilitate piping installation, in accordance with approved shop drawings.

B. Flexible Joints at Concrete Backfill or Encasement: Install within 18-inch or one-half pipe diameter, whichever is less, from the termination of any concrete backfill or concrete encasement.

C. Flexible Joints at Concrete Structures:
1. Install 18-inch or less from the face of structures; joint may be flush with face.
2. Install a second flexible joint, whether shown or not.
   a. Pipe Diameter 18-inch and smaller: Within 18-inch of the first joint.
   b. Pipe Diameter Larger than 18-inch: Within one pipe diameter of the first joint.

3.6 PIPING TRANSITION

A. Applications:
1. Provide complete closure assembly where pipes meet other pipes or structures.
2. Pressure Pipeline Closures: Plain end pieces with double flexible couplings, unless otherwise shown.
3. Restrained Joint Pipe Closures: Install with thrust tie-rod assemblies as shown or in accordance with NFPA 24.
4. Gravity Pipe Closures: As specified for pressure pipelines, or concrete closures.
5. Concrete Closures: Use to make connections between dissimilar pipes where standard rubber gasketed joints or flexible couplings are impractical, as approved.
6. Elastomer sleeves bonded to pipe ends are not acceptable.

B. Installation:
1. Flexible Transition Couplings: Install in accordance with coupling Manufacturer's instructions to connect dissimilar pipe and pipes with a small difference in outside diameter.
2. Concrete Closures:
   a. Locate away from structures so that there are at least two flexible joints between the closure and pipe entering the structure.
   b. Clean pipe surface before closure collars are placed.
   c. Wet non-metallic pipe thoroughly prior to pouring collars.
   d. Prevent concrete from entering pipe.
   e. Extend collar a minimum of 12-inch on each side of joint with minimum thickness of 6-inch around outside diameter of pipe.
   f. Make entire collar in one placement.

g. After concrete has reached initial set, cure by covering with well¬ moistened earth.

3.7 PIPING EXPANSION

A. Piping Installation: Allow for thermal expansion due to differences between installation and operating temperatures.

B. Expansion Joints:
1. Grooved Joint and Flanged Piping Systems: Elastomer Bellows Expansion Joint.
2. Nonmetallic Pipe: Teflon Bellows Expansion Joint.
3. Screwed and Soldered Piping Systems: Copper or Galvanized and Black Steel Pipe Expansion Compensator, as applicable.
4. Pipe Run Offset: Flexible Metal Hose.

C. Bellows Type Expansion joints:
1. Install bellows type expansion control joints at piping connections to mechanical equipment to prevent damaging stresses due to normal expansion and contraction with temperature changes in piping and connected equipment.
2. Install bellows type expansion joints to allow 2-1/4-inch expansion per 100 linear feet of piping.
3. Install expansion joints adjacent to an anchor and provide 1 concentric guide on piping within 12 pipe diameters, but not more than 5 feet, from the end of the joint opposite the anchor.
    a. Locate a similar guide approximately 30 diameters but not more than 10 feet from the first.
4. For expansion joints not installed adjacent to an anchor provide 2 concentric guides similarly located at each end of the joint.
5. Space intermediate supports a minimum of 10 feet, and tack weld the protective saddles to the pipe.

D. Anchors and Anchor Walls: Install to withstand expansion thrust loads and to direct and control thermal expansion.

3.8 SERVICE SADDLES AND THRUST TIES

A. Service Saddles:
1. Ferrous Metal Piping (except stainless steel): Double-strap iron.
2. Plastic Piping: Nylon-coated iron.
3. All service saddles shall be provided with a corporation stop.

B. Thrust Ties:
1. Install where shown and where required to restrain the force developed by the specified test pressure.
2. Steel Pipe: Attach with fabricated lugs.
3. Ductile Iron Pipe: Attach with socket clamps against a grooved joint coupling or flange.
4. Flanged Coupling Adapters: For exposed installations, install Manufacturer’s anchor studs through the coupling sleeve.

C. Installation: Install in accordance with Manufacturer’s written instructions.
1. Before coupling, clean pipe holdback area of oil, scale, rust, and dirt.
2. Remove pipe coating, if necessary, to present smooth surface.

3.9 FLEXIBLE PIPE CONNECTIONS TO EQUIPMENT

A. Tie Bolts: Tighten snug prior to applying any pressure to the system.

3.10 INSULATING FLANGES, COUPLINGS, AND UNIONS

A. Applications:
   1. Copper to ferrous metal piping connections.
   2. Catholically protected piping penetration to buildings and watertight structures.
   3. Submerged to un-submerged metallic piping connections.
   4. Where required for electrically insulated connection.

B. Installation of Insulating Kits: Drill oversize to accommodate insulating sleeves through the bolt holes, assuming standard bolt sizes.

C. Pipe Installation:
   1. Insulating joints connecting immersed piping to non-immersed piping shall be installed above maximum water surface elevation.
   2. All submerged carbon steel, ductile iron, or galvanized piping in reinforced concrete basins shall be isolated from the concrete reinforcement steel.

3.11 WALL PIPES

A. Applications:
   1. As specified in Section 40 23 39, PROCESS PIPING, GENERAL.
   2. Watertight and Below Ground Penetrations:
      a. Wall pipes with thrust collars.
      b. Provide taps for stud bolts in flanges to be set flush with wall face.
      c. Existing Walls: Rotary drilled holes.
   3. Wall Pipe Installation:
      a. Isolate embedded metallic piping from concrete reinforcement.
      b. Support wall pipes securely by formwork to prevent contact with reinforcing steel and tie-wires.

3.12 PIPE SLEEVES

A. Application:
   1. As specified in Section 40 23 39, PROCESS PIPING, GENERAL.
   2. Above Grade in Non-submerged Areas: Hot-dip galvanized after fabrication.
   3. Below Grade or in Submerged or Damp Environments: Shop-lined and coated.

B. Installation:
   1. Support non-insulating type securely in form work to prevent contact with reinforcing steel and tie-wires.
   2. Caulk joint with rubber sealant or seal with wall penetration seal.

3.13 MISCELLANEOUS SPECIALTIES

A. Install in accordance with manufacturer's instructions.

3.14 FIELD QUALITY CONTROL

A. After installation, inspect for proper supports and interferences.

B. Repair damaged coatings with material equal to original coating.

3.15 CLEANING

A. Keep equipment interior clean as installation progresses.

END OF SECTION

SECTION 40 05 07 – HANGERS AND SUPPORTS FOR PROCESS PIPE

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following hangers and supports for mechanical system piping and equipment:
   1. Steel pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Metal framing systems.
   4. Thermal-hanger shield inserts.
   5. Fastener systems.
   6. Pipe positioning systems.
   7. Equipment supports.

B. Related Sections include the following:
   1. Section 01 33 00 – Submittal Procedures.
   2. Section 01 60 00 – Product Requirements.
   3. Section 40 23 39 – Process Piping, General

1.2 DEFINITIONS

A. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry Inc.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.3 REFERENCES

A. A. Manufacturer's Standardization Society (MSS):
   1. 1. SP-58 - Pipe Hangers and Supports - Materials, Design, and Manufacture.
   2. 2. SP-69 - Pipe Hangers and Supports - Selection and Application.

1.4 PERFORMANCE REQUIREMENTS

A. Design supports for multiple pipes, capable of supporting combined weight of supported systems, system contents, and test water.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. Design seismic-restraint hangers and supports for piping and equipment.

D. Design Responsibility:
   1. The manufacturer of all pipe support systems, all pipe hangers systems, and preformed channel pipe support systems shall be considered the designer of the support systems.
   2. Prepare design calculations utilizing the design criteria included in these Specifications.
   3. Prepare detailed Shop Drawings illustrating the layout of the support system and identifying the components of the support system.

E. Design Criteria:
   1. Include live, dead, and seismic loads associated with piping, valves, and appurtenances. Consider the content of the pipes in load calculations.
   2. Minimum Gauge Thickness: 12 gauge.

3. Allowable Stress of Channels:
    a. Steel Channels: The lesser of 25,000 pounds per square inch, or 0.66 times yield stress of steel.
    b. Stainless Steel Channels: 0.66 times the yield stress of the stainless steel alloy.
4. Maximum Deflection: 1/240 of span.
5. Allowable Column Loads: As recommended by manufacturer in published instruction for column's unsupported height and "K" value for calculating effective column length of not less than 1.0.
6. Future Loads:
    a. Support systems indicated on the Drawings may include spaces intended to accommodate future pipes.
    b. Assume such spaces are occupied by 6 inch diameter ductile iron pipes. Only the number of pipes that would physically fit into the space need be considered.
    c. Include the weight of the pipe contents in determining future loads. Assume pipe contents are water.
7. Spacing of Supports: As required to comply with design requirements but not more than 5 feet.

F. Supports below the top of walls of water bearing structures: Use Type 316 stainless steel for support system components.
1. Supports in other locations: Use hot-dipped galvanized components unless other materials are specifically indicated on the Drawings.

1.5 SUBMITTALS

A. General: Administrative, shop drawings, samples, quality control, and contract closeout submittals shall conform to the requirements of Section 01 33 00, SUBMITTAL PROCEDURES.

B. In addition to the requirements of Section 01 33 00, SUBMITTAL PROCEDURES, submit the following additional specific information:
1. Product Data, for the following (as applicable):
    a. Steel pipe hangers and supports.
    b. Thermal-hanger shield inserts.
        1) Pipe positioning systems.
    c. Non-metallic pipe hangers and supports.
2. Shop Drawings:
    a. Show fabrication and installation details and include calculations for the following:
        1) Trapeze pipe hangers.
        2) Metal framing systems.
        3) Equipment supports.
    b. Drawings of piping support system, locating each support, brace, hanger, guide, component and anchor. Identify support, hanger, guide, and anchor type by catalog number and Shop Drawing detail number.
    c. Revisions to support systems resulting from changes in related piping system layout or addition of flexible joints.
3. Welding certificates.
4. Contract Closeout Submittals: Maintenance information on piping support system.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel and ASME Boiler and Pressure Vessel Code: Section IX.

B. Welding: Qualify procedures and personnel according to the following:
1. AWS D1.1, "Structural Welding Code--Steel."
2. AWS D1.2, "Structural Welding Code--Aluminum."

3. AWS D1.3, "Structural Welding Code--Sheet Steel."
4. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
5. ASME Boiler and Pressure Vessel Code: Section IX.

C. Design Preformed Channel Pipe Support System for Loads in Accordance with Applicable Provisions of:
1. AISC Manual of Steel Construction.
2. AISI Cold-Formed Steel Design Manual.

D. Product Standards:
1. Pipe Support Components: Conform to MSS SP-69.
2. Pipe Support Materials: Conform to MSS SP-58.

1.7 DESIGN REQUIREMENTS

A. General:
1. Contractor shall be responsible for the design, size, and location of process piping support systems in accordance with the requirements specified herein and in general conformance with the Drawings and the Design Details. The design shall be provided by a company specifically specializing in the design of support systems. The pipe support system design company shall demonstrate that they have at least five years of experience in pipe support design and have successfully completed at least three designs in the previous year. The Contractor shall provide Certification of Compliance with these requirements.
2. Seismic Load: See structural notes found on the Drawings.
3. Piping smaller than 30 inch: Supports are shown only where specific types and locations are required. Additional pipe supports may be required.
4. Piping 30 inch and larger: Support systems have been designed for piping shown.
5. Process piping support systems shall meet the requirements of MSS SP 58, MSS SP 69, and MSS SP 89.

B. Pipe Support Systems:
1. Support Load: Dead loads imposed by weight of pipes filled with water, except air and gas pipes, plus insulation and capable of supporting combined weight of supported systems, system contents, and test water.
2. Safety Factor: Minimum of 5.
3. Maximum Support Spacing and Minimum Rod Size:
a. Steel or Ductile Iron Piping:

Steel or Ductile Iron Pipe Size	**Maximum Support/ Hanger Spacing**	**Minimum Rod Size Single Rod Hangers**
1 inch and Smaller	6 feet	1/4 inch
1.5 – 2.5 inches	8 feet	1/4 inch
3 – 4 inches	10 feet	3/8 inch
6 inches	12 feet	3/8 inch
8 inches	12 feet	1/2 inch
10 – 12 inches	14 feet	5/8 inch
14 inches	16 feet	3/4 inch
16 – 18 inches	16 feet	7/8 inch
20 inch	18 feet	1 inch
24 inch	18 feet	1-1/4 inch
30 inch and Larger	As shown on Drawings	As shown on Drawings

b. Copper Piping:
Maximum Support Spacing: 2 feet less per size than listed for steel pipe, with 1 inch and smaller pipe supported every 5 feet.
Minimum Hanger Rod Sizing: Same as listed for steel pipe.

c. Plastic and Fiberglass Piping:
Maximum support spacing: As recommended by manufacturer for flow temperature in pipe.
Minimum Hanger Rod Sizing: Same as listed for steel pipe.

d. Stainless Steel Piping:

Stainless Steel Pipe Size	Maximum Support/ Hanger Spacing	Minimum Rod Size Single Rod Hangers
1 – 4 inches	8 feet	1/4 inch
6 inches	8 feet	3/8 inch
8 – 10 inches	10 feet	1/2 inch
12 inches	10 feet	1/2 inch
14 – 16 inches	12 feet	5/8 inch
18 – 20 inches	14 feet	3/4 inch
24 inches	14 feet	7/8 inch
30 inches and Larger	As shown on Drawings	As shown on Drawings

C. Framing Support System:
1. Beams: Size such that beam stress does not exceed 25,000 psi and maximum deflection does not exceed 1/240 of span.
2. Column Members: Size in accordance with Manufacturer's recommended method.
3. Support Loads: Calculate using weight of pipes filled with water.
4. Maximum Spans:
   a. Steel and Ductile Iron Pipe, 3-inch Diameter and Larger: 10-foot centers, unless otherwise shown.
   b. Other Pipelines and Special Situations: May require supplementary hangers and supports.
5. Electrical Conduit Support: Include in design of framing support system.

D. Anchoring Devices: Design, size, and space support anchoring devices, including anchor bolts, inserts, and other devices used to anchor support, to withstand shear and pullout loads imposed by loading and spacing on each particular support.

E. Vertical Sway Bracing: 10-foot maximum centers, or as shown.

F. Existing Support Systems: Use existing supports systems to support new piping only if Contractor can show that they are adequate for additional load, or if they are strengthened to support the additional load.

PART 2 - PRODUCTS

2.1 GENERAL

A. When specified items are not available, fabricate pipe supports of correct material and to general configuration indicated by catalogs.

B. Special support and hanger details are shown for cases where standard catalog supports are inapplicable.

C. Materials:
1. Wetted and Submerged: Stainless steel.
2. Atmospheric Exposed: Galvanized or painted steel in accordance with Section 09 90 00, PAINTING AND PROTECTIVE COATINGS.
3. Corrosive Areas: FRP
4. Stainless Steel (Type 304 or 316): Use in all submerged locations, above water level but below top of wall inside water bearing structures, and where specifically indicated on the Drawings:
   a. Shop-Fabricate: Perform pickling and passivation on all surfaces inside and out.
   b. Field welding is prohibited.
5. Hot-Dip Galvanized Steel: Use in areas other than above and where specifically indicated on the Drawings. Hot-dip galvanize pipe supports after fabrication.
6. Plastic, aluminum, FRP, and other miscellaneous materials: Use where specifically indicated on the Drawings.
7. Non-metallic pipe support systems shall be used in areas where exposed to reactive chemicals such as chemical pumping area and chemical storage area.
8. Fiberglass Resin: Corrosion resistant premium grade vinylester.
9. Injection Molded Components: Polyurethane thermoplastics.
10. Flame Spread of Fiberglass:
    a. Vinylester Fiberglass (Series VF): Class 1, ASTM E 84.
    b. Polyurethane: V-O UL 94V.
11. Physical Properties of Fiberglass:

	Longitudinal	**Transverse**
Tensile Strength	37,500 psi	10,000 psi
Tensile Modules	3.0×10^6 psi	1.0×10^6 psi
Flexural Strength	37,500 psi	14,000 psi
Flexural Modules	2.0×10^6 psi	1.0×10^6 psi
Compressive Strength	37,500 psi	20,000 psi
Shear Strength	6,000 psi	5,500 psi
Izod Impact	30 foot-pounds per square inch	5 foot-pounds per square inch

12. Surface Veil: Fiberglass channel shall have polyester surface veil over 100 percent of the surface to provide protection against degradation from ultraviolet light.
13. Touch-Up Resin:
    a. Manufacturers: One of the following or equal:
       1) Krylon, 7006-Satin Polyurethane Clear Finish.

2.2 STEEL PIPE HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

B. Manufacturers:
1. B-Line Systems, Inc.; a division of Cooper Industries.
2. Empire Industries, Inc.
3. ERICO/Michigan Hanger Co.
4. Globe Pipe Hanger Products, Inc.
5. Grinnell Corp.
6. GS Metals Corp.

7. National Pipe Hanger Corporation.

C. Galvanized, Metallic Coatings: Pre-galvanized or hot dipped.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.4 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

B. Manufacturers:
1. B-Line Systems, Inc.; a division of Cooper Industries.
2. Power-Strut Div.; Tyco International, Ltd.
3. Thomas & Betts Corporation.
4. Tolco Inc.
5. Unistrut Corp.; Tyco International, Ltd.

C. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.5 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig- minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Manufacturers:
1. Carpenter & Paterson, Inc.
2. ERICO/Michigan Hanger Co.
3. PHS Industries, Inc.
4. Pipe Shields, Inc.
5. Rilco Manufacturing Company, Inc.
6. Value Engineered Products, Inc.

C. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass with vapor barrier.

D. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass.

E. Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

F. Clevis or Band Hangers: Insert and shield shall cover lower 180° of pipe.

G. Insert Length: Extend 2-inches beyond sheet metal shield for piping operating below ambient air temperature.

2.6 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened Portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
   1. Manufacturers:
      a. Hilti, Inc.
      b. ITW Ramset/Red Head.
      c. Masterset Fastening Systems, Inc.
      d. MKT Fastening, LLC.
      e. Powers Fasteners.

B. Mechanical-Expansion Anchors: Insert-wedge-type stainless steel, for use in hardened Portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
   1. Manufacturers:
      a. B-Line Systems, Inc.; a division of Cooper Industries.
      b. Empire Industries, Inc.
      c. Hilti, Inc.
      d. ITW Ramset/Red Head.
      e. MKT Fastening, LLC.
      f. Powers Fasteners.

2.7 PIPE POSITIONING SYSTEMS

A. Description: IAPMO PS 42, system of metal brackets, clips, and straps for positioning piping in pipe spaces for plumbing fixtures for commercial applications.

B. Manufacturers:
   1. C & S Mfg. Corp.
   2. HOLDRITE Corp.; Hubbard Enterprises.
   3. Samco Stamping, Inc.

2.8 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

2.9 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
   1. Properties: Nonstaining, noncorrosive, and nongaseous.
   2. Design Mix: 5000-psi, 28-day compressive strength.

2.10 PREFORMED CHANNEL PIPE SUPPORT SYSTEM

A. Fabricate preformed channel pipe support system using, as a minimum, parts specified below and meeting the requirements specified under Design Criteria.
   1. Manufacturers: One of the following or equal:

a. Unistrut, Series P1000 or P1001; P5500 or P5501.
b. Allied Support Systems, Power Strut, Figure PS-200 or PS-200 2TS; PS-150 or PS-150 2TS.
c. B-Line Systems, Inc., Channel Type B22 or B22A; B12 or B12A.

B. Preformed Channel Concrete Inserts: Minimum 12 inches long.
1. Manufacturers: One of the following or equal:
a. Unistrut, Series P-3200.
b. Allied Support Systems, Figure 282.
c. B-Line Systems, Series B32I.

C. 90-Degree Angle Fittings:
1. Manufacturers: One of the following or equal:
a. Unistrut, P1026.
b. Allied Support Systems, Power Strut, P603.

D. Pipe Straps:
1. Pipes, 8-inches in diameter and smaller: Use 2-piece universal strap with slotted hex head screw and nut.
a. Manufacturers: One of the following or equal:
1) Unistrut, Series P1109 through P1126.
2) Allied Support Systems, PS1100.
3) B-Line Systems, Inc., Series B2000.
2. Pipes, greater than 8-inches in diameter: Unless different material is otherwise indicated on the Drawings, use one-piece 1-inch wide by 1/8-inch thick steel strap, hot-dip galvanized after fabrication.
3. Stainless Steel Pipes: Use type of strap required for the pipe sizes specified above but with Type 316 stainless steel materials.

E. Touch-Up Paint Galvanized Surfaces:
1. Manufacturers: One of the following or equal:
a. Galvinox, Galvo-Weld.

F. Touch-Up Paint for Painted Surfaces: Same formulation as factory paint.

G. Hot-dip galvanize support system components after fabrication to required length and shape.

H. Do not galvanize or paint stainless steel components.

2.11 NON-METALLIC PIPE SUPPORT SYSTEM

A. Manufacturers:
1. StrutTech, Redmond, Washington.
2. Unistrut, Wayne, Michigan.

B. Supply all materials from a single manufacturer with sole responsibility for the pipe support system.

C. The supplied system, including pipe clamps, shall be interchangeable with industry standard 1-5/8-inch steel and fiberglass channel framing systems.

D. Channel Framing:
1. All channel framing shall be supplied with integral notches 1-inch on center.
2. Locate notches on interior flange to prevent slippage of pipe clamps and fittings after installation.

E. Pipe Clamps:
   1. Adjustable Type: Non-metallic and non-conductive.
   2. Fixed Type:
      a. Pipe clamps for pipe less than 6 inches in diameter shall be non-metallic and non-conductive.
      b. Pipe clamps for pipe equal to and greater than 6 inches in diameter shall be fiberglass.

F. Channel Fittings:
   1. Make fittings and post bases from glass-filled polyurethane or polyester.

G. Fasteners:
   1. Make fasteners from one of the following materials:
      a. Glass-filled polyurethane.
      b. Vinylester fiberglass.

PART 3 - EXECUTION

3.1 GENERAL

A. Install support systems in accordance with MSS SP 69, Pipe Hangers and Supports-Selection and Application and MSS SP 89, Pipe Hangers and Supports-Fabrication and Installation, unless shown otherwise.

B. Support piping connections to equipment by pipe support and not by the equipment.

C. Support large or heavy valves, fittings, and appurtenances independently of connected piping.

D. Support no pipe from the pipe above it.

E. Support pipe at changes in direction or in elevation, adjacent to flexible joints and couplings, and where shown.

F. Do not install pipe supports and hangers in equipment access areas or bridge crane runs.

G. Brace hanging pipes against horizontal movement by both longitudinal and lateral sway bracing.

H. Install lateral supports for seismic loads at all changes in direction.

I. Install pipe anchors where required to withstand expansion thrust loads and to direct and control thermal expansion.

J. Repair mounting surfaces to original condition after attachments are made.

3.2 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use padded hangers for piping that is subject to scratching.

F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated stationary pipes, NPS 1/2 to NPS 30.
   2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 °F pipes, NPS 4 to NPS 16, requiring up to 4” of insulation.
   3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4” of insulation.
   4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
   5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
   6. Adjustable Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of non-insulated stationary pipes, NPS 3/4 to NPS 8.
   7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of non-insulated stationary pipes, NPS 1/2 to NPS 8.
   8. Adjustable Band Hangers (MSS Type 9): For suspension of non-insulated stationary pipes, NPS 1/2 to NPS 8.
   9. Adjustable Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated stationary pipes, NPS 1/2 to NPS 2.
   10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of non-insulated stationary pipes, NPS 3/8 to NPS 8.
   11. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of non-insulated stationary pipes, NPS 3/8 to NPS 3.
   12. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
   13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
   14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
   15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
   16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
   17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.
   18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.
   19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
   20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
   21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6" for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 °F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 °F piping installations.

I. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

J. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

K. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.

2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4".
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25% to absorb expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25% to absorb expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25% to absorb expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

L. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.

M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

N. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

O. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

3.3 HANGER AND SUPPORT INSTALLATION

A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

C. Fiberglass Pipe Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.

D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.

E. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

F. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4” thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool Manufacturer. Install fasteners according to powder-actuated tool Manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to Manufacturer's written instructions.

G. Pipe Positioning System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.

H. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

I. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

J. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

K. Install lateral bracing with pipe hangers and supports to prevent swaying.

L. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

M. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

N. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.

O. Insulated Piping: Comply with the following:
1. Attach clamps and spacers to piping.
    a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.
2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180°.
    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
    a. NPS 1/4 to NPS 3-1/2: 12” long and 0.048” thick.
    b. NPS 4: 12” long and 0.06” thick.
    c. NPS 5 and NPS 6: 18” long and 0.06” thick.
    d. NPS 8 to NPS 14: 24” long and 0.075” thick.
    e. NPS 16 to NPS 24: 24” long and 0.105” thick.

5. Pipes NPS 8 and Larger: Include wood inserts.
6. Insert Material: Length at least as long as protective shield.
7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.4 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.5 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.6 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1.5-inch.

3.7 PAINTING

A. Paint exposed surfaces immediately after erecting hangers and supports as specified in Section 09 90 00, PROTECTIVE PAINTING AND COATINGS.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 40 23 39 – PROCESS PIPING, GENERAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Basic Process Piping Materials, Methods, and Appurtenances.

B. Related sections:
1. Section 01 60 00 – Product Requirements.
2. Section 03 30 00 – Cast-In-Place Concrete.
3. Section 09 90 00 – Painting and Protective Coatings.
4. Section 31 23 23.16 – Trench Backfill.
5. Section 40 05 00 – Piping Leakage Testing.
6. Section 40 05 06 – Process Piping Specialties.
7. Section 40 05 07 – Hangers and Supports for Process Piping
8. Section 40 41 13 – Heat Tracing
9. Section 40 42 00 – Process Mechanical Insulation

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this Section and any supplemental Data Sheets:
1. American Association of State Highway and Transportation Officials (AASHTO): Standard Specifications for Highway Bridges.
2. American National Standards Institute (ANSI):
a. A21.52, Ductile Iron Pipe, Centrifugally Cast, for Gas.
b. B1.20.1, Pipe Threads, General Purpose (Inch).
c. B16.1, Cast Iron Pipe Flanges and Flanged Fittings.
d. B16.3, Malleable Iron Threaded Fittings.
e. B16.5, Pipe Flanges and Flanged Fittings.
f. B16.9, Factory-Made Wrought Steel Butt welding Fittings.
g. B16.11, Forged Fittings, Socket-Welding and Threaded.
h. B16.15, Cast Bronze Threaded Fittings, Classes 125 and 250.
i. B16.21, Nonmetallic Flat Gaskets for Pipe Flanges.
j. B16.22, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
k. B16.24, Cast Copper Alloy Pipe Flanges and Flanged Fittings Class 150,300,400,600,900, 1500 and 2500.
l. B16.25, Butt Welding Ends.
m. B16.42, Ductile Iron Pipe Flanges and Flanged Fittings, Classes 150 and 300.
3. American Petroleum Institute (API): 5L, Specification for Line Pipe.
4. American Society of Mechanical Engineers (ASME):
a. Boiler and Pressure Vessel Code, Section VITI, Division 1, Pressure Vessels.
b. Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications.
c. B31.1, Power Piping.
d. B31.3, Chemical Plant and Petroleum Refinery Piping.
e. B31.9, Building Services Piping.
f. B36.10M, Welded and Seamless Wrought Steel Pipe.
5. American Society for Nondestructive Testing (ASNT): SNT-TC-1A, Recommended Practice for Nondestructive Testing Personnel Qualifications.
6. American Society for Testing and Materials (ASTM):
a. A47, Standard Specification for Ferritic Malleable Iron Castings.
b. A53 Rev A, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
c. A105/ A105M, Standard Specification for Forgings, Carbon Steel, for Piping Components.

d. A106, Standard Specification for Seamless Carbon Steel Pipe for High Temperature Service.
e. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
f. A135, Standard Specification for Electric-Resistance-Welded Steel Pipe.
g. A139 Rev A, Standard Specification for Electric-Fusion (Arc) -Welded Steel Pipe (NPS 4 and Over).
h. A153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
i. A181/A181M Rev A, Standard Specification for Forgings, Carbon Steel, for General-Purpose Piping.
j. A182/A182M Rev C, Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
k. A183, Standard Specification for Carbon Steel Track Bolts and Nuts.
l. A193/A193M Rev A, Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.
m. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service.
n. A197, Standard Specification for Cupola Malleable Iron.
o. A216/A216M, Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service.
p. A234/A234M, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures.
q. A240, Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels.
r. A276, Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes.
s. A283/A283M Rev A, Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
t. A285/ A285M, Standard Specification for Pressure Vessel Plates, Carbon Steel, Low and Intermediate Tensile Strength.
u. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
v. A312/A312M, Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes.
w. A320/A320M, Standard Specification for Alloy Steel Bolting Materials for Low-Temperature Service.
x. A395, Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
y. A403/ A403M Rev A, Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.
z. A409/ A409M, Standard Specification for Welded Large Diameter Austenitic Steel Pipe for Corrosive or High-Temperature Service.
aa. A536, Standard Specification for Ductile Iron Castings.
bb. A563, Standard Specification for Carbon and Alloy Steel Nuts.
cc. 587, Standard Specification for Electric-Resistance-Welded Low-Carbon Steel Pipe for the Chemical Industry.
dd. A774/A774M, Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures.
ee. A778 Rev A, Standard Specification for Welded, Un-annealed Austenitic Stainless Steel Tubular Products.
ff. B32, Standard Specification for Solder Metal.
gg. B43, Standard Specification for Seamless Red Brass Pipe, Standard Sizes.
hh. B61, Standard Specification for Steam or Valve Bronzed Casting.
ii. B62, Standard Specification for Composition Bronzed or Ounce Metal Castings.
jj. B75, Standard Specification for Seamless Copper Tube.
kk. B88 Rev A, Standard Specification for Seamless Copper Water Tube.

ll. B98, Standard Specification for Copper-Silicone Alloy Rod, Bar, and Shapes.
mm. 582, Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion Resistant Equipment.
nn. D412, Standard Testing Method for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers-Tension.
oo. D413, Standard Testing Methods for Rubber Property-Adhesion to Flexible Substrate.
pp. D1248, Standard Specification for Polyethylene Plastics Molding and Extrusion Materials.
qq. D1784, Standard Specifications for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
rr. D1785, Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
ss. D2000, Standard Classification System for Rubber Products in Automotive Applications.
tt. D2310, Standard Classification for Machine-Made "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
uu. D2464, Standard Specification for Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
vv. 2466, Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
ww. D2467, Standard Specification for Socket-Type Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
xx. D2564, Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.
yy. D2665, Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe for Drain, Waste, and Vent Pipe and Fittings, Schedule 40.
zz. D2996, Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe.
aaa. D3222 Rev A, Standard Specification for Unmodified Poly (Vinylidene Fluoride) (PVDF) Molding Extrusion and Coating Materials.
bbb. D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
ccc. D4101 Rev B, Standard Specification for Propylene Plastic Injection and Extrusion Materials.
ddd. F437, Standard Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
eee. F439 Rev A, Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
fff. F441, Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
ggg. F491 Rev A, Standard Specification for Poly (Vinylidene Fluoride) (PVDF) Plastic-Lined, Ferrous Metal Pipes, and Fittings.
hhh. F493 Rev A, Standard Specification for Solvent Cements for Chlorinated Poly Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
iii. F714, Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) based on outside diameter.

7. American Welding Society (AWS):
   a. A5.8, Specification for Filler Metals for Brazing and Braze Welding.
   b. QC 1, Standard for AWS Certification of Welding Inspectors.
8. American Water Works Association (AWWA):
   a. C104/A21.4, Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
   b. C110/A21.10, Ductile-Iron and Gray-Iron Fittings, 3" through 48"for Water and Other Liquids.
   c. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   d. C115/A21.15, Flanged Ductile-Iron Pipe with Threaded Flanges.
   e. C151/A21.51, Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids.

f. C153/A21.53, Ductile-Iron Compact Fittings 3” through 16”, for Water and Other Liquids.
g. C200, Steel Water Pipe – 6” and Larger.
h. C205, Cement-Mortar Protective Lining and Coating for Steel Water Pipe-4” and Larger-Shop Applied.
i. C207, Steel Pipe Flanges for Water Works Service, Sizes 4” through 144”.
j. C208, Dimensions for Fabricated Steel Water Pipe Fittings.
k. C214, Fusion Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
l. C606, Grooved and Shouldered Type Joints.
m. M11, Steel Pipe - A Guide for Design and Installation.

9. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS): SP 43, Wrought Stainless Steel Butt-Welding Fittings Including Reference to Other Corrosion Resistant Materials.
10. National Fire Protection Association (NFPA): 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

1.3 DEFINITIONS

A. Submerged or Wetted:
1. Zone below elevation of:
a. Top face of channel walls and cover slabs.
b. Top face of basin walkways.
c. Top face of clarifier walkways.
d. Top face of digester walls, including structure piping penetrations.
e. Liquid surface or within 2 feet above top of liquid surface.
f. Top of tank wall or under tank cover.

1.4 SUBMITTALS

A. Shop Drawings:
1. Shop Fabricated Piping:
a. Detailed pipe fabrication or spool drawings showing special fittings and bends, dimensions, coatings, and other pertinent information.
b. Layout drawing showing location of each pipe section and each special length; number or otherwise designate laying sequence on each piece.
2. Pipe Wall Thickness: Identify wall thickness and rational method or standard applied to determine wall thickness for each size of each different service including exposed, submerged, buried, and concrete-encased installations for Contractor-designed piping.
3. Hydraulic Thrust Restraint for Restrained Joints: Details including materials, sizes, assembly ratings, and pipe attachment methods.
4. Thrust Blocks: Concrete quantity, bearing area on pipe, and fitting joint locations.
5. Dissimilar Buried Pipe Joints: Joint types and assembly drawings.
6. Gasket material, temperature rating, and pressure rating for each type of pipe and each type of service.

B. Quality Control Submittals:
1. Manufacturer’s Certification of Compliance.
2. Qualifications:
a. Weld Inspection and Testing Agency: Certification and qualifications.
b. Welding Inspector: Certification and qualifications.
c. Welders:
1). List of qualified welders and welding operators.
2). Current test records for qualified welder(s) and weld type(s) for factory and field welding.

3. Weld Procedures: Records in accordance with ASME Boiler and Pressure Vessel Code, Section IX for weld type(s) and base metal(s).
4. Nondestructive inspection and testing procedures.
5. Manufacturer's Certification of Compliance:
    a. Pipe and fittings.
    b. Factory applied resins and coatings.
6. Certified weld inspection and test reports.
7. Test logs.

1.5 QUALITY ASSURANCE

A. Weld Inspection and Testing Laboratory Qualifications:
1. Retain approved independent testing laboratory that will provide the services of an AWS certified welding inspector qualified in accordance with AWS QC1 with prior inspection experience of welds specified herein.
2. Perform weld examinations with qualified testing personnel who will carry out radiography, ultrasonic, magnetic particle, and other nondestructive testing methods as specified herein.
3. Welding Inspector:
    a. Be present when shop or field welding is performed to certify that welding is in accordance with specified standards and requirements.
    b. Duties include, but are not limited to, the following:
        1). Job material verification and storage.
        2). Qualification of welders.
        3). Certify conformance with approved welding procedure specifications.
        4). Maintain records and prepare reports in a timely manner.
        5). Notify Engineer within 1 hour of discovery of unsatisfactory weld performance and within 24 hours of weld test failure.
        6). Supervision of testing personnel.

B. Welder and Welding Operator Performance:
1. Qualify welders and welding operators by approved testing laboratory before performing any welding under this section.
2. Perform welder qualification tests in accordance with Section IX, Article III of the ASME Boiler and Pressure Vessel Code.
3. Qualification tests may be waived if evidence of prior qualification is deemed suitable by the Engineer.
4. Qualify welders and operators in the performance of making groove welds in each different pipe material, including carbon steel pipe, in Positions 2G and 5G for each welding process to be used.
5. Qualify welders and welding operators for stainless steel as stated herein on the type of stainless steel being welded with the welding process used.

C. Certifications:
1. Coal-Tar Epoxy Applicator: Certified by Piping Manufacturer to be qualified to apply coal-tar epoxy coating to submerged or embedded ductile iron or cast iron soil piping.
2. Weld Testing Agency: Certified in accordance with current American Society for Nondestructive Testing (4153 Arlingate Plaza, Columbus, OH 43228) recommended practice SNT-TC-1A, NDT Level II.

D. Quality Control Submittals:
1. Manufacturer's Certification of Compliance.
2. Laboratory Testing Equipment: Certified calibrations, Manufacturer's product data, and test procedures.
3. Certified welding inspection and test results.
4. Qualifications:
    a. Weld Inspection and Testing Agency: Certification and qualifications.

b. Welding Inspector: Certification and qualifications.
c. Welders:
1). List of qualified welders and welding operators.
2). Current test records for qualified welder(s) and weld type(s) for factory and field welding.

5. Weld Procedures: Records in accordance with ASME Boiler and Pressure Vessel Code, Section IX for weld type(s) and base metal(s).
6. Nondestructive inspection and testing procedures.
7. Manufacturer's Certification of Compliance:
a. Pipe and fittings.
b. Welding electrodes and filler materials.
c. Factory applied resins and coatings.
8. Certified weld inspection and test reports.
9. Pipe coating applicator certification.

1.6 DELIVERY, STORAGE, AND HANDLING

A. In accordance with Section 01 60 00, PRODUCT REQUIREMENTS, and:
1. Flanges: Securely attach metal, hardboard, or wood protectors over entire gasket surface.
2. Threaded or Socket Welding Ends: Fit with metal, wood, or plastic plugs or caps.
3. Linings and Coatings: Prevent excessive drying.
4. Cold Weather Storage: Locate products to prevent coating from freezing to ground.
5. Handling: Use heavy canvas or nylon slings to lift pipe and fittings.

PART 2 - PRODUCTS

2.1 PIPING

A. As specified on Piping Data Sheet(s) and Process Piping Schedule located at the end of this section as Supplement.

B. Diameters Shown:
1. Standardized Products: Nominal size.
2. Fabricated Steel Piping (Except Cement-Lined): Outside diameter, ASME 836.l0M.
3. Cement-Lined Steel Pipe: Lining inside diameter.

2.2 JOINTS

A. Grooved End System:
1. Rigid, except where joints are used to correct misalignment, to provide flexibility, or where shown, furnish flexible type.
2. Flanges: When required, furnish with grooved type flange adapters of same manufacturer as grooved end couplings.

B. Flanged Joints:
1. Flanges for ductile iron pipe shall conform to AWWA C115 at pressure rating meeting requirements of the connecting piping.
2. Flanges for steel pipe shall conform to ANSI/ASME B16.5 at pressure rating meeting requirements of the connecting piping.
3. Higher pressure rated flanges as required, to mate with equipment when equipment flange is of higher pressure rating than required for piping.

C. Threaded Joints: NPT taper pipe threads in accordance with ANSI B 1.20. 1.

D. Thrust Tie-Rod Assemblies: NFPA 24; tie-rod attachments relying on clamp friction with pipe barrel to restrain thrust are unacceptable.

E. Mechanical Joint Anchor Gland Follower:
   1. Ductile iron anchor type, wedge action, with break off tightening bolts.
   2. Manufacturer and Product: EBAA Iron Inc.; Megalug.

F. Flexible Mechanical Compression Joint Coupling:
   1. Stainless steel, ASTM A276, Type 305 bands.
   2. Manufacturers:
      a. Pipeline Products Corp.
      b. Ferno Joint Sealer Co.

G. Mechanical connections of the high-density polyethylene pipe to auxiliary equipment such as valves, pumps, tanks, and other piping systems shall be through flanged connections consisting of the following:
   1. A polyethylene stub end thermally butt-fused to the end of the pipe.
   2. ASTM A240, Type 304 stainless steel backing flange, 125-pound, ANSI B16.1 Standard. Insulating flanges shall be used where shown.
   3. Bolts and nuts of sufficient length to show a minimum of three complete threads when the joint is made and tightened to the Manufacturer's standard. Re-torque the nuts after 4 hours.
   4. Gaskets as specified on Data Sheet.
   5. Connection to buried mechanical joint fittings and valves shall be by restrained mechanical joint follower glad designed for HDPE pipe. Provide stainless steel stiffener as required by pipe manufacturer.

2.3 COUPLINGS

A. Steel Middle Rings and Followers:
   1. Fusion bonded, epoxy-lined, and coated in accordance with Section 09 90 00, PAINTING AND PROTECTIVE COATINGS.

B. Flexible Couplings:
   1. Manufacturers and Products:
      a. Steel Pipe:
         1). Dresser; Style 38.
         2). Smith-Blair; Style 411.
         3). Romac 501
      b. Ductile Iron Pipe:
         1). Dresser; Style 38.
         2). Smith-Blair; Style 411.
         3). Romac 501

C. Transition Couplings:
   1. Manufacturers and Products:
      a. Dresser; Style 62.
      b. Smith-Blair; Style 413.
      c. Romac RC501

D. Flanged Coupling Adapters:
   1. Manufacturers and Products:
      a. Steel Pipe:
         1). Smith-Blair; Series 913.
         2). Dresser Industries, Inc.; Style 128-W.
         3). Romac FC400

b. Ductile Iron Pipe (12-inch diameter and smaller):
   1). Smith-Blair; Series 912.
   2). Dresser Industries, Inc.; Style 128-W.
   3). Romac FCA501
c. Ductile Iron Pipe (greater than 12-inch diameter):
   1). Romac FC400
   2). Smith-Blair; Series 911

E. Dismantling Joints:
1. Manufacturers and Products:
   a. Steel or Ductile Iron Pipe:
      1). Smith-Blair; Series 975.
      2). Dresser Industries, Inc.; Style 131.
      3). Romac DJ400.

2.4 HARDWARE

A. All hardware on submerged piping or piping below the top elevation of tanks and directly exposed to water, wastewater and/or wastewater solids, including but not limited to bolts, nuts, washers, and threaded rod shall be stainless steel.

2.5 GASKET LUBRICANT

A. Lubricant shall be supplied by pipe Manufacturer and no substitute or “or-equal” will be allowed.

2.6 DOUBLE WALL CONTAINMENT PIPING SYSTEM

A. All system components shall be pre-engineered, factory fabricated, tested, and assembled such that field assembly is minimized to primarily that of straight joints.

2.7 THRUST RESTRAINT

A. Buried piping shall be restrained joint piping unless specified otherwise or when connecting to existing piping systems. When connecting to existing piping systems, concrete thrust blocking shall be used as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

B. All above grade piping shall be adequately restrained and supported.

2.8 VENT AND DRAIN VALVES

A. Pipeline 2-1/2-inch Diameter and Larger: Vent connections shall be 3/4-inch with V300 ball valve. Drain connection shall be 1-inch with V300 ball valve, unless shown otherwise.

B. Pipeline 2-inch Diameter and Smaller: Vent connections shall be 1/2-inch with V300 ball valve. Drain connection shall be 1-inch with V300 ball valve, unless shown otherwise.

C. Provide galvanized steel pipe plug in each ball valve.

2.9 FABRICATION

A. Mark each pipe length on outside:
1. Size or diameter and class.
2. Manufacturer’s identification and pipe serial number.
3. Location number on laying drawing.
4. Date of manufacture.

B. Code markings according to approved Shop Drawings.

C. Flanged pipe shall be fabricated in the shop, not in the field, and delivered to the site with flanges in place and properly faced. Threaded flanges shall be individually fitted and machine tightened on matching threaded pipe by the Manufacturer.

2.10 FINISHES

A. Factory prepare, prime, and finish coat in accordance with Pipe Data Sheet(s), Piping Schedule, and Section 09 90 00, PAINTING AND PROTECTIVE COATINGS.

B. Galvanizing:
1. Hot-dip applied, meeting requirements of ASTM A153.
2. Electroplated zinc or cadmium plating is unacceptable.
3. Stainless steel components may be substituted where galvanizing is specified.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify size, material, joint types, elevation, horizontal location, and pipe service of existing pipelines to be connected to new pipelines or new equipment.

B. Inspect size and location of structure penetrations to verify adequacy of wall pipes, sleeves, and other openings.

C. Welding Electrodes: Verify proper grade and type, free of moisture and dampness, and coating is undamaged.

3.2 PREPARATION

A. Notify Engineer at least 2 weeks prior to field fabrication of pipe or fittings.

B. Inspect pipe and fittings before installation, clean ends thoroughly, and remove foreign matter and dirt from inside.

C. Damaged Coatings and Linings: Repair using original coating and lining materials in accordance with Manufacturer’s instructions, except for damaged glass-lined pipe or PVDF-lined pipe that is to be promptly removed from the site.

3.3 WELDING

A. Perform in accordance with Section IX, ASME Boiler and Pressure Vessel Code and ASME B31.1 for Pressure Piping, as may be specified on Piping Data Sheets, and if recommended by piping or fitting Manufacturer.

B. Weld Identification: Mark each weld with symbol identifying welder.

C. Pipe End Preparation:
1. Machine Shaping: Preferred.
2. Oxygen or Arc Cutting: Smooth to touch, true, and slag removal by chipping or grinding.
3. Beveled Ends for Butt Welding: ANSI B16.25.

D. Surfaces:
1. Clean and free of paint, oil, rust, scale, slag, or other material detrimental to welding.

2. Clean stainless steel joints with stainless steel wire brushes or stainless steel wool prior to welding.
3. Thoroughly clean each layer of deposited weld metal, including final pass, prior to deposition of each additional layer of weld metal with a power-driven wire brush.

E. Alignment and Spacing:
1. Align ends to be joined within existing commercial tolerances on diameters, wall thicknesses, and out-of-roundness.
2. Root Opening of Joint: As stated in qualified welding procedure.
3. Minimum Spacing of Circumferential Butt Welds: Minimum four times pipe wall thickness or 1", whichever is greater.

F. Climatic Conditions:
1. Do not perform welding if there is impingement of any rain, snow, sleet or high wind on the weld area, or if the ambient temperature is below 32 degrees Fahrenheit.
2. Stainless Steel and Alloy Piping: If the ambient is less than 32 degrees Fahrenheit, local preheating to a temperature warm to the hand is required.

G. Tack Welds: Performed by qualified welder using same procedure as for completed weld, made with electrode similar or equivalent to electrode to be used for first weld pass, and not defective. Remove those not meeting requirements prior to commencing welding procedures.

H. Surface Defects: Chip or grind out those affecting soundness of weld.

I. Weld Passes: As required in welding procedure.

J. Weld Quality: Free of cracks, incomplete penetration, weld undercutting, excessive weld reinforcement, porosity slag inclusions, and other defects in excess of limits shown in applicable piping code.

3.4 INSTALLATION - GENERAL

A. Join pipe and fittings in accordance with Manufacturer's instructions, unless otherwise shown or specified.

B. Remove foreign objects prior to assembly and installation.

C. Flanged Joints:
1. Install perpendicular to pipe centerline.
2. Bolt Holes: Straddle vertical centerlines, aligned with connecting equipment flanges or as shown.
3. Use torque-limiting wrenches to ensure uniform bearing and proper bolt tightness.
4. Plastic Flanges: Install annular ring filler gasket at joints of raised-face flange.
5. Raised-Face Flanges: Use flat-face flange when joining with flat-faced ductile or cast iron flange.

D. Threaded and Coupled Joints:
1. Conform to ANSI B1.20.1.
2. Produce sufficient thread length to ensure full engagement when screwed home in fittings.
3. Countersink pipe ends, ream and clean chips and burrs after threading.
4. Make connections with not more than three threads exposed.
5. Lubricate male threads only with thread lubricant or tape as specified on Piping Data Sheets.

E. Soldered Joints:

1. Use only solder specified for particular service.
2. Cut pipe ends square and remove fins and burrs.
3. After thoroughly cleaning pipe and fitting of oil and grease using solvent and emery cloth, apply non-corrosive flux to the male end only.
4. Wipe excess solder from exterior of joint before hardened.
5. Before soldering, remove stems and washers from solder joint valves.

F. Couplings:
   1. General:
      a. Install in accordance with Manufacturer's written instructions.
      b. Before coupling, clean pipe holdback area of oil, scale, rust, and dirt.
      c. Remove pipe coating if necessary to present smooth surface.
   2. Application:
      a. Metallic Piping Systems: Flexible couplings, transition couplings, and flanged coupling adapters.
      b. Nonmetallic Piping Systems: Teflon bellows connector.
      c. Concrete Encased Couplings: Sleeve type coupling.
      d. Corrosive Service Piping: Elastomer bellows connector.
      e. Grit Slurry Piping: Elastomer bellows connector.

G. Pipe Connections at Concrete Structures: As specified in article PIPING FLEXIBILITY PROVISIONS in Section 40 05 06, PROCESS PIPING SPECIALTIES.

H. Penetrations:
   1. Watertight Penetrations:
      a. Provide wall pipes with thrust collars, as specified in Section 40 05 06, PROCESS PIPING SPECIALTIES.
      b. Provide taps for stud bolts in flanges to be set flush with wall face.
   2. Non-watertight Penetrations:
      a. Pipe sleeves with seep ring as specified in Section 40 05 06, PROCESS PIPING SPECIALTIES.
      b. Pipe sleeves with modular mechanical seal may be provided where fabrication of seep ring on pipe sleeve is impractical.
   3. Existing Walls:
      a. Rotary drilled holes with modular mechanical seal as specified in Section 40 05 06, PROCESS PIPING SPECIALTIES.
   4. Fire-Rated or Smoke-Rated Walls, Floor, or Ceilings: Insulated and encased pipe sleeves as specified in Section 40 05 06, PROCESS PIPING SPECIALTIES.

I. PVC and CPVC Piping:
   1. Provide Schedule 80 threaded nipple where necessary to connect to threaded valve or fitting.
   2. Use strap wrench for tightening threaded plastic joints. Do not over tighten fittings.
   3. Do not thread Schedule 40 pipe.

J. Ductile Iron, Cement-Lined Ductile Iron, and Glass-Lined Ductile Iron Piping:
   1. Cutting Pipe: Cut pipe with milling type cutter, rolling pipe cutter, or abrasive saw cutter. Do not flame cut.
   2. Dressing Cut Ends:
      a. General: As required for the type of joint to be made.
      b. Rubber Gasketed Joints: Remove sharp edges or projections.
      c. Push-On Joints: Bevel, as recommended by pipe Manufacturer.
      d. Flexible Couplings, Flanged Coupling Adapters, and Grooved End Pipe Couplings: As recommended by the coupling or adapter Manufacturer.

3.5 INSTALLATION-EXPOSED PIPING

A. Piping Runs:
   1. Parallel to building or column lines and perpendicular to floor, unless shown otherwise.
   2. Piping upstream and downstream of flow measuring devices shall provide straight lengths as required for accurate flow measurement.

B. Supports: As specified in Section 40 05 07, HANGERS AND SUPPORTS FOR PROCESS PIPING.

C. Group piping wherever practical at common elevations; installing to conserve building space and not interfere with use of space and other work.

D. Unions or Flanges: Provide at each piping connection to equipment or instrumentation on equipment side of each block valve to facilitate installation and removal.

E. Install piping so that no load or movement in excess of that stipulated by equipment Manufacturer will be imposed upon equipment connection; install to allow for contraction and expansion without stressing pipe, joints, or connected equipment.

F. Piping clearance, unless otherwise shown:
   1. Over Walkway and Stairs: Minimum of 7.5-feet, measured from walking surface or stair tread to lowest extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
   2. Between Equipment or Equipment Piping and Adjacent Piping: Minimum 3-feet, measured from equipment extremity and extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
   3. From Adjacent Work: Minimum 1-inch from nearest extremity of completed piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
   4. Do not route piping in front of or to interfere with access ways, ladders, stairs, platforms, walkways, openings, doors, or windows.
   5. Head room in front of openings, doors, and windows shall not be less than the top of the opening.
   6. Do not install piping containing liquids or liquid vapors in transformer vaults or electrical equipment rooms.
   7. Do not route piping over, around, in front of, in back of, or below electrical equipment including controls, panels, switches, terminals, boxes, or other similar electrical work.

3.6 INSTALLATION-BURIED PIPE

A. Joints:
   1. Dissimilar Buried Pipes:
      a. Provide flexible mechanical compression joints for pressure pipe.
      b. Provide concrete closure collar for gravity and low pressure (maximum 10 psi) piping or as shown.
   2. Concrete Encased or Embedded Pipe: Do not encase joints in concrete unless specifically shown.

B. Placement:
   1. Keep trench dry until pipe laying and joining are completed.
   2. Pipe Base and Pipe Zone: As specified in Section 31 23 23.16, TRENCH BACKFILL.
   3. Exercise care when lowering pipe into trench to prevent twisting or damage to pipe.
   4. Measure for grade at pipe invert, not at top of pipe.
   5. Excavate trench bottom and sides of ample dimensions to permit visual inspection and testing of entire flange, valve, or connection.

6. Prevent foreign material from entering pipe during placement.
7. Close and block open end of last pipe section laid when placement operations are not in progress and at close of day's work.
8. Lay pipe upgrade with bell ends pointing in the direction the pipe is laying.
9. Install closure sections and adapters for gravity piping at locations where pipe laying changes direction.
10. Deflect pipe at joints for pipelines laid on a curve using unsymmetrical closure of spigot into bell. If joint deflection of standard pipe lengths will not accommodate horizontal or vertical curves in alignment, provide:
    a. Shorter pipe lengths.
    b. Special mitered joints.
    c. Standard or special fabricated bends.
11. After joint has been made, check pipe alignment and grade.
12. Place sufficient pipe zone material to secure pipe from movement before next joint is installed.
13. Prevent uplift and floating of pipe prior to backfilling.

C. PVC and CPVC Pipe Placement:
1. Lay pipe snaking from one side of trench to other.
2. Offset: As recommended by Manufacturer for maximum temperature variation between time of solvent welding and during operation.
3. Do not lay pipe when temperature is below 40 °F, or above 90 °F when exposed to direct sunlight.
4. Shield ends to be joined from direct sunlight prior to and during the laying operation.

D. Tolerances:
1. Deflection from Horizontal Line, Except PVC, CPVC, or HDPE: Maximum 2-inches.
2. Deflection from Vertical Grade: Maximum 1/4-inch.
3. Joint Deflection: Maximum of 75 percent of Manufacturer's recommendation.
4. Horizontal position of pipe centerline on alignment around curves maximum variation of 1.75-feet from position shown.
5. Pipe Cover: Minimum 5-feet, unless otherwise shown.

3.7 THRUST RESTRAINT

A. Location:
1. Buried Piping: At pipeline tees, plugs, caps, bends, and other locations where unbalanced forces exist.
2. Exposed Piping: At all joints in pressure piping.

B. Thrust Ties:
1. Install as detailed.
2. Anchoring retainer glands or thrust ties with setscrews is unacceptable.

C. Mechanical Joint Valve Restraint in Proprietary Restrained Joint Piping: Install pipe joint Manufacturer's adapter gland follower and pipe end retainer or thrust tie-rods and socket clamps.

D. Thrust Blocking:
1. Place between undisturbed ground and fitting to be anchored.
2. Quantity of Concrete: Sufficient to cover bearing area on pipe and provide required soil bearing area as shown.
3. Place blocking so that pipe and fitting joints will be accessible for repairs.
4. Place concrete in accordance with Section 03 30 00, CAST-IN-PLACE CONCRETE.

3.8 BRANCH CONNECTIONS

A. Do not install branch connections smaller than 1/2-inch nominal pipe size, including instrument connections, unless shown otherwise.

B. When line of lower pressure connects to a line of higher pressure, requirements of Piping Data Sheet for higher pressure rating prevails up to and including the first block valve in the line carrying the lower pressure, unless otherwise shown.

C. Threaded Pipe Tap Connections:
   1. Ductile Iron Piping: Connect only with service saddle or at a tapping boss of a fitting, valve body, or equipment casting.
   2. Welded Steel or Alloy Piping: Connect only with welded thread-o-let or half-coupling as specified on Piping Data Sheet.
   3. Limitations: Threaded taps in pipe barrel are unacceptable.

3.9 VENTS AND DRAINS

A. Vents and drains at high and low points in piping required for completed system may or may not be shown. Install the vents on high points, and drains on low points of pipelines, whether shown or not.

3.10 CLEANING

A. Following assembly and testing, and prior to disinfection and final acceptance, flush pipelines (except as stated below) with water at 2.5-feet per second minimum flushing velocity until foreign matter is removed.

B. Blow clean of loose debris plant process air, natural gas, and instrument air-lines with compressed air at 4,000 fpm; do not flush with water.

C. If impractical to flush large diameter pipe at 2.5-feet per second or blow at 4,000-feet per minute velocity, clean in-place from inside by brushing and sweeping, then flush or blow line at lower velocity.

D. Insert cone strainers in flushing connections to attached equipment and leave in-place until cleaning is complete.

E. Remove accumulated debris through drains 2-inch and larger or by removing spools and valves from piping.

3.11 DISINFECTION

A. Disinfect pipelines intended to carry potable water (W1).

3.12 FIELD FINISHING

A. Notify Engineer at least 3 days prior to start of any surface preparation or coating application work.

B. As specified in Section 09 90 00, PAINTING AND PROTECTIVE COATINGS.

3.13 PIPE IDENTIFICATION

A. See Section 09 90 00 PAINTING AND PROTECTIVE COATINGS.

3.14 INSULATION

A. See Section 40 42 00, PROCESS MECHANICAL INSULATION.

3.15 HEAT TRACING

A. See Section 40 41 13, HEAT TRACING.

3.16 FIELD QUALITY CONTROL

A. Pressure Leakage Testing: As specified. See Section 40 05 00, PIPING SYSTEMS TESTING.

B. Minimum Duties of Welding Inspector:
1. Job material verification and storage
2. Qualifications of welders.
3. Certify conformance with approved welding procedures.
4. Maintenance of records and preparation of reports in a timely manner.
5. Notification to Engineer of unsatisfactory weld performance within 24 hours of weld test failure.

C. Required Weld Examinations:
1. Perform Examinations in accordance with Piping Code ASME B31.1.
2. Perform examinations for every pipe thickness and for each welding procedure, progressively, for all piping covered by this section.
3. Examine at least one of each type and position of weld made by each welder or welder operator.
4. For each weld found to be defective under the acceptable standards or limitations on imperfections contained in the applicable Piping Code, examine two additional welds made by the same welder that produced the defective weld. Such additional examinations are in addition to the minimum required above in item 3.16.C.3. Examine, progressively, two additional welds for each tracer examination found to be unsatisfactory.

3.17 SUPPLEMENTS

A. The supplements listed below, following “END OF SECTION,” are a part of this Specification.
1. Piping Schedule.
2. Data Sheets.

Number	Title
40 23 39.13	Ductile Iron Pipe and Fittings
40 23 39.16	Welded Steel Pipe and Fittings
40 23 39.36	Stainless Steel Pipe and Fittings
40 23 39.43	Polyvinyl Chloride (PVC) Pipe and Fittings

END OF SECTION

PROCESS PIPING SCHEDULE											
Service	**Flow Stream Identifier**	**Installation (Note 1)**	**Nominal Diameter (Note 2)**	**Material (Note 3)**	**Coating (Note 8)**	**Spec / Data Sheet No.**	**Max Operating Temp (°F)**	**Max Operating Pressure (psig)**	**Test Pressure (psig) & Method (Note 4)**	**Pipe Color (Note 5)**	**Remarks**
Air, Low Pressure	ALP	Aboveground (Inside, Outside)	All	SST	None	40 23 39.36	250	15	20, AM		1, 5
Natural Gas	G	ALL	All	CS	None	40 23 39.31	Ambient	40	100, H		3
Digester Gas	DG	Aboveground (Inside, Outside)	ALL	SST	None	40 23 39.36	150	10	See Remark		4
Digested Sludge	DS	Underground	ALL	CELDI	None	40 23 39.13	105	25	100, HH		2
Digested Sludge	DS	Aboveground (Inside, Outside)	ALL	CELDI	EPP	40 23 39.13	105	25	100, HH		
Digested Sludge	DS	Submerged	ALL	CELDI	EPP	40 23 39.13	105	25	100, HH		
Plant/Process Drain	PD	ALL	ALL	CELDI	None	40 23 39.13	Ambient	Gravity Flow	4, G		
Water, Potable	W1	ALL	< 4 inches	PVC	None	40 23 39.43	Ambient	100	125, HH		
Water, Potable	W1	ALL	≥ 4 inches	CLDI	None	40 23 39.43	Ambient	100	125, HH		
Water, Plant Service Non-Potable	W2	ALL	< 4 inches	PVC	None	40 23 39.43	Ambient	100	125, HH		
Water, Plant Service Non-Potable	W2	ALL	≥ 4 inches	CLDI	None	40 23 39.43	Ambient	100	125, HH		
Waste Activated Sludge	WAS	Underground	ALL	CELDI	None	40 23 39.13	Ambient	25	100, H		2
Waste Activated Sludge	WAS	Aboveground (Inside, Outside)	ALL	CELDI	EPP	40 23 39.13	Ambient	25	100, H		

Notes:

1 All buried piping under concrete slabs and/or structures shall be concrete encased per Detail 1/99-P902 unless indicated otherwise on the Drawings.

2 > Greater Than
< Less Than
≤ Less Than or Equal To
≥ Greater Than or Equal To

3 CELDI – Ceramic Epoxy Lined Ductile Iron Pipe
CLDI – Cement Lined Ductile Iron Pipe
CS – Carbon Steel Pipe
PVC – Polyvinyl Chloride Pipe
SST – Stainless Steel Pipe

4 H – Hydrostatic Test
P – Pneumatic Test
G – Gravity Piping
AM – Air Method
HH – High Head
LH – Low Head
LP – Low-Pressure Pneumatic Test
See Section 40 05 00, PIPING SYSTEMS TESTING, for pipe leakage testing requirements for systems specified in Division 40.
Pipe testing required as specified above.

5 See Section 09 90 00, PAINTING AND PROTECTIVE COATINGS, for required painting.
For buried piping, no color shall be required. Coordinate for proper coatings, as necessary.
Where no color is indicated, color to be selected by Owner.
For exposed piping not coated, provide colored banding and identification.

6 General: Deviations from this schedule are indicated directly by note on Drawings where deviation is required.

7 General: The piping material shall conform to the requirements for the services listed being drained or vented.

8 EPP – Epoxy and Polyurethane Coating System
HSE – High Solids Epoxy
CTP – Coal Tar Pitch
HT – High Temperature
PEE – Polyethylene Encasement
Where no coating is listed, refer to Section 09 90 00, PAINTING AND PROTECTIVE COATINGS.

Remarks:

1 Insulate exposed piping per Specification Section 40 42 00, PROCESS MECHANICAL INSULATION.
2 All joints shall be restrained joints.
3 Natural gas piping shall be tested in accordance with Section 406 of the International Fuel Gas Code.
4 Digester gas piping to be tested in accordance with NFPA 54, National Fuel Gas Code.
5 Welded or flanged, flanged where shown.

SECTION 40 23 39.13 DUCTILE IRON PIPE AND FITTINGS	
Item	**Description**
Pipe	**Buried Liquid Service**: Push-On, Mechanical, or Proprietary Restrained Joints. AWWA C110/A21.10-93, AWWA C115/A21.15-88, and AWWA C151/A21.51-91, pressure class conforming to Tables 51.1 and 51.3 for Type 4 trench, 250 psi minimum working pressure. **Exposed Pipe**: Grooved End or Flange Joints. AWWA C115/A21.15-88, and AWWA C151/A21.51-91, thickness Class 53 minimum conforming to Table 51.7, 250 psi minimum working pressure.
Coating	**Buried Pipe:** Exterior coating used under normal conditions shall be an asphaltic coating approximately 1 mil (25 µm) thick and per AWWA C151/A21.51-17. **Exposed Pipe:** Shall be as indicated in the schedule.
Lining	Lining shall be Cement-Mortar AWWA C104/A21.4-90 unless noted otherwise. Ceramic Epoxy Protecto 401 or equal shall be used where indicated in the pipe schedule. Glass Lining: VITCO Corp. SG-14 or equal shall be used where indicated in the schedule. Linings for fittings shall be as indicated below.
Joints	**Push-On**: 250 psi minimum working pressure, AWWA C110/A21.10-93 and C111/A21.11-90. American Cast Iron Pipe Co., Fastite Joints; U.S. Pipe and Foundry, Tyton Joint. **Mechanical**: 250 psi minimum working pressure, AWWA C111. American Cast Iron Pipe Co., Mechanical Joint; U.S. Pipe and Foundry, Mechanical Joint. **Proprietary Restrained**: 150 psi minimum working pressure. Clow Corp., Super-Lock; American Cast Iron Pipe Co., Flex-Ring or Lok-Ring; U.S. Pipe, TR Flex. **Grooved End**: Rigid type radius cut conforming to AWWA C606-87, 250 psi minimum working pressure. Manufacturers: Victaulic; Gustin-Bacon. **Flange**: 125-pound flat face, 250-pound raised face, ductile iron, threaded conforming to AWWA C115/A21-15.88. Gray cast iron will NOT be allowed.

SECTION 40 23 39.13 DUCTILE IRON PIPE AND FITTINGS	
Item	**Description**
Fittings	**Push-On**: AWWA C110/A21.10-93 and C111/A21.11-90, gray or ductile iron, 250 psi minimum working pressure. American Cast Iron Pipe Co., Fastite Joints; U.S. Pipe and Foundry, Tyton Joint. **Mechanical Joint**: For Buried Service. AWWA C110/A21.10-93, C111/A21.11-90, and C153/A21.53-88 gray or ductile iron, 250 psi minimum working pressure. Coating/lining shall be Fusion-Bonded Epoxy meeting AWWA C116. American Cast Iron Pipe Co., Mechanical Joint; U.S. Pipe and Foundry, Mechanical Joint. **Proprietary Restrained Joint**: AWWA C111/A21.11-90 and C153/A21.53-88, ductile iron, 250 psi minimum working pressure. Coating/lining shall be Fusion-Bonded Epoxy meeting AWWA C116. Clow Corp., Super-Lock Joint; American Cast Iron Pipe Co., Flex-Ring or Lok-Ring Joint; U.S. Pipe, TR Flex. **Proprietary Restrained River Crossing**: Clow Ball and Socket; U.S. Pipe Usiflex. Coating/lining shall be Fusion-Bonded Epoxy meeting AWWA C116. **Grooved End**: AWWA C606-87 and C110/A21.10-93, ductile iron, 250 psi minimum working pressure. Lining and coating shall match connecting pipe. Victaulic; Gustin-Bacon. **Flange**: AWWA C110/A21.10-93 and ANSI B16.1-89, ductile or gray cast iron, faced and drilled, 125-pound flat face or 250-pound raised face. Gray cast iron will NOT be allowed. Lining and coating shall match connecting pipe.
Couplings	Grooved End: 250 psi minimum working pressure, malleable iron per ASTM A47-90 or ductile iron per ASTM A536-84. Victaulic; Gustin-Bacon. Grooved End Adapter Flanges: 250-pound malleable iron per ASTM A47-90 or ductile iron per ASTM A536-84. Victaulic; Gustin-Bacon.
Bolting	**Mechanical, Proprietary Restrained, and Grooved End Joints**: 316 Stainless Steel Hardware. **125-pound Flat-Faced Flange**: Exposed piping - ASTM A307-94, Grade A carbon steel hex head bolts and ASTM A563-93, Grade A steel hex head nuts. **250-pound Raised-Face Flange**: Exposed piping - ASTM A307-94, Grade B carbon steel hex head bolts and ASTM A563-93, Grade A carbon steel heavy hex head nuts. All hardware on submerged piping or piping below the top elevation of tanks and directly exposed to water, wastewater and/or wastewater solids, including but NOT limited to bolts, nuts, washers, and threaded rod shall be stainless steel.

SECTION 40 23 39.13 DUCTILE IRON PIPE AND FITTINGS	
Item	**Description**
Gaskets	**Mechanical, and Proprietary Restrained Joints, Water and Sewage**: Rubber conforming to ANSI/AWWA C111/A21.11-90 Locking gaskets produced in accordance with AWWA C111 are acceptable for use as a joint restraint mechanism for buried push-on type joints. Locking gaskets shall be rated for the same working pressure as the pipe. American Cast Iron Pipe Co., Fast-Grip Gasket; US Pipe, Field LOK Gaskets. **Mechanical and Proprietary Restrained Joints, Air**: Viton, Fluorel, or Manufacturer's standard for high temperature air service, rated to 300 degrees F minimum, conforming to ANSI/AWWA C111/A21.11-90 **Grooved End Joints**: Halogenated butyl conforming to ASTM D2000-90 and AWWA C606-87. Gaskets for air service shall be pressure-responsive synthetic rubber, rated to 300 degrees F minimum, conforming to ASTM D2000. **Flanged, Water and Sewage Services**: 1/8-inch thick, unless otherwise specified, homogenous black rubber (EPDM), hardness 60 (Shore A), rated to 212 degrees F., conforming to ANSI B16.21 and ASTM D1330 Steam Grade. **Flanged, Air Service**: 1/8-inch thick, unless otherwise specified, Teflon, PTFE, or compressed inorganic fiber with nitrile binder, rated to 300 degrees F. minimum, conforming to ANSI B16.21 and ASTM D1330. Ring gaskets shall NOT be permitted. Blind flanges shall be gasketed covering the entire inside face with the gasket cemented to the blind flange. Gasket pressure rating equal to the pressure rating as the pipe or fitting.
Joint Lubricant	Manufacturer's Standard.

END OF SECTION

SECTION 40 23 39.31 STEEL PIPE AND FITTINGS – BLACK	
Item	**Description**
Pipe	Black carbon steel ASTM A53, Grade B seamless or electric resistance welded, except piping 1.5-inch and small shall be ASTM A106, Grade B. **Screwed, Butt-Welded, and Flanged Pipe Wall Thickness:** 1 1/4-inch and smaller: Schedule 80 1 1/2-inch through 6-inch: Schedule 40 8-inch through 12-inch: Schedule 30 14-inch through 24-inch: Schedule 20 **Grooved End Pipe Wall Thickness:** 2 1/2-inch through 6-inch: Schedule 40 8-inch through 12-inch: Schedule 30 14-inch and Greater: Standard weight
Joints	Grooved end, butt-welded, flanged, or screwed as follows: 2-inch and smaller: Screwed 2 1/2-inch and Larger: Grooved end meeting the requirements of AWWA C606, butt-welded, or flanged, unless shown otherwise.
Fittings	**2-inch and Smaller:** Screwed, 150-pound malleable iron, black, ASTM A197 or ASTM A47, with dimensions meeting the requirements of ANSI B16.3 Unions: 300-pound malleable iron, black ASTM A197 or ASTM A47, with dimensions meeting the requirements of ANSI B16.3, and a brass to iron seat. **2 1/2-inch through 24-inch, Grooved End:** Malleable iron, ASTM A47, or ductile iron, ASTM A536, grooved ends to accept mechanical couplings without field preparation. Where cast fittings are not available, fabricate segmentally welded steel fittings, ASTM A53, Grade B, meeting the requirements of Manufacturer's recommended wall thicknesses. Manufacturers: Victaulic; Gustin-Bacon. **2 1/2-inch through 24-inch, Butt Welding Type:** Carbon steel, to match pipe wall thickness, ASTM A234, Grade WPB, meeting the requirements of ANSI B16.9. All ells shall be LR, unless otherwise designated.
Branch Connections	**2-inch and Smaller:** Screwed, straight, or reducing tees as specified under Fittings. 2,000- or 3,000-pound WOG forged carbon steel, ASTM A105, Grade II, commercial welding branch fittings with threaded outlet. **2 1/2-inch and Larger:** Straight or reducing tees, as specified under Fittings. Standard weight forged steel, ASTM A105, Grade II, commercial welding branch fittings with butt-welding outlet. Use tee for branch outlet full size of run or one size reduced.
Flanges	Forged steel, ASTM A181, Class 60, 70, slip-on or welding neck, faced and drilled 150-pound, 1/16-inch raised face, ANSI B16.5 Standard, or AWWA C207, Class D hub, faced and drilled 125-pound flat face, ANSI B16.1 Standard. Grooved End Pipe Adapter Flanges: Malleable iron, ASTM A47, or ductile iron, ASTM A536. Welding Neck Flanges: Provide when abutting butt-weld fittings. Welding neck bore shall match pipe ID. Flat Face Flange Mating: Machine off the raised face of steel flange when mating with a cast iron flat faced flange.

SECTION 40 23 39.31 STEEL PIPE AND FITTINGS – BLACK	
Item	**Description**
Couplings	**Grooved End Pipe:** Flexible rigid joint malleable iron, ASTM A47, or ductile iron, ASTM A536. Manufacturers: Victaulic; Gustin-Bacon. **Screwed Pipe:** Malleable iron, ASTM A197 or ASTM A47, with dimensions meeting the requirements of ANSI B16.3.
Bolting	**Grooved End Joints:** Heat-treated carbon steel, ASTM A183 bolts and nuts, with minimum tensile strength of 110,000 psi. **150-pound RF Flanges:** Carbon steel, ASTM A307, Grade A hex head bolts and ASTM A563, Grade A hex head nuts. **125-pound FF AWWA Class D Flanges:** Carbon steel, ASTM A307, Grade A hex head bolts and ASTM A563, Grade A hex head nuts. When mating flange on equipment is cast iron and gasket is flat ring type, provide ASTM A307, Grade B square head bolts and ASTM A563, Grade A heavy hex head nuts.
Gaskets	**Grooved End Joints:** EPDM or chlorinated butyl with properties meeting the requirements of ASTM D2000. Dimensions meeting the requirements of AWWA C606, pipe diameters and couplings provided. **Flanged Joints, General Service:** 150-pound RF Flanges: 1/16-inch thick compressed nonasbestos composition flat ring type. 125-pound FF Flanges: 1/16-inch thick compressed nonasbestos composition flat ring type, except for wafer type valves and similar equipment which shall be ring type gaskets. **Flanged Joints, Potable Water Service:** 150-pound RF Flanges: 1/8-inch thick cloth inserted rubber flat ring type meeting the requirements of ANSI B16.21 and AWWA C207. 125-pound FF Flanges: 1/8-inch thick cloth inserted rubber full face type except for wafer style valves and similar equipment which shall be ring type gaskets meeting the requirements of ANSI B16.21 and AWWA C207. Provide gasket materials free from corrosive alkali or acid ingredients and suitable for use in potable water service.
Thread Lubricant	Pipe joint compound that is lead face, non-hardening, insoluble in the presence of natural gas, and compliant with ANSI/NSF 61. Temperature service range of -15 to 400°F.
Corrosion Protection	Provide cathodic protection for buried piping as required.

END OF SECTION

SECTION 40 23 39.36 STAINLESS STEEL PIPE AND FITTINGS – GENERAL SERVICE	
Item	**Description**
Pipe	**2-inch and Smaller:** Schedule 40S, ASTM A312, Type 304L seamless, pickled and passivated. **3-inch through 6-inch:** Schedule 10S, ASTM A312 or ASTM A778, Type 304L. **8-inch and Greater:** Schedule 5S, ASTM A312 or ASTM A778, Type 304L.
Joints	**2-inch and Smaller:** Flanged, welded, or screwed with Teflon tape thread lubricant. **3-inch and Greater:** Design and shop fabricate piping sections utilizing type of joint illustrated or scheduled. Joints at Valves and Pipe Appurtenances: Provide flanged valves and flanged pipe appurtenances in stainless steel piping systems with flanged ends. Design and fabricate piping sections to make connections with flanged valves and pipe appurtenances using piping stub ends with backing flanges, flanged coupling adapters, or flanged joints. Joints in Digester Gas Systems: Butt-welded or flanged. **Welded Joints:** Pipe 12-inches and larger in diameter: Automatically weld joints using gas tungsten-arc procedures. Piping 4-inches through 12-inches in diameter: Double butt-welded joints. Piping less than 4-inches in diameter: Single butt-welded joints. Mark each weld with a symbol that identifies the welder. **Piping Stub Ends and Backing Flanges for Piping 3-inches and Larger:** Cast stainless steel to match the pipe material with machined gasket and wetted surfaces of stub ends free of crevices, pits, cracks and protrusions. Backing Flanges: Forged or plate stainless steel (type to match pipe material) with drilled bolt patterns in accordance with ASME B16.1, Class 125 or ASME B16.5, Class 150, 300, or 600, as scheduled. Stub ends and backing flanges are not allow for use with wafer style or lugged style valves. **Flanges for Schedule 40S and Schedule 80S Pipe:** Provide forged stainless steel (type matching piping system) welding neck flanges or slip-on flanges in accordance with ASME B16.5 Class 150. Material to be in accordance with ASTM A182. Bore shall match pipe.

SECTION 40 23 39.36 STAINLESS STEEL PIPE AND FITTINGS – GENERAL SERVICE	
Item	**Description**
Fittings	**2-inch and Smaller:** Material: In accordance with ASTM A240 stainless steel, grade to match pipe. Manufacturing Standard: In accordance with ASTM A403, Class WP. Wall Thickness and Dimensions of Fitting: In accordance with ASME B16.11 for the schedule of pipe specified. End Configuration: As needed to comply with specified type of joint. Forgings in accordance with ASTM A182, or barstock in accordance with ASTM A276. Match forging or barstock material to the piping materials. **3-inch and Larger:** Material: In accordance with ASTM A240 stainless steel, grade to match pipe. Manufacturing Standard: In accordance with ASTM A774. Wall Thickness of Fitting: In accordance with ASME B36.19 for the schedule of pipe specified. End Configuration: As needed to comply with specified type of joint. Dimensional Standards: Welded ends in accordance with ASME B16.11; Flanged ends in accordance with ASME B16.5, Class 150. All ells LR, unless otherwise designated.
Branch Connections	**2-inch and Smaller:** Tee or reducing tee in conformance with Fittings above. **Larger than 2-inch:** Butt-welding tee or reducing tee in accordance with Fittings above.
Flanges	Conforming to the requirements in accordance with ASME B16.5, Class 150. Bore shall match pipe. **4-inch and Smaller:** Forged stainless steel, ASTM A182, and Grade F304L, ANSI B16.5- Class 150 or Class 300 threaded, slip-on, or weld neck with raised face. **6-inch through 24-inch:** Forged stainless steel, ASTM A182 Grade F304L, ANSI B16.5- Class 150 or Class 300 slip-on or weld neck with raised face. Bore shall match pipe. **Larger than 24-inch:** Forged stainless steel, ASTM A182 F304L, ANSI B16.47 Series A Class 125 or 150 weld neck with raised face. Bore shall match pipe. **Flanges for Schedule 40S and Schedule 80S Pipe:** Provide forged stainless steel (type matching piping system) welding neck flanges or slip-on flanges in accordance with ASME B16.5 Class 150. Material to be in accordance with ASTM A182. Bore shall match pipe.

SECTION 40 23 39.36 STAINLESS STEEL PIPE AND FITTINGS – GENERAL SERVICE	
Item	**Description**
Unions	**2-inch and Smaller:** Threaded Forged, ASTM A182 Grade F304, 2,000 pound or 3,000 pound WOG, integral ground seats, AAR design meeting the requirements of ANSI B16.11, bore to match pipe.
Bolts and Nuts	Type 316 stainless steel in accordance with ASTM A193 heavy hex head. Bolt length such that after installation, end of bolt projects 1/8-inch to 3/8-inch beyond outer face of nut. Nuts in accordance with ASTM A194 heavy hex pattern.
Gaskets	**Water Service:** Ring gasket type, 1/8-inch minimum thickness, cloth inserted rubber, red rubber, or neoprene and shall be suitable for the service intended. **Process Air Service:** Premium Grade, EPDM, full face type, 1/8-inch thick, smooth surface, 60 Shore hardness, rated for 300 degrees Fahrenheit and compressed air service conforming to ANSI B16.21. **Digester Gas Service:** Viton or silicone material, Ring gasket type, 1/8-inch minimum thickness, and suitable for 300 degrees Fahrenheit continuous service at 25 psig. Dielectric gaskets shall be used at all transitions to material other than stainless steel. Segmented gaskets will not be acceptable.
Thread Lubricant	**2-inch and Smaller:** Teflon Tape

END OF SECTION

SECTION 40 23 39.43 POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS	
Item	**Description**
Pipe	**Schedule 80 PVC:** Type I, Grade I or Class 23447-B conforming to ASTM D1785-05. **Threaded Nipples:** Schedule 80 PVC.
Fittings	Schedule 80 PVC, conforming to the requirements of ASTM D2467.
Joints	Solvent socket-weld except where connection to valves and equipment may require future disassembly. Threaded joints shall not be used unless specifically approved by ENGINEER.
Flanges	One piece, molded hub type PVC flat face flange in accordance with Fittings above, 125-pound ANSI B16.1-89 drilling.
Bolting	**Flat Face Mating Flange or In Corrosive Areas:** ASTM A193/A193M Rev A-94 Type 316 stainless steel Grade B8M hex head bolts and ASTM A194/A194M-94 Grade 8M hex head nuts. **With Raised Face Mating Flange:** Carbon steel ASTM A307-94 Grade B square head bolts and ASTM A563-93 Grade A heavy hex head nuts.
Gaskets	**Flat Face Mating Flange:** Full faced 1/8" thick. **Raised Face Mating Flange:** Flat ring 1/8" thick, with filler gasket between OD of raised face and flange OD to protect the flange from bolting moment. Gasket material shall be suitable for each service. Submit recommended gasket material for each service to ENGINEER.
Solvent Cement	As recommended by the pipe and fitting manufacturer conforming to ASTM F493 Rev A. Solvent cement shall be rated for use with each service. Provide manufacturer's certification that the solvent is appropriate for respective service.
Thread Lubricant	Teflon Tape

END OF SECTION

SECTION 40 23 43 – PROCESS VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Basic requirements for Process Valves.

B. Related sections:
1. Section 01 33 00 – Submittal Procedures.
2. Section 01 40 00 – Quality Requirements.
3. Section 01 60 00 – Product Requirements.
4. Section 01 75 00 – Startup Testing and Training.
5. Section 01 77 00 – Closeout Procedures.
6. Section 09 90 00 – Painting and Protective Coatings.
7. Section 40 23 39 – Process Piping, General.
8. Section 40 92 16 – Manual Valve and Gate Operators.

1.2 GENERAL

A. See Section 40 23 39, PROCESS PIPING, GENERAL, which contains information and requirements that apply to the work specified herein and are mandatory for this project.

B. Certain valves are specified in Division 44 to be furnished by equipment manufacturer as part of their equipment package and/or system. These valves are to be installed by the Contractor as specified herein. In addition to installation, the Contractor shall be responsible for test, inspection, and assisting the equipment suppliers in startup services as required to the place the valves into continuous, reliable operation.

1.3 SUBMITTALS

A. Submittals shall be made as required in Section 01 33 00, SUBMITTALS. The following specific information shall be provided:
1. Shop Drawings:
   a. Product data sheets for make and model.
   b. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
   c. Refer to specific valve type for additional submittal requirements.
2. Quality requirements Submittals:
   a. Tests and inspection data.
   b. Manufacturer’s Certificate of Proper Installation.
   c. Manufacturer’s printed installation instructions.
   d. Special shipping, storage and protection, and handling instructions.
   e. Suggested spare parts list to maintain the equipment in service for a period of 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
   f. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.

1.4 OPERATION AND MAINTENANCE DATA

A. O&M Manuals: Content, format, and schedule for providing as specified in Section 01 77 00, CLOSEOUT PROCEDURES.

B. Maintenance Summary Forms: As specified in Section 01 77 00, CLOSEOUT PROCEDURES.

1.5 WARRANTY

A. The valve(s) shall be covered by a minimum three year warranty against defects in materials and workmanship. The electrical components shall have a minimum one year warranty. The stainless steel seat shall be covered by a lifetime replacement warranty.

PART 2 - PRODUCTS

2.1 GENERAL

A. Valve to include operator, actuator, hand wheel, chain wheel, extension stern, floor stand, worm and gear operator, operating nut, chain, wrench, and accessories for a complete operation. For operator specifications, see Section 40 92 16, VALVE AND GATE OPERATORS.

B. Valve shall be suitable for intended service. Renewable parts not to be of a lower quality than specified.

C. Valve shall be the same size as adjoining pipe.

D. Valve ends to suit adjacent piping.

E. Valve shall open by turning counterclockwise unless otherwise specified.

F. Operator, actuator, and accessories shall be factory mounted.

G. EFFECTIVE JANUARY 4, 2014 ANY VALVE, PIPE, FITTING, SOLDER, OR FLUX USED OR IN CONTACT WITH POTABLE WATER SHALL COMPLY WITH THE REDUCTION OF LEAD IN DRINKING WATER ACT, AN AMENDMENT TO SECTION 1417 OF THE SAFE DRINKING WATER ACT (SDWA). VALVES SPECIFIED IN THIS SECTION MAY NOT MEET REQUIRMENTS OF THIS ACT, HOWEVER THIS DOES NOT RELIEVE THE CONTRACTOR FROM PROVIDING A VALVE TO MEET REQUIREMENTS OF THE (SDWA) AND THE SAME FUNCTIONAL REQUIREMENTS OF THIS SPECIFICATION.

2.2 SCHEDULE

A. Requirements relative to this section for certain type of actuated or process valves are shown on the Valve Schedules attached as Supplements to the related Sections.

2.3 MATERIALS

A. Brass and bronze valve components and accessories that have surfaces in contact with water shall be alloys containing less than 16% zinc and 2% aluminum.

B. Approved alloys are of the following ASTM designations:
   1. B61, B62, B98 (Alloy UNS No.C65100, C65500, or C66100), B139 (Alloy UNS No.C51000), B584 (Alloy UNS No.C90300 or C94700), B164, B194, and B127.
   2. Stainless steel, AISI Type 316 may be substituted for bronze.

2.4 FACTORY FINISHING

A. Epoxy Lining and Coating:
   1. In accordance with AWWA C550 unless otherwise specified. Coating shall be either two-part liquid material or heat-activated (fusion) material except only heat-activated material if specified as “fusion” or “fusion bonded” epoxy.
   2. Minimum 7-mil dry film thickness except where limited by valve operating tolerances.

B. Exposed Valves Field Finish:
1. Final paint coating shall be in accordance with Section 09 90 00, PAINTING AND PROTECTIVE COATINGS. System and color shall match adjacent piping system.
2. Safety isolation valves and lockout valves with handles, hand wheels, or chain wheels "safety yellow."

2.5 VALVES

A. Gate Valves:
1. Not Used.

B. Globe Valves:
1. Not Used.

C. Ball Valves:
1. Not Used.

D. Plug Valves:
1. Type V405: Eccentric Plug Valve, 4-inches through 12-inches
a. Water and Wastewater Applications: Non-lubricating type rated 175 psig CWP, drip-tight shutoff with pressure from either direction, cast iron body, or stainless steel body where indicated, with flanged ends or grooved ends in accordance with AWWA C606 for rigid joints, mechanical joint ends for buried valve. Plug cast iron with round or rectangular port of no less than 80% of connecting pipe area and coated with Buna-N or Hycar, seats nickel, stem bearing self-lubricating stainless steel, stem seal multiple V -rings or V-cups of nitrile rubber, grit seals on stem.
b. Digester Gas Applications: Valves shall be suitable for operation in a wet anaerobic digester gas stream with moderate concentrations of hydrogen sulfide. The body materials shall be of ASTM B26 aluminum, Alloy 7130, Temper T5 or ASTM A743, Type 316 stainless steel, Grade CF-8M. The eccentric plug shall be fabricated from the same material as the body of the valve. The bottom bearing shall be Type 316 stainless steel. The top bearing shall be Type 316 stainless steel, sintered. The valve bonnet shalol be fabricated from the same material as the body of the valve. The bonnet screws shall be 18-8 stainless steel. Packing shall be NBR acrylonitrile-butadiene, V-type. Thurst bearing ring shall be PTFE.
c. Valves 4-inches or less to be provided with wrench lever manual operator. Valves 6-inches through 12-inches to be provided with totally enclosed, geared, manual operator with hand wheel, 2" nut, or chain wheel.
d. Manufacturers and Products:
1) DeZurik.
2) Henry Pratt.
3) Val-Matic.
4) Crispin Valve.
2. Type V406: Eccentric Plug Valve, 14-inches and Larger
a. Non-lubricating type rated 150 psig CWP, drip-tight shutoff with pressure from either direction, cast iron body with flanged ends or grooved ends in accordance with AWWA C606 for rigid joints, mechanical joint ends for buried valve. Plug cast iron with round or rectangular port of no less than 80% of connecting pipe area and coated with Buna-N or Hycar, seats nickel, stem bearing self-lubricating stainless steel, stem seal multiple V -rings or V-cups of nitrile rubber, grit seals on stem.
b. Provide with totally enclosed, geared, manual operator with hand wheel, 2" nut, or chain wheel.
c. Manufacturers and Products:
1) DeZurik.
2) Henry Pratt.
3) Val-Matic.

4) Crispin Valve.

E. Butterfly Valves:
1. General:
a. Provide valves designed and manufactured in accordance with AWWA C504, Class 150B or Class 250B, AWWA C516, and the following requirements:
b. Valve class shall meet the requirements of the connecting line or as indicated in valve schedule or as indicated on the drawings.
c. Suitable for throttling operations and infrequent operation after periods of inactivity.
d. Elastomer seats bonded to body shall have adhesive integrity of bond between seat and body assured by testing with minimum 75-pound pull in accordance with ASTM D429, Method B. Seat may be retained by mechanical means on valves 24-inches and larger. No epoxy attachment method shall be allowed.
e. Bubble-tight with rated pressure, or any pressure lower than rated, applied from either side with the valve mounted in any orientation.
f. No travel stops for the disc on interior of the body.
g. Shaft seal shall include V-type packing for self-adjusting and wear compensation.
h. Isolate metal-to-metal thrust bearing surfaces from flow stream.
i. Valves intended for air service shall meet ANSI B16.104 and ANSI B16.5.
2. Type V510: Lug-style Butterfly Valves, 2-inches and Larger
a. General:
1) Minimum Rated Working Pressure: 150 psig in compliance with ASME Class 150.
2) Maximum Process Fluid Temperature: 250°F.
3) Suitable for air and/or water service.
b. Construction and Materials:
1) Body:
a) Type: Lugged.
b) ASTM A536 Grade 65-45-12 ductile iron.
2) Disc:
a) Material: ASTM A351 Grade CF8N stainless steel.
b) No disc stops shall be installed on the interior of the valve body.
3) Seat:
a) Type: Resilient and replaceable. Shall have a full 360-degree circumference around the valve body without interruption. Seat shall cover the entire inner surface of the valve body and extend over the outside face of the valve body to form a flange gasket.
b) Mounting: On the valve body.
c) Seats shall have adhesive integrity of bond between seat and body or seat and disc assured by testing with minimum 75-pound pull in accordance with ASTM D429 Method B.
d) Material: EPDM.
4) Shafts: ASTM A582 Type 416 stainless steel or ASTM A582 Type 420 stainless steel.
5) Packing: V-type and replaceable without dismantling valve.
6) Bearings: Shall be sleeve type that is PFTE lined and self-lubricating. Metal-to-metal thrust bearings shall not be installed on the interior of the valve body.
7) Hardware: ASTM A276 Type 304 or 316 stainless steel.
8) End Connections: Lug pattern (flanged), comply with ASME B16.1 Class 125.
9) Finishes: Factory primer, field finish to match connecting pipe.
c. Manufacturers:
1) DeZurik: On-Center, Resilient Seated Butterfly Valves BOS-CL
2) Henry Pratt Co.: BF Series
3. Type V513: High-Performance Butterfly Valves, 2-inches and Larger

a. General:
    1) Minimum Rated Working Pressure: 150 psig in compliance with ASME Class 150.
    2) Maximum Process Fluid Temperature: 500 degrees Fahrenheit.
    3) Maximum Process Fluid Velocity: 20 feet per second.
b. Construction and Materials:
    1) Body:
        a) Type: Lugged.
        b) Material: ASTM A351 Grade CF8M Stainless Steel
    2) Disc:
        a) Material: ASTM A351 Grade CF8M Stainless Steel
        b) No disc stops shall be installed on the interior of the valve body.
    3) Seat:
        a) Type: Resilient and replaceable. Shall have a full 360-degree circumference around the valve body without interruption.
        b) Mounting: ASTM A351 Grade CF8N stainless steel seat retainer held in place by 316 stainless steel retaining screws.
        c) Material: Reinforced PTFE seat.
    4) Shafts: ASTM A479 Type 316 stainless steel.
    5) Packing: V-type and replaceable without dismantling valve.
    6) Bearings: Shall be sleeve type that is PFTE lined and self-lubricating. Metal-to-metal thrust bearings shall not be installed on the interior of the valve body.
    7) Hardware: ASTM A276 Type 316 stainless steel.
    8) End Connections: Lug pattern (flanged), comply with ASME B16.1 Class 125.
    9) Finishes: Field finish to match connecting pipe.
c. Manufacturers:
    1) DeZurik: High Performance Butterfly Valves BHP
    2) Bray Valve: High Performance Butterfly Valves McCannalok Series 41

F. Check and Flap Valve:
1. Not Used.

G. Self-Contained Automatic Valves:
1. Type V752: Wastewater Combination Air Valves, 1-inch and Larger
    a. Valve shall be automatic float operated valve designed to exhaust large quantities of air during the filling of a piping system and close upon liquid entry. The valve shall open during draining or if a negative pressure occurs. The valve shall also release accumulated air from a piping system while the system is in operation and under pressure.
    b. Valve shall perform functions of both air release and Air/Vacuum valves and be furnished as a single body.
    c. Valve shall be suitable for use with domestic sewage.
    d. Valve body and structure shall be constructed of cast iron or ductile iron. Float, guide shafts and bushings shall be stainless steel.
    e. Manufacturers:
        1) Val-Matic.
        2) DeZurik.
        3) Crispin Valve.

H. Miscellaneous Valves:
1. Type V910: Telescoping Valve, 4-inches and Larger
    a. Valve configuration shall be as shown on the Drawings and detailed within the Supplements following End of Section.

b. Complete assembly consisting of rising stem, slip tube, seal flange, lifting bail, valve stand with indicator and motor, when required, and Type 316 stainless steel anchor bolts and mounting hardware.
c. Slip tube shall be Type 304 stainless steel, manufactured from seamless pipe or tube, with a minimum wall thickness of 1/8" and shall be of sufficient length to facilitate valve travel and maintain an appropriate insert depth.
d. A stainless steel companion flange and neoprene slip seal gasket shall be provided. The gasket shall be a minimum 1/4-inch thick, mounted to allow sliding and shall be watertight throughout the travel of the slip tube.
e. Lift shall be handwheel type and stem shall be of the rising type, stainless steel, thrust bearings, automatic self-locking, and provide infinite valve positioning. A clear plastic Butyrate stem cover shall be provided with a mylar strip type position indicator, calibrated in 1/4-inch increments to illustrate valve position.
f. Manufacturers and Products:
    1) Troy Valve
    2) Waterman; TS-2
    3) Golden Harvest
    4) Amwell; Type RP

2.6 TAGGING REQUIREMENTS

A. The tags shall be attached to the valves by soldered split key rings so that ring and tag cannot be removed. The tag shall bear the 1/4-inch die-stamped equipment identification number as indicated in the Contract Documents.

2.7 ACCESSORIES

A. T-Handled Operating Wrench:
    1. Two each, galvanized operating wrenches, 4-feet long.
    2. Manufacturers and Products:
        a. Mueller; No. A-24610.
        b. Clow No.; F-2520.
    3. Two each, galvanized operating keys for cross handled valves.

B. Cast Iron Valve Box: Designed for traffic loads, sliding type, with minimum of 6-inch ID shaft.
    1. Box: Cast iron with minimum depth of 9-inches.
    2. Lid: Cast iron, minimum depth 3-inches, marked for the appropriate service.
    3. Extensions: Cast iron.

PART 3 - EXECUTION

3.1 SHIPPING, STORAGE, HANDLING, AND PROTECTION

A. As specified in Section 01 60 00, PRODUCT REQUIREMENTS.

3.2 INSTALLATION

A. Flange Ends:
    1. Flanged valve bolt holes shall straddle vertical centerline of pipe.
    2. Clean flanged faces, insert gasket and bolts, and tighten nuts progressively and uniformly.

B. Screwed Ends:
    1. Clean threads by wire brushing or swabbing.

2. Apply joint compound.

C. Valve Orientation:
1. Install operating stem vertical when valve is installed in horizontal runs of pipe having centerline elevations 4’ 6” or less above finished floor, unless otherwise shown.
2. Install operating stem horizontal in horizontal runs of pipe having centerline elevations between 4’ 6” and 6’ 9” above finish floor, unless otherwise shown.
3. Orient butterfly valve shaft so that unbalanced flows or eddies are equally divided to each half of the disc, i.e., shaft is in the plane of rotation of the eddy.
4. If no plug valve seat position is shown, locate as follows:
   a. Horizontal Flow: The flow shall produce an “unseating” pressure, and the plug shall open into the top half of valve.
   b. Vertical Flow: Install seat in the highest portion of the valve.

D. Install a line size ball valve and union upstream of each solenoid valve, in-line flow switch, or other in-line electrical device, excluding magnetic flow meters, for isolation during maintenance.

E. Install safety isolation valves on compressed air.

F. Locate valve to provide accessibility for control and maintenance. Install access doors in finished walls and plaster ceilings for valve access.

G. Extension Stem for Operator: Where the depth of the valve is such that its centerline is more than 3 feet below grade. Furnish an operating extension stem with 2”operating nut to bring the operating nut to a point 6” below the surface of the ground and/or box cover.

H. Torque Tube: Where operator for quarter-turn valve is located on floor stand. Furnish extension stem torque tube of a type properly sized for maximum torque capacity of the valve.

I. Floor Box and Stem: Steel extension stem length shall locate operating nut in floor box.

3.3 TESTS AND INSPECTION

A. Valve may be either tested while testing pipelines, or as a separate step.

B. Test that valves open and close smoothly with operating pressure on one side and atmospheric pressure on the other, in both directions for two-way valve and applications.

C. Inspect air and vacuum valves as pipe is being filled to verify venting and seating is fully functional.

D. Count and record number of turns to open and close valve; account for any discrepancies with Manufacturer’s data.

E. Set, verify, and record set pressures for all relief and regulating valves.

F. Automatic valve to be tested in conjunction with control system testing.

G. Test hydrostatic relief valve seating; record leakage. Adjust and retest to maximum leakage of 0.1 gpm per foot of seat periphery.

3.4 MANUFACTURER’S SERVICES

A. A Manufacturer’s representative for the equipment specified herein shall be present at the jobsite for the minimum person-days listed for the services herein under, travel time excluded:

1. 2 person-days for installation assistance, inspection, and certification of the installation. Provide certificate.
2. 2 person-days for functional and performance testing.
3. 2 person-days for pre-startup classroom or jobsite training of Owner's personnel.

B. Training of Owner's personnel shall be at such times and at such locations as requested by Owner.

C. See Section 01 75 00, STARTUP TESTING AND TRAINING.

3.5 MANUFACTURER'S CERTIFICATE(S)

A. Provide Manufacturer's certificate(s) in accordance with Section 01 75 00, STARTUP TESTING AND TRAINING.

3.6 SUPPLEMENTS

A. The supplements listed below, following "END OF SECTION," are a part of this Specification.
1. None.

END OF SECTION

SECTION 40 41 13 – HEAT TRACING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Basic requirements for heat tracing including:
   1. Heating Cables.
   2. Control Panels.
   3. Temperature Sensors.
   4. Temperature Controllers.
   5. Contactors.
   6. Enclosures.
   7. All other auxiliary equipment and controls required to complete a heat tracing system.

B. Related Sections:
   1. Section 01 33 00 – Submittal Procedures.
   2. Section 01 75 00 – Startup Testing and Training.
   3. Section 40 42 00 – Mechanical Insulation.

1.2 SUBMITTALS

A. General: Administrative, shop drawings, samples, quality control, and contract closeout submittals shall conform to the requirements of Section 01 33 00, SUBMITTAL PROCEDURES.

B. In addition to the requirements of Section 01 33 00, SUBMITTAL PROCEDURES, submit the following additional specific information:
   1. Product Data:
      a. Catalog number, wattage output, voltage rating, and product data.
      b. Installation instructions.
      c. Length of cable.
      d. Cable spacing.
      e. Electrical power requirements.
   2. Shop Drawings: Include plans, sections, details, wiring diagrams, and attachments to other work. The wiring diagrams shall include power, signal, and control wiring.
   3. Operational and maintenance data shall be included.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements and Reference Standards: The electric heat tracing system shall conform to this specification and shall be designed, manufactured and tested in accordance with the minimum applicable requirements of the latest edition of the following codes and standards. Additional specific requirements shall be further defined in the testing requirements for each section.

1.4 WARRANTY

A. Cables: All cables shall be warranted for a period of 10 years for manufacturing defects.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Design Requirements:
   1. General: Heat tracing applications shall use self-regulating heating cables and pads.

2. Self-regulating heating cable shall vary its heat output relative to the temperature of the surface of the pipe or the tank allowing cable to be crossed over itself without overheating and to be cut to length in the field.
3. Design for a useful life of 20 years or more with “power on” continuously. The criteria for life shall be to retain at least 75 percent of its original power when tested according to UL 746B.

2.2 HEAT TRACING CABLE

A. The heating element shall be a pair of parallel No. 16 AWG stranded copper bus wires embedded in cross linked conductive polymer core, which varies heat output in response to temperature along its length. Cables shall be terminated with waterproof, factory assembled non heating leads with connects at one and seal the opposite end watertight. The cable shall be capable of crossing over itself without overheating.

B. The electrical insulating jacket shall be flame retardant polyolefin.

C. The cable cover shall be tinned copper braid and TPR outer jacket.

D. The maximum power on operating temperature shall be 150 degrees Fahrenheit.

E. The maximum power off exposure temperature shall be 185 degrees Fahrenheit.

F. The capacities and characteristics shall be:
1. Heat Output: 5.0 watts per foot at 50 degrees Fahrenheit, 1 watt per foot at 150 degrees Fahrenheit.
2. Pipe Diameter: As indicated on the Drawings and Process Piping Schedule.
3. Number of Parallel Cables: 1
4. Volts: 120
5. Phase: 1
6. Hertz: 60
7. Full Load Amps: Variable, depending on the length of the cable.
8. Minimum Circuit Ampacity: 30
9. Maximum Over Current Protection: 30

G. Manufacturers:
1. Raychem Chemelex Auto-Trace.
2. Chromalox Type SLR Rapid Trace.
3. Thermon, BSX.
4. Nelson, CLT or LT.

2.3 CONTROLLER

A. Manufacturer:
1. Raychem Monitrace1000.

B. Operating Characteristics:
1. Controller shall provide continuous monitoring of heat tracing circuit analyzing temperature through a hard-wired RTD.
2. Controller shall energize system automatically if the temperature drops below a preset point. Controller shall be equipped with local alarm to alert maintenance personnel if heat trace circuit is interrupted.
3. Controller shall have the capability of performing a self-diagnostic check on the system and advising maintenance personnel of the exact nature of any circuit problems.

C. Controller shall be fully compatible with heat trace and provided by same manufacturer as heat trace.
   1. Controller shall be powered from 208 VAC. A configurable dry contact shall be provided for heat trace fault.
   2. Controller shall have double pole solid state switching, temperature control from -40°F to 125 degrees Fahrenheit and a 30-amp rating from -40 degrees Fahrenheit to 125 degrees Fahrenheit, ambient temperature.
   3. Power Supply: Controller power supply shall be either 110-240 VAC with adjustable ground fault detection.
   4. Controller shall have battery backup system to retain programmed parameters in the event of a power failure.
   5. Enclosure: Unit shall be enclosed in a NEMA 4X panel.
   6. When installed within a Class 1 Division 1 or Class 1 Division 2 hazardous location, the controller shall be rated for the installed location.
   7. Network Capabilities: Controller shall have network capabilities enabling monitoring and programming from a central location.

2.4 CONNECTION KITS, END SEALS, SPLICE AND TEE KITS

A. Heat trace connection, end, splice and tee kits shall be designed to meet or exceed the life of the heat trace and shall be given equal consideration and evaluation.

2.5 ACCESSORIES

A. Heat tracing systems shall be provided complete with the following accessories:
   1. Power connection kits.
   2. Termination kits.
   3. Splice kits.
   4. End seal kits.
   5. Straps.
   6. Thermostat.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer’s written instructions and approved submittals.

B. Install heat tracing cable on piping subject to freezing in the following areas and as indicated on the drawings:
   1. Digester Gas Scrubber Drain Lines

C. Wrap heat tracing tape with aluminum tape prior to installing insulation.

D. Install pipe insulation as specified in Section 40 42 00, MECHANICAL INSULATION.

E. Install heat tape and controls in accordance with manufacturer’s published installation instructions.

F. Thermostat:
   1. Thermostat shall be powered by 120 VAC.
   2. One single 120-volt power source shall be provided to the heat tracing control system panel as indicated on the Drawings.
   3. Thermostats shall be powered from the control panel box by the Contractor.

3.2 FIELD QUALITY CONTROL

A. Field testing shall be performed in accordance with Section 01 75 00, STARTUP TESTING AND TRAINING.

B. Functional tests shall be performed after cable installation but before the application of coverings such as insulation, wall or ceiling construction, or concrete. The cables shall be tested for electrical continuity and insulation integrity before energizing. The cables shall be tested to verify rating and power input. The cables shall be energized and voltage and current measured simultaneously. Test repeatedly after repairing heating cables with new products.

3.3 MANUFACTURER'S SERVICES

A. A manufacturer's representative for the equipment specified herein shall be present at the job site for the minimum person-days listed for the services hereinunder, travel time excluded.
   1. Installation, Startup, and Testing Services (for each digester mixing system)
      a. 1 person-days for installation assistance, inspection, and Certificate of Proper Installation.
      b. 1 person-day for functional and performance testing.
      c. Provide Qualifications of Manufacturer's Representative.
   2. Training Services (total)
      a. 1 person-day of prestart classroom or jobsite training of Owner's personnel.
      b. Training of Owner's personnel shall be at such times and at such locations as required and approved by the Owner.

B. See Section 01 75 00, STARTUP TESTING AND TRAINING.

3.4 MANUFACTURER'S CERTIFICATES

A. Provide Manufacturer's certificate(s).

END OF SECTION

SECTION 40 42 00 – PROCESS MECHANICAL INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Insulation, jackets, and accessories for piping and related systems.

B. Related Sections:
   1. Section 01 33 00 – Submittal Procedures.
   2. Section 09 90 00 – Painting and Protective Coatings.
   3. Section 40 05 07 – Hangers and Supports for Process Pipe.
   4. Section 40 23 39 – Process Piping, General.

1.2 REFERENCES

A. ASTM International:
   1. A53 – Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless.
   2. C168 – Standard Terminology Relating to Thermal Insulation.
   3. C177 – Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
   4. C335 – Standard Test Method for Steady-State Heat Transfer Properties of Pipe Insulation.
   5. C518 – Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
   6. C533 – Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
   7. C534 – Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
   8. C547 – Standard Specification for Mineral Fiber Pipe Insulation.
   9. C552 – Standard Specification for Cellular Glass Thermal Insulation.
   10. C585 – Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing.
   11. C591 – Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation.
   12. C795 – Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
   13. C929 – Standard Practice for Handling, Transporting, Shipping, Storage, Receiving, and Application of Thermal Insulation materials for Use in Contact with Austenitic Stainless Steel.
   14. C1136 – Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
   15. D2310 – Classification of Machine-Made “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
   16. E84 – Standard Test Method for Surface Burning Characteristics of Building Materials.
   17. E96 – Standard Test Methods for Water Vapor Transmission of Materials.

1.3 DEFINITIONS

A. Buried: Piping that is installed below buildings, foundations or finish grade, either in soil or encased in concrete in soil.

B. Concealed: Piping above suspended ceilings and within walls, partitions, shafts, or service spaces and spaces NOT normally exposed to view but NOT buried.

C. Exterior: Piping that is installed outside a building or within a pipe trench or tunnel.

D. Flame Spread and Smoke Density: Burning characteristics determined in accordance with ASTM E84. No units apply to value.

E. Interior: Piping that is installed inside a building.

F. K Factor: Thermal conductivity determined in accordance with ASTM C177 or C518 and expressed in units of Btu-inch/hour-feet^2 – °F.

G. Mineral Fiber: Fibers manufactured of glass, rock, or slag processed from a molten state, with or without a binder.

H. Water Vapor Permeance: Water vapor transmission determined in accordance with ASTM E96 and expressed in units of perm-inch.

1.4 SUBMITTALS

A. General: Administrative, shop drawings, samples, quality control, and contract closeout submittals shall conform to the requirements of Section 01 33 00, SUBMITTAL PROCEDURES.

B. In addition to the requirements of Section 01 33 00, SUBMITTAL PROCEDURES, submit the following additional specific information:
   1. Product Data:
      a. Insulation Properties: Include K factor, thickness, density, operating temperature limits, tensile strength, compressive strength, moisture absorption, flame spread, and smoke developed in accordance with ASTM E84 and corrosivity to stainless steel piping in accordance with ASTM C795.
      b. Jacket Properties: Include covering material, cover thickness, tensile strength, tear strength, permeability per ASTM E96, flame spread, and smoke developed in accordance with ASTM E84, closure type or devices, and accessories.
      c. Insulating Blankets: Include materials, performance characteristics, method of attaching to equipment, listing of locations where insulating blankets shall be installed.
   2. Manufacturer's Application Instructions: Include assembly and application drawings and detailed instructions.
   3. Laboratory Report: Provide certified laboratory report stating that insulation is NOT manufactured using chlorinated polymers and does NOT contain chlorides, bromides, sulfates, or fire-rated materials.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store insulation materials and accessories under cover and protected from moisture.

B. Handle and store insulation for use on stainless steel in accordance with ASTM C929.

1.6 SEQUENCING AND SCHEDULING

A. Pressure test piping and complete application of coating system before applying insulation.

B. When piping is to be heat traced, install and functionally test heat tracing before installation of insulation.

C. Before beginning installation of piping insulation, verify that the Engineer has accepted piping tests, pipe coating applications, and heat tracing tests.

1.7 WARRANTY

A. Furnish one – year minimum warranty.

B. Furnish five – year manufacturer warranty.

PART 2 - PRODUCTS

2.1 PIPE INSULATION, GENERAL REQUIREMENTS

A. Insulation Thicknesses: Provide insulation thickness in accordance with the following table. Service temperature ranges are as designated in insulation schedule at end of this Section.

Required Insulation Thicknesses (inches)					
Service Temperature Range(1)	**Nominal Pipe Diameters (Inches)**				
	≤ 1	**1.25 – 2**	**2.5 – 4**	**5 – 10**	**> 10**
> 200°F	2.0	2.5	3.0	3.5	3.5
100 – 200°F	1.5	1.5	1.5	2.0	2.5
40 – 100°F	0.5	1.0	1.0	1.5	2.0
< 40°F	1.0	1.0	1.5	2.0	2.0
Heat Traced Pipes	1.0	1.0	1.0	1.5	2.0
Process (Aeration) Air Pipes	0.5	0.5	1.0	1.0	1.0

2.2 PIPE INSULATION

A. Insulation Types: Provide in accordance with the insulation types listed and scheduled.

B. Insulation, Type 1:
1. Insulation Material:
   a. Closed cell elastomeric insulation
2. Minimum Temperature Range: -40 – 220 degrees Fahrenheit.
3. K Factor at 75 degrees Fahrenheit: NOT more than 0.27 BTU-in/hr-ft^2-°F.
4. Fire Ratings:
   a. Flame Spread: 25 or less.
   b. Smoke Density: 50 or less for insulation thicknesses up to 1.5 inches.
5. Joints: Seal with manufacturer's recommended contact adhesive to form continuous water barrier.
6. Manufacturers:
   a. Armacell Engineered Systems – AP/Armaflex
   b. Or Approved Equal.

C. Insulation, Type 2:
1. Insulation Material: Preformed mineral fiberglass insulation made from glass fibers bonded with a thermosetting-resin.
   a. Conform to ASTM C547, Class 1.
   b. Provide with factory installed vapor barrier.
      1) Material: White kraft paper bound to aluminum foil meeting ASTM C1136, Type I.
      2) Longitudinal Lap Seals: Pressure sensitive, self-sealing longitudinal lap strip with factory applied adhesive.

3) Circumferential Butt Seals: 4-inch-wide tape or similar properties or 4-inch wide overlap with adhesive seal.
4) Vapor Barrier Permeability: 0.02 perms or lower.
5) Vapor Barrier Flame Spread Rating: 25 or less.

2. Minimum Temperature Range: 0-850 degrees Fahrenheit.
3. K Factor at 75 degrees Fahrenheit: NOT more than 0.23 BTU-in/hr-ft^2-°F.
4. Average Insulation Density: 3.3 lbs/ft^3.
5. Maximum Moisture Absorption, Volume Percent: 0.2%.
6. Manufacturers:
   a. Owens Corning.
   b. Johns Manville
   c. Knauf Insulation
   d. Or Approved Equal.

D. Insulation, Type 3:
1. Insulation Material: Rigid polyisocyanurate foam in accordance with ASTM C591, Type IV.
2. Temperature Range: -297 – 300 degrees Fahrenheit.
3. K Factor at 75 degrees Fahrenheit: NOT more than 0.19 BTU-in/hr-ft^2-°F.
4. Minimum Average Density: 4.0 lbs/in^2.
5. Maximum Moisture Absorption, Volume Percent: 0.7%.
6. Minimum Compressive Strength: 25 lbs/in^2.
7. Moisture Permeability: 4.00 perm-inch.
8. Manufacturers:
   a. ITW Insulation Systems.
   b. Kingspan Insulation LLC/Dyplast.
   c. Or Approved Equal.

E. Insulation, Type 4:
1. Insulation Material: Rigid cellular glass in accordance with ASTM C553, Type II.
2. Temperature Range: -450 – 900 degrees Fahrenheit.
3. K Factor at 75 degrees Fahrenheit: NOT more than 0.32 BTU-in/hr-ft^2-°F.
4. Minimum Average Density: 7.5 lbs/ft^3.
5. Maximum Moisture Absorption, Volume Percent: 0.2%.
6. Minimum Compressive Strength: 87 lbs/in^2.
7. Moisture Permeability: 0.00 perm-inch.
8. Manufacturers:
   a. Owens Corning – Foamglas, Ultra-CUF.
   b. Or Approved Equal.

F. Insulation, Type 5:
1. Insulation Material: Asbestos free, rigid calcium silicate in accordance with ASTM C533; Type 1 for process temperatures up to 1,200 degrees Fahrenheit.
2. K Factor at 500 degrees Fahrenheit: 0.55 for Type 1.
3. Maximum Average (Dry) Density: 14.5 pounds per cubic foot.
4. Compressive Strength: 100 lbs/in^2, to produce a 5% compression.
5. Manufacturers:
   a. John Manville/Industrial Insulation Group, LLC – Thermo-12 Gold.
   b. Or Approved Equal.

2.3 INSULATION JACKETS

A. Jacket, Type 1:
1. Material: 28 oz/yd^2 polyvinyl chloride on polyester fabric; total thickness 0.028 inches minimum.
2. Fire Rating: 25 maximum flame spread, smoke developed 50 or less.

3. Color: As selected by the Engineer from manufacturer's standard colors.
4. Overlap: One-inch minimum at joints and fittings.
5. Joint Seal: Self-sealing lap tape.
6. Fittings: Factory made with full thickness insulation.
7. Manufacturers:
    a. Accessible Products Company
    b. Or Approved Equal.

B. Jacket, Type 2:
1. Material: Ultraviolet resistant polyvinyl chloride jacketing, 20 mil minimum thickness.
2. Fire Rating: 25 maximum flame spread, smoke developed 50 or less.
3. Color: White.
4. Overlap: One-inch minimum at joints and fittings.
5. Joint Seal: PVC solvent welded or adhesive as recommended by the manufacturer.
6. Fittings: Factory made with full thickness insulation.
7. Manufacturers:
    a. Johns Manville – Zeston 2000 PVC.
    b. Proto Corp. – LoSMOKE PVC.
    c. Speedline Corp. – Smoke Safe PVC Jacketing System.
    d. Knauf Covering System.
    e. Or Approved Equal.

C. Jacket, Type 3:
1. Material: Aluminum, Allow 5005; 0.016-inch (26 gauge) minimum thickness.
2. Overlap: Overlap circumferential joints 4 inches minimum; overlap longitudinal joints 1-inch minimum; longitudinal joints oriented to minimize water entry.
3. Bands: 0.5 inch wide, 0.0508 inch (16 gauge) thick aluminum, same alloy as jacket or 0.0179-inch thick Type 304 stainless steel; install on 18-inch centers, uniformly spaced and at all fitting joints.
4. Joint Seal: Apply waterproof adhesive at joints and overlaps.
5. Fittings: Custom fit of same materials.
6. Manufacturers:
    a. Foster Products/Childers Products.
    b. Or Approved Equal

2.4 VAPOR BARRIERS

A. Vapor Barrier, Type 1:
1. Material: White kraft paper bound to aluminum foil and meeting requirements of ASTM C1136, Type 1.
2. Permeability: 0.02 perms or lower.
3. Maximum Flame Spread Rating: 25.
4. Edge Seal: Pressure sensitive tape lap seal.
5. Circumferential Joints: 4-inch wide tape or 4-inch overlap with adhesive seal.
6. Manufacturers:
    a. Owens Corning – all service jackets with double sure adhesive lap seal.
    b. Johns Manville – Micro-Lok AP-T plus.
    c. Or Approved Equal

B. Vapor Barrier, Type 2:
1. Material: Mastic.
2. Manufacturers:
    a. Foster Products, 36-10/46-10 Weatherite.
    b. Foster Products/Childers Products – CP10 or CP11 Vi-Acryl.
    c. Or Approved Equal

2.5 RELATED MATERIALS

A. Cover Adhesive: Premium adhesive as recommended by the insulation cover supplier for heavy-duty service in corrosive, wet environments. Standard duty adhesives are NOT permitted.

2.6 REMOVABLE INSULATING BLANKETS

A. In piping systems specified to be insulated, use removable insulating blankets for valves, meters, strainers, filters, catalytic converters, engine exhaust silencers, and other in-line piping appurtenances and equipment requiring periodic servicing.

B. Size Limits: Use removable insulating blankets for equipment and piping appurtenances 3-inch in nominal size and larger. Insulate equipment and piping appurtenances less than 3-inch with molded sections of insulation or by field cutting insulation to conform to the shape of the component and to fit tightly around the component.

C. Manufacturers:
1. Owens Corning, Temp-Mat.
2. Accessible Products Co.
3. Thermal Energy Products, Inc., Energy Wrap.
4. Or Approved Equal

D. Low temperature insulating blankets rated up to 800 degrees Fahrenheit:
1. Use: For service temperatures up to 800 degrees Fahrenheit.
2. Insulation: Fiberglass fiber, K factor 0.27 at 75 degrees Fahrenheit.
3. Cover: 17-ounce fabric with both sides covered with silicone impregnated glass cloth suitable for temperatures up to 800 degrees Fahrenheit.
4. Dover Fasteners:
    a. Grommets in the blanket and stainless-steel wire
    b. 1-inch-wide straps with stainless steel rectangular ring buckles and Velcro on strap tail.

E. High temperature insulating blankets rated up to 1,400 degrees Fahrenheit F:
1. Rated for sustained service temperatures up to 1,400 degrees Fahrenheit F.
2. Insulation: Ceramic fiber, K factor 0.50 at 600 degrees Fahrenheit, insulation material suitable for up to 2,300 degrees Fahrenheit, thickness to match adjacent piping insulation specified thickness.
3. Cover: 17-ounce silicone impregnated fiberglass cloth suitable for temperatures up to 1,400 degrees Fahrenheit.
4. Cover Fasteners:
    a. Grommets in the blanket and stainless-steel wire
    b. 1-inch-wide straps with stainless steel rectangular ring buckles and Velcro on strap tail.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verification of Conditions: Before installing insulation, verify satisfactory completion of pressure tests of piping systems and functional tests of heat tracing equipment.

B. Examine piping surfaces and verify that surfaces are dry and free of loose scale, rust, dirt, oil, or water before applying insulation. When specified, paint or coat pipe surfaces as specified in Section 09 90 00, PAINTING AND PROTECTIVE COATINGS.

C. Examine insulation materials and accessories before installation. DO NOT install insulation and jackets that have been damaged or insulation that has become wet due to exposure to water.

3.2 INSTALLATION

A. Install insulation and jacket materials in accordance with manufacturer's written instructions.

B. Apply insulation in smooth, clean manner with tight and finished smooth joints. Fits insulation tightly against surfaces. Insulate each continuous run of pipe with full-length sections of insulation with a single piece cut to length to complete the run of pipe. DO NOT use cut pieces or scraps to complete the installation.

C. Butt longitudinal and circumferential insulation joints firmly together.

D. Maintain the integrity of vapor barrier jacketing. DO NOT use staples to hold vapor barrier overlaps in place.

E. Apply sealant or cement when previous applications of adhesives and cement have thoroughly dried.

F. Apply insulation to permit expansion or contraction of pipelines without damage to insulation or jacketing.

G. Fittings:
1. Insulate fittings by covering with mitered sections of insulation or utilize factory made prefabricated fitting shapes.
2. Terminate preformed pipe jackets or covering at sufficient distance from flanges to permit removal of bolts.
3. Overlap flange and flanged fitting insulation on adjacent pipe covering by at least 2 inches.

H. Valves:
1. Insulate valves 3-inch in nominal size and larger with removable insulating blankets.
2. Size blanket to extend up to packing gland only so that replacement of packing does NOT require removal of insulating blanket.

I. Provide continuous insulation through and over pipe supports and provide protection saddles at supports.

J. Extend insulation against insulation end protection shields or covers so that insulation voids DO NOT exist and provide water tight end seals and covers where insulation terminates.

K. Insulate pipeline strainers to permit removal of strainer basket without disturbing insulation on strainer body.

L. Provide continuous pipe insulation and covering through sleeves or openings in walls and floors. When buried pipe enters a building through a below grade wall or slab penetration, begin insulation system on interior side of penetration.

M. Apply pre-molded pipe insulation with extended legs when used on pipe traced with either tubing or electric cable type.

N. For Type 1 or 2 jacket installation on piping with potential reach temperatures greater than 150 degrees Fahrenheit shall be thermally isolated from piping at all insulation closure locations (end caps, transitions, etc.).

O. Apply piping identification on jackets as specified in Section 22 05 53, MECHANICAL IDENTIFICATION.

3.3 INSULATION SCHEDULE

Service Designation (1)	Location (2)	Insulation Type (3)	Jacket Type (3)	Service Temp. (°F)(4)	Vapor Barrier
Heat Traced Pipes (5)	Exterior	1 or 2	2	Use thickness established in Table in paragraph 2.1	Install on Type 2 insulation

Notes:
1. Refer to Process Piping Schedule in Section 40 23 39, PROCESS PIPING - GENERAL for service designations.
2. Insulation jackets are NOT required for interior installations that are concealed. See definitions for description of concealed locations.
3. Contractor may select from options listed.
4. Unless noted otherwise, use service temperature range provided in this table to establish insulation thickness as required by Table in paragraph 2.1 A.
5. Insulate all piping systems that are specified to be heat traced.

END OF SECTION

SECTION 40 61 13 – PROCESS CONTROL SYSTEM GENERAL PROVISIONS

PART 1 - GENERAL

1.1 SUMMARY

A. The work to be included under this section shall consist of furnishing all materials, labor, equipment, tools, supplies, and incidentals necessary for the installation and testing of all process control systems.

B. Related Sections:
1. Section 40 61 96 – Process Control Descriptions
2. Section 40 67 23 – Control Panels
3. Section 40 68 63 – PLC and HMI Programming
4. Division 40 – Instrumentation Specifications

1.2 REFERENCES

A. Definitions: Symbols, Definitions, and Abbreviations: All symbols, definitions, and engineering unit abbreviations utilized shall conform to IEEE 100-84, S50.1, and S51.1, where applicable.
1. SCADA – Supervisory Control and Data Acquisition
2. HMI – Human Machine Interface (Graphical Screens, Text Displays)
3. OIT – Operator Interface Terminal
4. PLC – Programmable Logic Controller
5. I/O – Input/Output
6. VFD – Variable Frequency Drive
7. SSRVS – Solid State Reduced Voltage Starter (“Soft Starter”)
8. RTU – Remote Telemetry Unit
9. MTU – Master Telemetry Unit
10. MCC – Motor Control Center
11. Operating Program – Operating system, SCADA, or other core software.
12. Integrated Operating Platform – System of installed, connected, and configured hardware, operating programs, and networking equipment.
13. PLC and HMI Programming – Software configuration of operating programs to implement process control strategies.
14. Control System Specialist – a company specializing in process control hardware and software, including instrumentation, PLCs, networking, installation, and configuration.

1.3 QUALITY ASSURANCE

A. The Contractor shall designate in writing the qualified Control System Specialist, including a detailed listing of the firm, resumes and work history of each person working on the project, and project specific references. The qualifications of the Control System Specialist shall be subject to approval of the Owner and the Engineer.

B. The minimum qualifications for the Control System Specialist shall include:
1. An established firm in operation as a control and automation company for a minimum of 5 years, with demonstrated water and wastewater industry experience.
2. Staffed with experienced personnel capable of executing the required aspects of the project.

1.4 SCOPE OF WORK

A. The Contractor shall engage the services of a Control System Specialist, who shall furnish all materials, equipment, labor, and services to achieve a fully functional process control system for this project.

B. The Control System Specialist shall be responsible for providing and installing all instrumentation, PLC control panels, PLC programming, HMI graphics development and configuration, computer equipment, networking equipment, and other control system hardware as specified for a complete process control system installation.

C. In general, the Control System Specialist shall perform the following tasks:

1. Provide PLC programming and HMI screen development to implement process control of equipment as described within Section 40 61 96 – Process Control Descriptions.
2. Furnish, install, configure, and calibrate instrumentation as detailed on the drawings and in the specifications.
3. Fabricate and install all control panels as indicated in the drawings, except for those provided as part of a vendor supplied equipment package. Terminate all field control wiring inside control panels.
    a. Where existing control panels are being replaced with new, field investigate and develop as-builts of the existing instrumentation and control installation to identify and label all I/O and communication wiring entering the existing panels. The contractor shall be responsible for properly identifying and labelling all existing wiring and re-connecting to the new control panel. Perform point-to-point wiring checks and startup testing for re-connected existing components and wiring following the same requirements as new equipment.
4. Provide all hardware required to properly communicate between all control panels and remote sites, whether or not explicitly identified in the drawings or specifications.
5. Install networking equipment and communication cables between control devices as indicated in the drawings and specifications. Provide configuration of equipment, including network switches and firewalls, to ensure proper communication between all devices associated with the integrated operating platform.
6. Provide all instrumentation and control device relocation work associated with the relocation of equipment, including disconnecting all existing wiring and conduit and terminating, calibrating, and replacing service to relocated equipment.
7. Modification to existing instrumentation and control systems as required to new and existing equipment to maintain process operations.
8. Provide overall coordination, installation, supervision, and installation of control panels, instrumentation, computer hardware, networking systems, and other miscellaneous control system components as specified.
9. Provide coordination with the Contractor and participate in all meetings as directed by the specifications or Contractor.
10. Execute the testing procedures outlined in this document.

D. Vendor system packages may be provided under other sections of this contract that may interface with the process control system via communications protocol and/or hard-wired I/O. Refer to the associated specification sections and the contract drawings for additional details. The Control System Specialist shall be responsible for coordination, furnishing, installing, and configuring any communication devices or drivers necessary to ensure proper communication with each of the vendor-furnished systems.

E. Vendor system packages may include instrumentation or control panels that shall be installed and configured by the Control System Specialist according to vendor instructions. Upon satisfactory installation, configuration, and calibration, the Control System Specialist shall coordinate with each vendor to inspect finished work. The Control System Specialist shall submit documentation indicating that the vendor has inspected and approved the installation.

1.5 SUBMITTALS

A. General: Submittals shall conform to the requirements of Section 01 33 00, SUBMITTAL PROCEDURES.

B. Product Data:
   1. Instrument Installation Details.
   2. Certified Calibration Sheets.
   3. Complete and detailed instruction manuals on each item furnished including but not limited to all devices and instruments. Information to be contained in the instruction manuals shall include but not be limited to drawings, dimensions, manufacturer's recommendations, ratings, performance charts, power requirements, schematics, maintenance requirements and procedures, calibration recommendations and procedures, repair instructions, complete and recommended spare parts lists and related information.
   4. Proposed tagging and attachment materials and methods.

C. Shop Drawings shall be submitted for approval by the Engineer.
   1. The Contractor shall submit to the Engineer, for approval, Shop Drawings of the equipment to be installed to meet the Specifications. The Drawings shall be supported by notes or written directions as required to fully define the installation. The submission shall be made as soon as feasible after award of the Contract and, in any event, shall be submitted and approval obtained before installation of the equipment.
   2. The information required on the Shop Drawings shall include, but is not necessarily limited to, the following:
      a. Full and complete specifications covering the equipment proposed to be furnished.
      b. Detail Drawings showing plan, network connections and elevation dimensions of the equipment proposed to be furnished.
      c. Guarantees of performance of the equipment proposed to be furnished.
      d. Nearest location of factory maintenance and service facilities that will be available to service the equipment offered.
      e. To scale plans, sections and elevations detailing entire installation. Include mounting hardware, brackets, assemblies, and other devices as required for a complete installation.
   3. Control panels:
      a. Panel and sub-panel layout
      b. Point-to-Point Wiring and Interconnection Diagrams
      c. System hardware

D. Contract Closeout Submittals:
   1. Project Record Documents
   2. Operating and Maintenance Data
   3. Warranty
   4. Final as-built copies of documented PLC and HMI programs for vendor supplied equipment packages, on electronic media, suitable for future troubleshooting or modifications by others.

E. Instrumentation and control testing documents shall be submitted for approval by the Engineer:
   1. Credentials of technicians doing the inspection and testing.
   2. Written certification as detailed under testing requirements in this specification section.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Storage and Protection: Delivery, storage, and handling shall be in accordance with Manufacturers' recommendation and the requirements of other sections herein.

1.7 PROJECT AND SITE CONDITIONS

A. Environmental Requirements: Instrumentation and control elements may be installed outdoors exposed to sun, rain and excessive humidity and shall be capable of continuous operation without significant reduction of their operating life under the following ambient conditions:

Temperature:	-25 °C to 80 °C
Pressure:	650 mm Hg to 800 mm Hg
Relative Humidity:	20% to 100% condensing
Vibration Frequency:	10 - 2000 Hz.
Vibration Position:	1.5 mm peak-to-peak
Vibration Acceleration:	10 G.

B. Where the ratings of individual components cannot meet the requirements, provide suitable means of physical protection. Suitable physical protection shall consist of an assembly which meets the requirements listed, while limiting the ambient conditions at the non-conforming component to 90% of the component's rating (Example: A component rated for vibration at only 5 G. acceleration would be required to be combined with vibration isolation to limit the acceleration of the component to 4.5 G. when subjected to ambient acceleration of 10 G. from 10 - 2000 Hz.).

C. Operating Environmental Conditions: All instruments and control devices provided shall be rated for continuous operation in their installed operating environment and shall be capable of continuous operation at the operating conditions without significant reduction of their operating life.

D. All controlling devices shall be NEMA or IEC rated.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

A. All meters, instruments, control units, and other components shall be the most recent field proven models marketed by their respective manufacturers at the time of the submittal of the shop drawings unless otherwise specified to match existing equipment.

B. Analog measurements and control signals shall be electrical and shall vary in direct linear proportion to the variable being measured. All analog signals whether inputs or outputs shall be 4-20mA DC unless otherwise noted. The analog input signals shall maintain loop integrity with the installation of properly sized resistors across the input terminals. Provide surge protection for all analog signal terminations.

C. All of the elements, instruments, accessories, and assemblies shall be installed in accordance with the manufacturer’s installation instructions, and as detailed on the Drawings. Shielded instrumentation cables shall be used for all analog signals from the instruments to the programmable logic controller panels. Separate conduits shall be used for instrument power, instrument signals, and fiber optic cables.

D. All instruments installed outdoors subject to direct sunlight shall include a stainless-steel sunshade.

E. All digital inputs and outputs shall be isolated from the field equipment through an interposing relay. The relays shall be mounted inside the cabinet housing the associated programmable logic controller as shown on Drawings.

F. The Contractor shall make the necessary power connections and signal connections from the field devices (i.e., instruments, control valves, etc.) to the programmable logic controllers.

G. The Contractor shall configure and verify proper operation of the Integrated Operating Platform, included but not limited to the following requirements:
   1. The computers, PLCs, OITs, networking hardware, surge protection devices, uninterruptible power supplies, and other incidental equipment shall be configured and installed as shown on the Drawings and as specified herein.
   2. All networked devices shall be configured for proper communication via the topology and protocol shown on the Drawings or specified herein.
   3. Verify that all system devices power up, function, and properly communicate prior to commencing any startup or testing procedures as described herein.

3.2 SYSTEM WIRING COORDINATION

A. The Control System Specialist shall develop complete point-to-point interconnection wiring termination sheets for all control connections to be provided for the project. The sheets shall identify all external interconnecting wiring associated with all new control panels or existing control panels.
   1. Develop point-to-point interconnection wiring termination sheets for performance of the Work and to document terminations.
   2. Use information from shop drawings, record drawings, plan drawings, and field inspections to develop sheets. Contractor shall field investigate the existing installation to determine the connections for equipment that is to remain and reconnected.
   3. The interconnection wiring termination sheets shall include the following information:
      a. External wiring for each piece of equipment, panel, instrument, local control stations, and other field devices with an electrical connection.
      b. Numbered terminal block identification for each wire termination.
      c. Identification of the assigned wire numbers for all interconnections.
      d. Conduit tags, terminal numbers, and pull box identifications through which wiring is routed between end points.
      e. Identification equipment documents from which the wire numbering and termination information was obtained.
   4. Conduct point-to-point wiring checks to determine that wiring and terminations are installed in compliance with the point-to-point interconnection diagrams. The Control System Specialist shall document all wiring checks and sign-off on completed wiring termination sheets. Submit signed documentation to Owner and Engineer.

3.3 TESTING AND INSTALLATION REQUIREMENTS

A. Testing and Installation Requirements: The Contractor shall be required to coordinate the following services during construction related to the testing and installation of the process control system. The complete system testing shall include all PLCs, computer systems, SCADA software and hardware, network devices, interconnecting cables, and other peripheral devices required for a complete and functional system. The testing of the system shall occur in stages as defined below. The Contractor shall develop and submit proposed testing procedures and documentation for each test. Testing documentation shall include signature lines for representatives of the Control Systems Specialist, Engineer, and Owner. Signatures shall be provided for each portion of the test, including a final sign-off indicating satisfactory completion of the entire test. Any deviations from the test procedure or corrections made during test must be recorded on the documentation and initialed by individual making the record. Testing documentation submittals must be approved by the Engineer prior to the scheduling of any actual tests.

B. Site Readiness Test

1. A Site Readiness Test shall be performed after the installation of all control system components including PLC control panels, communications, control wiring, device configurations, instrument calibrations, motor controllers, and variable frequency controllers in accordance with the Contract Documents. The test will be witnessed by, at minimum, representatives of both the Engineer and Owner. Additional witnesses may be present at the Engineer or Owner's discretion. The Control System Specialist shall provide notice to the Engineer a minimum of thirty (30) days in advance of the test.
2. The purpose of this test is for the Control System Specialist to verify the following:
    a. All instruments have been properly configured and calibrated.
    b. All field control wiring has been properly installed and terminated.
    c. All PLC control panel hardware is operating and communicating properly.
    d. The installation is ready to load PLC and HMI programming and begin functional process control testing.
3. Site Readiness Test shall include energization and testing for correct hardware integration of all system components, including PLC remote I/O assemblies, and reliable communications between components with correct protocols.
4. Provide point-to-point wiring checks for continuity between field devices to final PLC I/O terminations.
5. To the greatest extent possible, the Control System Specialist shall check I/O under process conditions to the end elements. For example, I/O for valve limit switches shall be checked by operating the valve to fully open and closed positions, rather than using jumpers or other means to simulate valve operation. Any testing performed that could upset or affect any live process shall be coordinated with the Owner.
6. Provide verification and documentation of normally closed or normally open contacts for discrete I/O signals.
7. Discrete inputs shall be tested by operating the end device to force a signal change. Observe results on all indicators such as PLC register, panel light, etc.
8. Discrete output signals shall be tested by forcing a value in the PLC register. Observe that the connected equipment properly responds.
9. Analog inputs shall be verified at 0 percent, 25 percent, 50 percent, 75 percent, and 100% of span. Observe results on all indicators such as PLC register, digital panel meters, etc.
10. Analog outputs shall be tested by entering values in the PLC register to force the outputs at 0 percent, 25 percent, 50 percent, 75%, and 100% of span. Observe that the connected equipment properly responds.
11. Personnel performing the test shall have International Society of Automation (ISA) Certified Control Systems Technicians (CCST) or equivalent credentials as approved by the Engineer or Owner.
12. The Control System Specialist shall submit completed testing documentation as record to the Engineer upon satisfactory completion of the Site Readiness Test.

C. Functional System Test

1. Upon the Engineer's approval of the Site Readiness Test, load the PLC and HMI programming to begin functional testing of control strategies.
2. The test will be witnessed by, at minimum, representatives of both the Engineer and Owner. Additional witnesses may be present at the Engineer or Owner's discretion. Although the Control System Specialist must provide notice to the Engineer a minimum of thirty (30) days in advance of the test, the Functional System Test may be performed consecutively with the Site Readiness Test if approved by the Engineer and Owner ahead of time.
3. The purpose of the functional system testing is to implement and test the automatic and manual process control strategies through PLC and HMI programming.
4. The Control System Specialist shall be available to assist with equipment operations, as necessary.
5. For this test, all equipment shall be installed, calibrated, and functioning as required in the contract documents.

6. Each analog and discrete I/O signal will be checked through the PLC to the HMI screens to verify proper mapping of tags.
7. Functionality of the system will be checked to ensure conformance with process control strategies.
8. PLC control loops will be tuned to achieve stable process control.
9. If during the Functional System Test the Engineer, or Owner finds that process control is not achievable due to errors in the installation, the functional testing shall stop, and the Control System Specialist shall correct the installation and repeat the Site Readiness Test at no additional cost to the Owner.

D. Final Acceptance Test:
1. After the system has been started up and running in automatic control to the greatest extent possible as determined by the Engineer/Owner, the Control System Specialist shall conduct a Final Acceptance test of the completed installation. The test shall start after satisfactory completion of all previous tests, the Engineer has received marked record (as-built) drawings from the Contractor, and when directed by the Owner/Engineer.
2. During this test, the Owner and Engineer shall have full use of the system. The duration of the test shall be 30 days.
3. Control System Specialist personnel shall be readily available to address issues onsite during the acceptance test.
4. The system shall operate with 100% reliability during the test period. Failure shall be defined as the inability to control or indicate status of specified inputs or outputs or any specified function of the control systems as described herein caused by defective hardware or software furnished in this project. Failure of hardware or software shall require repair or remedy of the defect to the satisfaction of the Engineer/Owner within 2 days. If the problem cannot be repaired in this time, the test shall be aborted and restarted after the problem is corrected and when directed by the Owner/Engineer. Restarting and satisfactory completion of the test shall be conducted at no additional cost to the Owner.
5. Throughout the duration of the test, no modifications shall be made to the system without prior approval from the Engineer or Owner.

3.4 TRAINING, STARTUP ASSISTANCE, & WARRANTY

A. Training: The Contractor shall provide training for the purpose of familiarizing Owner's personnel with the process control system. All training shall be as scheduled by the Owner. The training shall be scheduled a minimum of thirty (30) days in advance of when it is to be given. Proposed training materials, including a detailed training agenda itemizing relative emphasis on various topics of each course, shall be submitted to the Owner and Engineer at least fourteen (14) days in advance of when the training is to begin. The course content shall include, but not be limited to, a description of system philosophy, all major hardware components utilized in the system and hardware maintenance practices.

B. Startup Assistance
1. The Contractor shall be responsible for furnishing a qualified technical representative who shall supervise the installation of equipment and/or install equipment, and who shall test, adjust, field calibrate, and fully commission all flow metering equipment, instrumentation equipment, control equipment, and accessories specified herein and required as integral components of the complete systems. The commissioning will be deemed to be complete only after all systems are found to be performing satisfactorily following the final balancing of plant operation. The guarantee period, during which all defective materials shall be replaced, and all faulty workmanship will be corrected at no cost to the Owner, shall begin with the date on which the commissioning is judged to be complete.

C. Service:
1. Manufacturers shall provide as part of the equipment cost sufficient days of service by a factory-trained service engineer specifically trained on the type of equipment herein

specified to assist the Contractor during installation and start-up. The service time shall be sufficient to place the units in satisfactory service and instruct the Owner's personnel in proper operation and maintenance of the equipment.

2. A minimum of three (3) days service Engineer time shall be provided.

D. Maintenance Instruction:

1. Operating and maintenance instructions, along with a separate parts list, shall be furnished in three (3) copies to the Owner. Operating instructions shall also incorporate a functional description of the system, including the system schematics which reflect "as-built" modifications. Maintenance requirements particular to the system shall be clearly defined, along with calibration and test procedures.

E. Warranty:

1. All equipment and workmanship furnished under this contract shall be guaranteed to be free of defects in materials and workmanship for a period of one (1) year from and after the date of final acceptance of the work by the Owner, and any such defects which appear within the stipulated guaranty period shall be repaired, replaced, or made good without charge. This guarantee shall include the capacity and integrated performance of the component's parts.

END OF SECTION

SECTION 40 61 96 – PROCESS CONTROL DESCRIPTIONS - GENERAL

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes descriptions of process control strategies and intended functionality of new system equipment and processes. These descriptions shall serve as the starting point for process control and are expected to be continually refined throughout the execution of the project. The descriptions are not intended to identify every status or alarm indication required as part of the plant process control system. Refer to contract drawings and related specifications sections for additional process control information.

B. This section does not include process control strategies for equipment furnished as part of a vendor supplied control package. These systems will be programmed and implemented by the vendor. Refer to equipment specifications for process control requirements of vendor supplied systems.

C. Related Requirements:
   1. Section 40 61 13 – Process Control System General Provisions.

1.2 DEFINITIONS

A. Integrated Operating Platform – System of installed, connected, and configured hardware, operating programs, and networking equipment.

B. PLC and HMI Programming – Software configuration of operating programs to implement process control strategies.

C. Control System Specialist – a company specializing in process control hardware and software, including instrumentation, PLCs, networking, installation, and configuration.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 COMMON CONTROL STRATEGIES

A. This section provides an overview of common control strategies and alarms for equipment and instruments. Unless stated otherwise for specific equipment in subsequent control description documents, these strategies and alarms should be considered universal.

B. Constant Speed Motors/Pumps
   1. The pumps will be capable of LOCAL MANUAL control from the pump starters or MCC. REMOTE MANUAL and REMOTE AUTO control will be provided by the PLC program and SCADA HMI.
   2. Local control will be provided by a LOCAL-OFF-REMOTE selector switch at the pump starter or MCC.
      a. LOCAL-OFF-REMOTE Operation:
         1) In OFF mode, the motor is stopped and cannot be started.
         2) If hard interlocks are satisfied:
            a) In LOCAL mode, the motor is started and stopped locally.
            b) In REMOTE mode, motor start and stop control is from SCADA.
   3. Remote control will be provided by a virtual ON-OFF-AUTO selector on the SCADA HMI.
      a. ON-OFF-AUTO Operation:

1) In OFF mode, the motor is stopped.
2) If the motor is ready for remote control and interlocks are satisfied:
a) In ON mode, the motor starts.
b) In AUTO mode, the PLC program will control pump operations based on the automatic control strategy described herein.

C. Adjustable Speed Motors/Pumps
1. The pumps will be capable of LOCAL MANUAL control from the pump VFDs. REMOTE MANUAL and REMOTE AUTO control will be provided by the PLC program and SCADA HMI.
2. Local control will be provided by a LOCAL-OFF-REMOTE selector switch at the pump VFDs or MCC.
a. LOCAL-OFF-REMOTE Operation:
1) In OFF mode, the motor is stopped and cannot be started.
2) If hard interlocks are satisfied:
a) In LOCAL mode, the motor is started locally, and motor speed is controlled from the local speed potentiometer.
b) In REMOTE mode, motor start, stop, and speed control is from SCADA.
3. Remote control will be provided by a virtual ON-OFF-AUTO selector and MANUAL SPEED SETPOINT on the SCADA HMI.
a. ON-OFF-AUTO Operation:
1) In OFF mode, the motor is stopped.
2) If the motor is ready for remote control and interlocks are satisfied:
a) In ON mode, the motor starts, and motor speed is set by the virtual MANUAL SPEED SETPOINT on the HMI.
b) In AUTO mode, the PLC program will control pump operations based on the automatic control strategy described herein.

D. Discrete Gates/Valves
1. Local control will be provided by a LOCAL-OFF-REMOTE selector switch at the valve actuator.
a. LOCAL-OFF-REMOTE Operation:
1) In OFF mode, the actuator is off and cannot be controlled.
2) In LOCAL mode, the valve can be opened and closed from the actuator.
3) In REMOTE mode, the valve receives open and close commands from the PLC.
2. Remote control will be provided by a virtual MANUAL-AUTO selector on the SCADA HMI.
a. MANUAL-AUTO Operation:
1) If the valve is ready for remote control:
a) In MANUAL mode, the operator can manually open and close the valve.
b) In AUTO mode, the PLC program will control valve operations based on the automatic control strategy described herein.

E. Modulated Gates/Valves
1. Local control will be provided by a LOCAL-OFF-REMOTE selector switch at the valve actuator.
a. LOCAL-OFF-REMOTE Operation:
1) In OFF mode, the actuator is off and cannot be controlled.
2) In LOCAL mode, the valve can be opened, closed, and stopped in transition from the actuator.
3) In REMOTE mode, the valve position is modulated by the PLC.
2. Remote control will be provided by a virtual MANUAL-AUTO selector on the SCADA HMI.
a. MANUAL-AUTO Operation:
1) If the valve is ready for remote control:

a) In MANUAL mode, the operator can manually enter a valve position setpoint.
b) In AUTO mode, the PLC program will control valve operations based on the automatic control strategy described herein.

F. PLC Calculated Alarms
1. Analog Signal Diagnostic Alarms – These PLC calculated alarms will be generated for all analog input signals.
a. High Alarm – PLC generated alarm if the value exceeds operator high value alarm setpoint.
b. Low Alarm – PLC generated alarm if the value falls below operator low value alarm range setpoint.
c. Out of Range – PLC generated alarm if measurement is out of range, indicating an instrument fault. PLC shall hold last good value while measurement is out of range.
d. Broken Loop – PLC generated alarm if signal broken loop is detected. PLC shall hold last good value while broken loop is active.
e. No Flow – PLC generated alarm if a flow measurement is zero (flow readings only).
2. Equipment Alarms – These PLC calculated alarms will be generated for all equipment with PLC control.
a. Pumps/Motors
1) Command Fail – PLC generated alarm if speed setpoint is not achieved before a set time-delay after a speed command is given.
2) Fail to Start – PLC generated alarm if running feedback is not received before a set time-delay after run command is given.
3) Fail to Stop – PLC generated alarm if running feedback is not lost before a set time-delay after run command has been removed.
4) Uncommanded Change Alarm – PLC generated deviation alarm if equipment changes states (running, speed) without being given a command.
b. Gates/Valves
1) Command Fail – PLC generated alarm if position setpoint is not achieved before a set time-delay after a position command is given.
2) Fail to Open – PLC generated alarm if open feedback not received before a set time-delay after open command is given.
3) Fail to Close – PLC generated alarm if close feedback not received before a set time-delay after close command has been removed.
4) Uncommanded Change Alarm – PLC generated deviation alarm if equipment changes states (open/close status, position) without being given a command.

3.2 FACILITY CONTROL STRATEGIES

A. See attached process control description summary sheets:
1. Section 40 61 96.1 – Process Control Description: Anaerobic Digesters and Digested Sludge Storage Tank Level Monitoring
2. Section 40 61 96.2 – Process Control Description: Sludge Dewatering Feed Pumping
3. Section 40 61 96.3 – Process Control Description: Digester Heating

END OF SECTION

SECTION 40 61 96.1 – PROCESS CONTROL DESCRIPTION: ANAEROBIC DIGESTERS AND DIGESTED SLUDGE STORAGE TANK LEVEL MONITORING

PART 1 - GENERAL

1.1 REFERENCE

A. Section includes:
1. Tank level indication for Anaerobic Digester Nos. 1, 2 and 3 and Digested Sludge Storage Tank No. 1.

B. Related sections:
1. Section 40 61 13 – Process Control System General Provisions
2. Section 40 61 96 – Process Control Descriptions – General
3. Section 40 68 63 – PLC and HMI Programming

1.2 EQUIPMENT AND INSTRUMENTATION

A. Motors and Pumps:

Equipment Tag	Name	Existing/ Proposed	Type	Driver	Operation
P-13-2-1	Transfer Pump #1	Existing	C	EM	F
P-13-2-2	Transfer Pump #2	Existing	C	EM	F
C = Centrifugal PD = Positive-Displacement EM = Electric Motor PO = Pneumatic-Operated V = Variable-Speed F = Fixed-Speed					

B. Valves and Gates:

Equipment Tag	Name	Existing/ Proposed	Operator	Remote Operation
FV-13-1-1	3-Way Valve #1	Existing	-	OC
FV-13-1-2	3-Way Valve #2	Existing	-	OC

C. Instruments:
1. Discrete Instruments:

Equipment Tag	Name	Existing/ Proposed	Setpoint
LE-13-4-1	Digester #1 High Level	Existing	-
LE-13-4-2	Digester #2 High Level	Existing	-
LE-13-4-3	Digester #3 High Level	Existing	-

2. Analog Instruments:

Equipment Tag	Name	Existing/ Proposed	Nominal Range
LIT-13-3	Digested Sludge Storage Tank Level	Existing	-
LIT-13-4-1	Digester #1 Level	Existing	-
LIT-13-4-2	Digester #2 Level	Existing	-

Equipment Tag	Name	Existing/ Proposed	Nominal Range
LIT-13-4-3	Digester #3 Level	Existing	-

D. Controllers:

Equipment Tag	Name	Existing/ Proposed
20PLC1	Digester Control Room PLC	Proposed
20MCC1	Motor Control Center	Proposed

1.3 PROCESS DESCRIPTION

A. General:
1. Sludge feeding to each of the anaerobic digesters is manually controlled by the operator. Operations can control which digester is to received sludge utilizing one of two three-way valves. The valves are to be actuated from the OIT in the digester control room PLC panel. Level transmitters and switches located at the digesters provide feedback to the PLC control panel for level indication.
2. The PLC control panel OIT gives the level readout of each digester. A HIGH-LEVEL ALARM is indicated on the OIT from the high level switch in each digester. High level and low level setpoints can be entered on the OIT panel for alarming based on the level indicated from the level transmitters.
3. Transfer pumps can be started and stopped from the motor control center to transfer sludge from any anaerobic digester to the digested sludge holding tank or to one of the other digesters.

B. Automatic Mode:
1. There is not automatic mode for level control.

1.4 HMI CONTROLS

A. Control Setpoints
1. The following table lists the expected new adjustable control setpoints that will be added to the HMI graphics. The table should be utilized for initial system set up. Some control variables may require historical data logging for populating trends and reports.

Control Setpoint	Entry Range	Default	Description
Digester High Level	161.50 – 168.00	166.00	High level alarm setpoint entered in the OIT control panel for each digester and sludge storage tank.
Digester Low Level	134.50 – 158.00	156.00	Low level alarm setpoint entered in the OIT control panel for each digester.
Digested Sludge Storage Tank High Level	161.50 – 168.00	165.00	High level alarm setpoint entered in the OIT control panel for the digested sludge storage tank.
Digested Sludge Storage Tank Low Level	134.50 – 158.00	150.00	Low level alarm setpoint entered in the OIT control panel for the digested sludge storage tank.

B. Process Variables

1. The following table lists the expected process variables related to the control strategy. Not all variables (such as motor speeds, pump run statuses, valve open/closed statuses, etc.) are listed.

Process Variable	Units	Trend Default Range
Digester #1 Level	ft	-
Digester #2 Level	ft	-
Digester #3 Level	ft	-
Sludge Storage Tank Level	ft	-

C. Alarms

1. The following table lists the expected alarms on the HMI graphics. Alarm priority shall be determined through coordination with the Owner during project startup. Alarms described under the Common Control Strategies portion of this specification are not listed in this table but shall be provided as applicable.

Alarms	Description
Digester #1 High Level	Calculated from level transmitter and/or digester level switch.
Digester #2 High Level	Calculated from level transmitter and/or digester level switch.
Digester #3 High Level	Calculated from level transmitter and/or digester level switch.
Storage Tank Level	Calculated from level transmitter.

1.5 INTERLOCKS

A. Hard Interlocks

1. The following table lists hard-wired interlock conditions that must be satisfied for equipment operation in either Local or Auto/Remote modes.

Interlock	Description
Digester High Level	Dry contact signal to CMP panel.
3-Way valve fault	Dry contact signal to CMP panel.

1.6 COMMUNICATION INTERFACES

A. Data will be communicated over the SCADA network from the Digester Control Building to the Administration Building for data needed to monitor Digester tank levels and alarms.

Description	Receiving Controller
Administration Building	Master Ethernet Radio

END OF SECTION

SECTION 40 61 96.2 – PROCESS CONTROL DESCRIPTION: SLUDGE DEWATERING FEED PUMPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
1. Local control and interface between the sludge dewatering process (belt filter presses located in the Sludge Dewatering Building) and the dewatering equipment feed pumps (located in the basement of the Digester Control Building).

B. Related sections:
1. Section 40 61 13 – Process Control System General Provisions
2. Section 40 61 96 – Process Control Descriptions – General
3. Section 40 68 63 – PLC and HMI Programming

1.2 EQUIPMENT AND INSTRUMENTATION

A. Motors and Pumps:

Equipment Tag	Name	Existing/ Proposed	Type	Driver	Operation
P-16-6-1	Dewatering Feed Pump 1	Existing	PD	EM	V
P-16-6-2	Dewatering Feed Pump 2	Existing	PD	EM	V
C = Centrifugal PD = Positive-Displacement EM = Electric Motor PO = Pneumatic-Operated V = Variable-Speed F = Fixed-Speed					

B. Instruments:
1. Discrete Instruments:

Equipment Tag	Name	Existing/ Proposed	Setpoint
PSH-16-6-1	High Pressure Switch 1	Existing	-
PSH-16-6-2	High Pressure Switch 2	Existing	-

C. Controllers:

Equipment Tag	Name	Existing/ Proposed
20PLC1	Digester Control Room PLC	Proposed
20MCC1	Motor Control Center	Proposed

1.3 PROCESS DESCRIPTION

A. General:
1. The sludge dewatering feed pumps are called to run and a speed setpoint is sent from the belt filter press control panels to 20PLC1. Operations can select which dewatering pump is available. The run speed and call signals are sent from 20PLC1 to the pump VFDs in the motor control center. A high-pressure switch is used as a interlock to stop the pumps in the event of high pressure.

2. The PLC control panel OIT indicates pump status and high-pressure indication.
3. The dewatering feed pumps can be started and stopped from the OIT.

B. Automatic Mode:
1. When the dewatering feed pumps are placed in REMOTE mode at the OIT, the START, STOP and SPEED will be controlled from signals received from the sludge dewatering control panel.

1.4 HMI CONTROLS

A. Alarms
1. The following table lists the expected alarms on the HMI graphics. Alarm priority shall be determined through coordination with the Owner during project startup. Alarms described under the Common Control Strategies portion of this specification are not listed in this table but shall be provided as applicable.

Alarms	Description
Pump 1 High Discharge Pressure	Discharge header pressure switch.
Pump 2 High Discharge Pressure	Discharge header pressure switch.

1.5 INTERLOCKS

A. Hard Interlocks
1. The following table lists hard-wired interlock conditions that must be satisfied for equipment operation in either Local or Auto/Remote modes.

Interlock	Description
Pump 1 High Discharge Pressure	High pressure indication will inhibit pump run
Pump 2 High Discharge Pressure	High pressure indication will inhibit pump run

1.6 COMMUNICATION INTERFACES

A. Data will be communicated over the SCADA network from the Digester Control Building to the Administration Building.

Description	Receiving Controller
Administration Building	Master Ethernet Radio

END OF SECTION

SECTION 40 61 96.3 – PROCESS CONTROL DESCRIPTION: DIGESTER HEATING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
1. Digester heating control and monitoring for boilers 1 and 2 and heat exchangers 1, 2, and 3.

B. Related sections:
1. Section 40 61 13 – Process Control System General Provisions
2. Section 40 61 96 – Process Control Descriptions – General
3. Section 40 68 63 – PLC and HMI Programming

1.2 EQUIPMENT AND INSTRUMENTATION

A. Motors and Pumps:

Equipment Tag	Name	Existing/ Proposed	Type	Driver	Operation
P-15-8-1	Digester Heating Water Pump 1	Existing	C	EM	F
P-15-8-2	Digester Heating Water Pump 2	Existing	C	EM	F
P-15-8-3	Digester Heating Water Pump 3	Existing	C	EM	F
P-15-9-1	Sludge Recirculation Pump 1	Existing	C	EM	F
P-15-9-2	Sludge Recirculation Pump 2	Existing	C	EM	F
P-15-9-3	Sludge Recirculation Pump 3	Existing	C	EM	F
C = Centrifugal PD = Positive-Displacement EM = Electric Motor PO = Pneumatic-Operated V = Variable-Speed F = Fixed-Speed					

B. Valves and Gates

Equipment Tag	Name	Existing/ Proposed	Operator	Remote Operation
TCV-15-5	3-Way Temperature Control Valve	Existing	MO	MOD
TCV-15-7-1	3-Way Temperature Control Valve	Existing	MO	MOD
TCV-15-7-2	3-Way Temperature Control Valve	Existing	MO	MOD
TCV-15-7-3	3-Way Temperature Control Valve	Existing	MO	MOD
MAN = Manual MO = Electric Motor-Operated PO = Pneumatic-Operated HO=Hydraulic-Operated OC = Open/Close OSC = Open/Stop/Close MOD = Modulating				

C. Instruments
1. Discrete Instruments:

Equipment Tag	Name	Existing/ Proposed	Setpoint
OL-15-1-1-1	Boiler 1 Fail	Existing	-
OL-15-1-2-1	Boiler 2 Fail	Existing	-
OL-15-1-1	Boiler 1 FD Fan On/Off	Existing	-
OL-15-1-2	Boiler 2 FD Fan On/Off	Existing	-
OL-15-8-1	Digester Heating Water Pump 1 On/Off	Existing	-
OL-15-8-2	Digester Heating Water Pump 2 On/Off	Existing	-
OL-15-8-3	Digester Heating Water Pump 3 On/Off	Existing	-
OL-15-9-1	Sludge Recirculation Pump 1 On/Off	Existing	-
OL-15-9-2	Sludge Recirculation Pump 2 On/Off	Existing	-
OL-15-9-3	Sludge Recirculation Pump 3 On/Off	Existing	-
FSL-14-2-1	Digester 1 Foam Separator W3 flow switch	Existing	-
FSL-14-2-2	Digester 2 Foam Separator W3 flow switch	Existing	-
FSL-14-2-3	Digester 3 Foam Separator W3 flow switch	Existing	-
PSH-14-3	Digester Gas high pressure switch (FP-13-1)	Existing	-
PSLL-14-3	Digester Gas low pressure switch	Existing	-
PSL-15-1	Digester Fuel Low	Existing	-

2. Analog Instruments:

Equipment Tag	Name	Existing/ Proposed	Nominal Range
AIT-14-9	Explosive Gas Indicator		-
FIT-14-1-1	Digester 1 Gas Flow	Existing	-
FIT-14-1-2	Digester 2 Gas Flow	Existing	-
FIT-14-1-3	Digester 2 Gas Flow	Existing	-
PIT-14-3	Digester Gas Header pressure	Existing	-
FT-14-7	Digester Waste Gas Burner Gas Flow	Existing	-
TIT-15-7-1	Heat Exchanger 1 Hot Water Temperature	Existing	-
TIT-15-7-2	Heat Exchanger 2 Hot Water Temperature	Existing	-
TIT-15-7-3	Heat Exchanger 3 Hot Water Temperature	Existing	-
TIT-15-10-1	Recirc. Sludge Digester 1 Temperature	Existing	-
TIT-15-10-2	Recirc. Sludge Digester 2 Temperature	Existing	-
TIT-15-10-3	Recirc. Sludge Digester 3 Temperature	Existing	-
TIT-15-4	Boiler Hot Water Temperature	Existing	-

D. Controllers:

Equipment Tag	Name	Existing/ Proposed
20PLC1	Digester Control Room PLC	Proposed
20MCC1	Motor Control Center	Proposed
FP-15-1-1	Boiler 1 Control Panel	Existing
FP-15-1-2	Boiler 2 Control Panel	Existing
FP-14-6	Digester Waste Gas Burner Control Panel	Existing

1.3 PROCESS DESCRIPTION

A. See 1991 Contract Documents Tuscaloosa Wastewater Treatment Plant Expansion – Phase 1 for process loop descriptions. See 1991 Expansion and 2020 Digester Heating Upgrades record drawings for original P&IDs and drawings. Consolidate all original functionality into new PLC 20PLC1.

SECTION 40 67 23 – CONTROL PANELS

PART 1 - GENERAL

1.1 SUMMARY

A. This specification covers all control panels provided as part of the project, including those provided as part of a manufacturer supplied system specified in other Divisions.

B. Furnish and install functional control panels to operate control systems manually or automatically as specified in the detailed requirements of this section and related sections.

C. Related Sections:
   1. Section 40 61 13 – Process Control System General Provisions

1.2 SUBMITTALS

A. Submittals shall contain information on related equipment to be furnished under this Specification but described in the related Sections listed in the Related Work paragraph above. Incomplete submittals not containing the required information on the related equipment will also be returned un-reviewed.

B. All submittals for control panels provided as part of an equipment vendor's scope shall be submitted as a part of the Process Equipment manufacturer's submittal.

C. All submittals for control panels provided by the Control System Specialist shall be submitted as a part of the Control System Specialist's submittals.

D. The equipment manufacturer shall create all equipment shop drawings, including all wiring diagrams, in the manufacturer's Engineering department. All equipment shop drawings shall bear the mechanical equipment manufacturer's logo, drawing file numbers, and shall be maintained on file in the mechanical equipment manufacturer's archive file system.

E. Submit to the Owner/Engineer, shop drawings and product data, for the following:
   1. Custom unit elementary drawings. Drawings shall include all schematics for control logic as described in the Process Equipment Specifications, and any associated control schematics shown on the Engineer's Drawings for this project. Show interconnections between components and to remotely mounted devices. Include and identify all connecting equipment and remote devices on the schematics. The notation "Remote Device" will not be acceptable. Show wire and terminal numbers. Indicate special identifications for devices as required by the mechanical equipment manufacturer or as may be shown on the Drawings.
   2. Equipment outline drawings showing elevation, plan and interior views, front panel arrangement, dimensions, weight, shipping splits, conduit entrances and anchor bolt pattern. Indicate all options, special features, ratings, and deviations from this Section.
   3. Power and control schematics including external connections. Show wire and terminal numbers and color-coding.
   4. Network interface diagrams showing all panel network components and how they are interconnected.
   5. Instruction and replacement parts books, including manufacturer's part numbers and selections of component ratings.
   6. As-built final drawings.
   7. Documentation that the panel assembly facility is a UL-508 certified facility.
   8. Furnish complete Bill of Materials indicating manufacturer's name and part numbers.

9. Manufacturer's cut sheets for every component used in the panel assembly adequately marked to show the items being included. The manufacturer's name shall be clearly visible on each cut sheet submitted.
10. Assembly ratings including:
    a. Short-circuit rating.
    b. Voltage
    c. Continuous current
11. Major component ratings including:
    a. Voltage
    b. Continuous current
    c. Interrupting ratings
12. Cable terminal sizes.
13. Instruction and renewal parts books.

F. Factory Tests. Submittals shall be made for factory tests specified herein.

G. Field Test Reports. Submittals shall be made for field tests specified herein.

H. Operation and Maintenance Manuals.
1. Operation and Maintenance Manuals shall include the following information:
    a. Manufacturer's contact address and telephone number for parts and service.
    b. Instruction books and/or leaflets
    c. Recommended renewal parts list
    d. Record Documents for the information required by the Submittals paragraph above.

I. The manufacturer shall submit for approval, a training agenda for all training specified herein. Training agenda shall not be submitted until final approval of the Operation and Maintenance Manual.

1.3 REFERENCE CODES AND STANDARDS

A. All products and components shown on the Drawings and listed in this specification shall be designed and manufactured according to latest revision of the following standards (unless otherwise noted):
1. NEMA Standard ICS 2 – 2000 Industrial Control and Systems
2. NFPA 70 – National Electrical Code (NEC)
3. NFPA 70E – Standard for Electrical Safety in the Workplace
4. NFPA 79 – Electrical Standard for Industrial Machinery
5. UL 508/508A – Industrial Control Enclosures

B. All equipment components and completed assemblies specified in this Section of the Specifications shall bear the appropriate label of Underwriters Laboratories.

1.4 QUALITY ASSURANCE

A. The manufacturer of the control panels shall have produced similar equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

B. The control panels shall be assembled in a UL-508 certified facility. A submittal of documentation certifying that the panel fabrication facility is a UL-508 certified facility, is required. A UL label shall be affixed to the inside of the external door by the panel fabrication assembly.

C. All components and material shall be new and of the latest field proven design and in current production. Obsolete components or components scheduled for immediate discontinuation shall not be used.

D. Control panels submitted shall fit within the space shown on the Drawings. Equipment which does not fit within the space is not acceptable.

E. For the equipment specified herein, the manufacturer shall be ISO 9001 2000 certified.

1.5 JOBSITE DELIVERY, STORAGE AND HANDLING

A. Prior to jobsite delivery, the Contractor shall have successfully completed all submittal requirements, and present to the Owner/Engineer upon delivery of the equipment, an approved copy of all such submittals. Delivery of incomplete constructed equipment, onsite factory work, or failed factory tests will not be permitted.

B. Equipment shall be handled and stored in accordance with manufacturer's instructions. Two (2) copies of these instructions shall be included with the equipment at time of shipment and shall be made available to the Contractor and Owner/Engineer.

C. Shipping groups shall be designed to be shipped by truck, rail, or ship. Indoor groups shall be bolted to skids. Breakers and accessories shall be packaged and shipped separately.

D. Where space heaters are provided in equipment, provide temporary electrical power, and operate space heaters during storage, and after equipment is installed in permanent location, until equipment is placed in service.

1.6 WARRANTY

A. The Manufacturer shall warrant the equipment to be free from defects in material and workmanship for the same length of time as the associated mechanical equipment, but not less than 1 year from the date of final acceptance of the equipment by the Owner and Engineer. Within such period of warranty, the Manufacturer shall promptly furnish all material and labor necessary to return the equipment to new operating condition. Any warranty work, requiring shipping or transporting of the equipment, shall be performed by the Manufacturer, at no expense to the Owner.

PART 2 - PRODUCTS

2.1 RATINGS

A. The service voltage shall be as specified and as shown on the Drawings. The overall short circuit with stand and interrupting rating of the equipment and devices shall be not less than 22,000 amperes RMS symmetrical for panels operating at 480/277 Volts, and equal to or greater than the overall short circuit withstand and interrupting rating of the feeder device immediately upstream of the Control Panel. This includes all circuit breakers and combination motor starters. Systems of motor controllers employing series connected ratings for main and feeder devices shall not be used. Motor starter units shall be tested and UL 508A labeled for the specified short circuit duty in combination with the motor branch circuit protective device. The overall short circuit rating of the panel shall be not less than 10,000 amperes RMS symmetrical for panels operating at 120VAC.

B. There shall be selective device coordination between the Main Breaker, Feeder Breakers, and control circuit protective devices. When using a circuit breaker or fuses as a main protective device, the instantaneous trip levels of the main protective device shall be higher than the

available fault current to the control panel. If fuses are utilized in the control panel design, the protective devices for 3 phase loads shall contain single phase protection of such equipment. If a fault occurs in the circuit of one load of a design with a backup load, the feeder protective device shall not remove both loads from the control system.

C. The complete control panel assembly shall be UL certified and carry a UL listing for "Industrial Control Panels".

D. The control panel shall meet all applicable requirements of the National Electrical Code.

E. The control panel enclosure shall be NEMA rated as specified herein.

F. Motor controllers, including associated devices, shall be designed for continuous operation at rated current in a 50 degree C ambient temperature.

G. For additional ratings and construction notes, refer to the mechanical equipment specifications and the Drawings.

2.2 CONSTRUCTION

A. General
1. Submit actual layout and location of equipment and components; current ratings of devices, bus bars, components; protective relays, voltage ratings of devices, components, and assemblies; and other required details. NEMA ratings of all devices shall meet or exceed the rating of each panel.
2. Control units shall be arranged as shown on the Drawings.
3. Nameplates
   a. Exterior
      1) Nameplates shall be engraved, laminated impact acrylic. Nameplates shall be 316 SS screw mounted to all enclosures except for NEMA 4 and 4X. Nameplates for NEMA 4 and 4X enclosures shall be attached with double faced adhesive strips. Prior to installing the adhesive nameplates, the metal surface shall be thoroughly cleaned with 70% alcohol until all residues have been removed. Epoxy adhesive or foam tape is not acceptable.
      2) There shall be a master nameplate that indicates supply voltage equipment ratings, short circuit current rating, manufacturer's name, shop order number and general information. Cubicle nameplates shall be mounted on the front face, on the rear panel and inside the assembly, visible when the rear panel is removed.
      3) Provide permanent warning signs as follows:
      4) "Danger- High Voltage- Keep Out" on all doors.
      5) "Warning- Hazard of Electric Shock - Disconnect Power Before Opening or Working on This Unit" on Main Power Disconnect or Disconnects.
   b. Internal
      1) Provide the panel with a UL 508A label.
      2) Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification, corresponding to appropriate designations on manufacturer's wiring diagrams.
4. Control Devices and Indicators
   a. All operating control devices, indicators, and instruments shall be securely mounted on the panel door. All controls and indicators shall be 30mm, NEMA 4X/13 for outdoor panels, NEMA 4/13 for indoor panels, anodized aluminum or reinforced plastic. Booted control devices are not acceptable. Auxiliary contacts shall be provided for remote run indication and indication of each status and alarm condition. Additional controls shall be provided as specified herein and as required by the detailed mechanical and electrical equipment requirements.

b. Indicator lamps shall be LED type. For all control applications, indicator lamps shall incorporate a push-to-test feature.
c. Mode selector switches (HAND-OFF-AUTO, LOCAL-OFF-REMOTE, etc.) shall have the number of positions and contact arrangements, as required. Each switch shall have an extra dry contact for remote monitoring.
d. Panel meters for digital display of analog signal values shall be provided where indicated. Panel meters shall be 4-20mA loop powered, 1/8 DIN LCD displays, Precision Digital Model PD 6600 series or equal.
e. Panel Interface Connector (PIC): Each control panel with a PLC shall include a PIC mounted on the outside of the enclosure for providing an Ethernet connection to internal devices. The PIC shall include a 120 VAC single phase duplex receptacle with 3 Ampere externally resettable circuit breaker and an RJ45 pass-through connector.
f. Furnish nameplates for each device. All nameplates shall be laminated plastic, black lettering on a white background, attached with stainless steel screws. Device mounted nameplates are not acceptable.
g. The manufacturer shall not remove, reuse, alter, or replace original equipment nameplates or equipment tags associated with equipment or components supplied by the manufacturer's suppliers and sub-suppliers.

5. Control Relays
   a. Provide relays as required to implement indicated control functions. General purpose, alternating and time delay relays may be used within their ratings for logic, timing and sequencing but shall not be used to drive loads in excess of 80% of their contact "make" or "break" ratings. Provide interposing power relays to drive loads such as starters larger than NEMA size 1 and all other utilization equipment with loads greater than specified for general purpose and time delay relays. Provide relays rated to drive the load as required. Relays shall be provided with an LED status indicator.
   b. Discrete Input and Output Relays: Terminal block style interposing relays shall be used for all controller inputs and outputs. Devices shall be PLC-RSC series as manufactured by Phoenix Contact or equal. Provide pull-up or pull-down resistors on all digital outputs as required for the application.
6. Control and Instrument Power Transformers.
   a. Control power transformers shall be provided. Transformer shall be sized for the entire load, including space heaters, plus 25% spare capacity, and shall be not less than 100VA.
   b. Control power transformers shall be 120 volts grounded secondary. Primary side of the transformer shall be fused in both legs. One leg of the transformer secondary shall be solidly grounded, and the other leg shall be fused.
   c. Control power transformers shall be installed inside the control panel that they serve. They shall not be mounted exterior to the panel.
7. Power Supplies
   a. When required, the control panel shall be furnished with a separate DC power supply to provide DC power for control panel components and the loop power for 2-wire instruments. The power supplies shall be DIN rail mounted, 120VAC input, 24VDC output, with output load rated as required for the connected loads. Power supplies shall be provided by Phoenix Contact, Allen-Bradley, or Sola.

B. Enclosures
1. General
   a. Each enclosure shall incorporate a removable back panel, and side panels, on which control components shall be mounted. Back panel shall be secured to the enclosure with collar studs for wall mounted enclosures, and 316 SS hardware for free standing enclosures.
   b. All free-standing enclosures shall be provided with feet of the same construction as the enclosure.

c. Back panel shall be tapped to accept all mounting screws. Self-tapping screws shall not be used to mount any components.
d. All enclosure doors shall have bonding studs. The enclosure interior shall have a bonding stud.
e. Each enclosure shall be provided with a documentation pocket on the inner door.
f. Enclosures shall not have holes or knockouts.
g. Provide manufacturer's window kits where shown on the Drawings.
h. All enclosures shall be pad-lockable.

2. NEMA 4X
   a. NEMA 4X panels shall be provided for all outdoor locations, or indoor locations where directly exposed to process or wash-down water.
   b. NEMA 4X 316 Stainless Steel
   c. Type 316 stainless steel, body, and door
   d. Stainless steel continuous hinge
   e. Foam gasket
   f. Single point quarter turn latches (20"x24" and below). All others 3-point latch.
   g. Manufacturers
      1) Hoffman Comline Series
      2) EMF Company
      3) NEMA Enclosures Company
      4) Hammond Company
      5) Approved Equal
3. NEMA 12
   a. NEMA 12 panels shall be provided for clean and dry indoor locations.
   b. NEMA 12 Painted Steel.
   c. Painted steel, body, and door
   d. Continuous hinge
   e. Foam gasket
   f. Single point quarter turn latches (20"x24" and below). All others 3-point latch.
   g. Manufacturers
      1) Hoffman Comline Series
      2) EMF Company
      3) NEMA Enclosures Company
      4) Hammond Company
      5) Approved Equal

C. Environmental Conditioning
1. Air Conditioning
   a. A panel air conditioner shall be provided where panels include variable frequency drives and are installed outdoors or unconditioned indoor spaces.
   b. The air conditioner shall be powered from the panel. A separate power source shall not be required.
   c. The enclosure cooling system shall not compromise the enclosure's NEMA rating and shall be sized for the environment in which the control panel will be installed.
   d. The air conditioner shall be sized to provide cooling to maintain the interior temperature of the panel to meet VFD manufacturer recommendations for maximum ambient temperature.
2. Ventilation
   a. Where air conditioning is not required, panel fans and louvers shall be provided where panels are installed in unconditioned indoor spaces.
   b. Panel ventilation shall also be provided in indoor conditioned spaces where the panel manufacturer has determined it necessary in order to maintain the interior temperature of the panel within manufacturer recommended limits.
   c. The fans shall be powered from the panel. A separate power source shall not be required.

d. The enclosure ventilation system shall not compromise the enclosure's NEMA rating and shall be sized for the environment in which the control panel will be installed.
e. The ventilation shall be sized to maintain the interior temperature of the panel to meet manufacturer recommendations for maximum ambient temperature of all electronic components.

3. Condensation Control
   a. A self-contained enclosure condensation heater with thermostat and fan shall be mounted inside control panels if panel is mounted outdoors or in a non-air-conditioned space.
      1) Enclosure heaters shall be energized from 120 volt, single-phase power supply and sized to prevent condensation within the enclosure.
      2) Locate enclosure heaters to avoid overheating electronic hardware or producing large temperature fluctuations on the hardware.
      3) Enclosure heaters shall have an internal fan for heat distribution and shall be controlled with adjustable thermostats. The thermostat shall have an adjustment range of 40 degrees Fahrenheit to 90 degrees Fahrenheit. Provide a circuit breaker or fused disconnect switch within the enclosure.
      4) Enclosure heaters shall be Hoffman type DAH or equal.
   b. Strip heaters may be provided if they are 240 volt rated, powered at 120 volts AC, and do not have a surface temperature higher than 60°C. Strip heaters and thermostats shall be as manufactured by Chromalox or equal.
   c. Each panel shall have a ½" stainless steel condensate drain.

D. Internal Wiring
1. Power and control wiring shall be tinned stranded copper, minimum size No. 16 AWG, with 600 Volt, 90 degree C, flame retardant, Type MTW thermoplastic insulation. Line side power wiring shall be sized for the full rating or frame size of the connected device.
2. Analog signal wires shall be 600 Volt Class, insulated stranded tinned copper, twisted shielded #18 AWG pair.
3. All interconnecting wires between panel mounted equipment and external equipment shall be terminated at numbered terminal blocks. Field wiring shall not be terminated directly on any panel-mounted device.
4. All wiring shall be tagged and coded with an identification number as shown on the Drawings. Coding shall be typed on a heat shrinkable tube applied to each end showing origination and destination of each wire. The marking shall be permanent, non-smearing, solvent-resistant type similar to Raychem TMS-SCE, or equal.
5. All wiring shall be enclosed in PVC wire trough with slotted side openings and removable cover. Plan wire routing such that no low twisted shielded pair cable conducting analog 4-20 mA signals or low voltage analog signals are routed in the same wire trough as power conductors carrying greater than 120V.
6. All control panel wiring shall use the following color code.
   a. Black: AC power at line voltage
   b. Red: switched AC power
   c. Orange: May be energized while the main disconnect is in the off position
   d. White: AC neutral
   e. Orange/white stripe or white/orange stripe: separate derived neutral
   f. Red/white stripe or white/red stripe: switched neutral.
   g. Green or green w/ yellow tracer: ground/earth ground
   h. Blue: Ungrounded DC power
   i. Blue/white stripe or white/blue stripe: DC grounded common
   j. Brown: 480V AC 3 phase - phase A
   k. Orange: 480V AC 3 phase - phase B
   l. Yellow: 480V AC 3 Phase - phase C
   m. Purple: common for analog signal wiring
   n. Brown: positive leg of an analog signal

E. Field Installed Internal Wiring
   1. Field installed interior wiring shall be neatly grouped by circuit and bound by plastic tie wraps. Circuit groups shall be supported so that circuit terminations are not stressed. In addition, low signal wiring (millivolt and milliamp) shall be bundle separately from the rest of the control wiring.
   2. All field wiring shall be tagged and coded with an identification number. Coding shall be typed on a heat shrinkable tube applied to each end of the wire. The marking shall be a permanent, non-smearing, solvent-resistant type similar to Raychem TMS-SCE, or equal.
      a. Where existing field wiring is being used to connect to a new panel, provide new labels. Where an existing wiring identifier is present that differs from the wiring identifier documented on the panel drawings, provide label for both identification numbers.
   3. In general, all conduit entering or leaving outdoor panels shall be stubbed up into the bottom of the enclosure to the greatest extent possible.

F. Terminal Blocks
   1. Terminal blocks shall be DIN-rail-mounted one-piece molded plastic blocks with tubular-clamp-screw type and end barriers. Terminal blocks shall be rated for 600 volts except for control and instrumentation circuits, or 4-20 mA analog signal conductors.
   2. Provide 600 volt rated terminal blocks for any conductor carrying any voltage over 120 volts to ground.
   3. Provide 600 volt rated strap screw terminal blocks for any power conductors carrying over 20 amps, at any voltage. Terminals shall be double sided and supplied with removable covers to prevent accidental contact with live circuits.
   4. Power conductors carrying over 20 amps, at any voltage shall be terminated to strap-screw type terminal blocks with crimp type, pre-insulated, ring-tongue lugs. Lugs shall be of the appropriate size for the terminal block screws and for the number and size of the wires terminated. Do not terminate more than one conductor in any lug, and do not land more than two conductors under any strap-screw terminal point.
   5. Terminals shall have permanent, legible identification, clearly visible with the protective cover removed. Each terminal block shall have 20 percent spare terminals, but not less than two spare terminals.
   6. Use the manufacturer's provided bridge connectors to interconnect terminal blocks terminating common or ground conductors.
   7. Twisted shielded pair or triad cables shall have each individual conductor and shield drain wire landed on individual terminal blocks. Use the manufacturer's provided bridge connectors to interconnect terminal blocks terminating the shield drain wire conductors.
   8. Control circuits, 120 volts and below, and 4-20 mA analog signal conductors shall be terminated with manufacturer's recommended insulated connectors.
   9. Current Loop Surge Protection Devices: The 4-20mA signal loop channels on analog inputs and outputs shall be protected against static discharge, lightning, and faulty wiring with three stage surge protection terminal block devices. Devices shall be pluggable with indication status lights. Devices shall be PLUGTRAB series as manufactured by Phoenix Contact or equal.
   10. All wiring to hazardous locations shall terminate in intrinsically safe barrier devices.
   11. Provide an AC ground bar bonded to the panel enclosure (if metal) with 20 percent spare terminals.
   12. Provided ground terminal blocks for each twisted-shielded pair drain wire.

2.3 MAIN CIRCUIT PROTECTIVE DEVICE

A. For panels operating at 480VAC, unless otherwise shown on the Drawings, the main circuit protective device shall be a molded case (MCCB), 3 Pole, 600 Volt, fixed type, manually operated with stored energy closing mechanism. For MCCBs 200A and larger, trip device shall be solid state with adjustable long time pickup, and delay; adjustable short time pickup and delay; and short time i2t switch. Provide ground fault pickups where indicated on the drawings.

1. Provide a flange mounted main power disconnect operating handle with mechanical interlock having a bypass that will allow the panel door to open only when the switch is in the OFF position. Where panels are shown or specified with inner and outer doors, disconnecting handles and controls shall be located on the inner door.

2.4 ACROSS THE LINE MOTOR CONTROLLERS

A. General

1. Provide the NEMA size starter, circuit breaker trip ratings, control power transformers and thermal overload heater element ratings matched to the motors and control equipment actually supplied, in compliance with the NEC and the manufacturer's heater selection tables. All variations necessary to accommodate the motors and controls as actually furnished shall be made without extra cost to the Owner.
2. Furnish lugs for incoming wiring. Allow adequate clearance for bending and terminating of cable size and type specified.
3. A NEMA rated magnetic motor starter shall be furnished for each motor. Each motor starter shall be provided with a motor circuit protector, or circuit breaker, and equipped to provide undervoltage release and overload protection on all three phases. The short circuit protective device shall have an adjustable magnetic trip range up to 1400 percent of rated continuous current and a trip test feature. MCPs shall be labeled in accordance with UL489. NEMA starter sizes and breaker trip ratings shall be as required for the horsepower indicated but shall be in no case less than NEMA Size 1. If the manufacturer of the equipment utilizing the motor, supplies a motor horsepower larger than that shown on the Drawings, the Contractor shall supply a motor starter sufficient in size to control the motor supplied.
4. A mechanical disconnect mechanism, with bypass, shall be installed on each motor circuit protector, capable of being locked in the "OFF" position to provide a means of disconnecting power to each motor. Disconnects mechanisms shall be located inside the enclosure such that the main circuit breaker handle is the only device interlocked with the panel door.
5. Each motor starter shall have a 120-volt operating coil unless otherwise noted.
6. Overload relays shall be electronic type with adjustable features and remote reset. A normally closed contact shall be directly used in the start circuit and a normally open contact shall be wire to a terminal board for overload alarm.
7. All interfaces between control panel and remote devices shall be isolated via an interposing relay. Interposing relays shall have contacts rated for 250 VAC and 10 Amps continuous. Relays shall be Control Relays as specified herein.

B. Magnetic Motor Starters

1. Motor starters shall be 2 or 3 pole, single or 3 phase as required, 60 Hertz, 600 volt, magnetically operated, full voltage non reversing. NEMA sizes shall be as required for the horsepower shown on the Drawings.
2. Each motor starter shall have a 120-volt operating coil, and control power transformer. Starters shall have motor overload protection in each phase. Auxiliary contacts shall be provided as shown on the Drawings. A minimum of one N.O. and one N.C. auxiliary contacts shall be provided in addition to the contacts required.
3. Overload relays shall be electronic, adjustable, with remote and local reset.
4. Built in control stations and indicating lights shall be furnished where shown on the Drawings.
5. All wires shall be terminated on terminal blocks and shall be tagged.
6. Provide as built wiring diagram and post it in a protective cover inside the cell.

C. Contactors

1. Contactors shall be a circuit breaker and contactor, 600 Volt, 3 Pole, 60 Hz, magnetically operated. NEMA size shall be as required for the kilowatt ratings required for the equipment provided but shall be not less than NEMA size 1.

2. Contactors shall have a 120 Volt operating coil and control power transformer. Furnish the control power transformer with extra capacity for the unit heater fan.

D. Control Relays
1. Control relays shall be 300-volt, industrial rated, plug-in socket type, housed in a transparent polycarbonate dust cover, designed in accordance with UL Standard 508 for motor controller duty. Continuous contact rating shall be 10 amperes resistive, ¼ HP at 120 VAC, operating temperature minus 10 to plus 55 degrees C. Provide spare N.O. & N.C. contacts. Relays shall be Potter & Brumfield KRP Series or equal with neon coil indicator light. Timing relays shall be 300 Volt, solid state type, with rotary switch to select the timing range.

E. Elapsed Time Meter
1. A six-digit, non-resettable elapsed time meter shall be installed on the face of each motor starter.

2.5 VARIABLE FREQUENCY DRIVE MOTOR CONTROLLERS

A. Where variable frequency drives (VFDs) are provided for motor starting and control, comply with requirements of Division 26 specifications for VFDs.

2.6 INSTRUMENTATION DEVICES

A. Where instrumentation devices are specified or shown on the Drawings, refer to Division 40 Instrumentation specifications.

2.7 REMOTE MONITORING AND CONTROL INTERFACE

A. General: All control and interconnection points from the equipment to the plant control and monitoring system shall be brought to dedicated terminal blocks. No field connections shall be made directly to the equipment control devices. Functions to be brought out shall be as specified in related specification sections and the contract drawings.

B. Discrete control or status functions shall be from C relays with contacts rated at 120 volts AC. Analog signals shall be isolated from each other.

2.8 PROGRAMMABLE LOGIC CONTROLLERS (PLC)

A. Refer to Section 40 63 43, PROGRAMMABLE LOGIC CONTROLLERS, for PLC requirements.

2.9 OPERATOR INTERFACE TERMINALS (OIT)

A. General: Where indicated on drawings or within an equipment specification, an OIT shall be mounted on the front of the control panel for display and control of process-specific graphics. OITs shall meet the following requirements:
1. Allen-Bradley Panelview Plus 7.
2. Minimum Screen Size: 10” diagonal.
3. Provide Ethernet/IP communication capability compatible with Allen-Bradley family PLCs.
4. Provide devices with 2GB memory card.
5. Provide non-glare screen protector. For HMIs installed outdoors, provide hinged weatherproof cover.
6. OITs may also be referred to throughout contract documents as Human Machine Interface (HMI).

2.10 NETWORK DEVICES

A. Ethernet Switches
   1. Switches installed in control panels shall be DIN-rail mounted managed switches with RJ-45 and fiber ports as required for the application. Provide a minimum of two (2) spare RJ-45 ports and two (2) fiber ports for future connections. Provide at least two (2) fiber ports whether or not fiber connections are required.
   2. Switches shall support gigabit connection speeds.
   3. Provide power supply as required.
   4. Switches shall be manufactured by Red Lion, Hirschmann, Moxa, Cisco, or equal.

B. Media Converters
   1. Provide copper to fiber media converters where shown on the drawings or where required to interface with external cabling. Provide power supply as required.

C. Surge Protection
   1. Copper Ethernet cables entering control panels from other sources shall be protected against static discharge, lightning, and faulty wiring with network surge protective devices. The devices shall have integral RJ-45 connectors with all lines protected.

2.11 UNINTERRUPTIBLE POWER SUPPLY (UPS)

A. Each control panel provided with a PLC shall contain a UPS to provide seamless and continuous operation of control panel equipment during power outages. The UPS shall provide backup power meeting the following requirements:
   1. True sine wave output with on-line double conversion configuration
   2. Fault, overload, and replace batteries indicators.
   3. Voltage input: 120 VAC single phase
   4. Voltage output: 120VAC single phase
   5. Output power capacity: 1000 watts / 1500VA minimum
   6. Internal or external bypass.
   7. Hot-swap batteries ≥ 2min. (at 25 °C, full load = 600W, p.f. between 0.6 – 0.75)
   8. UPS to be manufactured by Allen Bradley, or equal.

2.12 SPARE PARTS

A. Provide the following spare parts in the quantities specified. For plant-wide PLC control panels provided by the Control System Specialist, provide 1 set of spare parts that are common to multiple panels. For equipment manufacturer supplied systems, provide one set of spare parts for each control panel.
   1. One (1) PLC processor module of each type furnished.
   2. Two (2) PLC I/O modules of each type furnished.
   3. One (1) communication module of each type furnished.
   4. One (1) OIT of each type furnished.
   5. Six replacement fuses, all types and sizes.
   6. One replacement lamp of each color, for pilot lights.
   7. One of each color replacement lens caps for pilot lights.
   8. One starter coil for each NEMA size furnished.
   9. One, 3-pole set of replacement overload heaters of each size range used.
   10. One, 3-pole set of starter contacts of each NEMA size used.

B. Spare parts shall be boxed or packaged for long term storage. Identify each item with manufacturer's name, description, and part number on the exterior of the package.

2.13 FACTORY TESTING

A. The entire control panel shall be completely assembled, wired, and adjusted at the factory and shall be given the manufacturer's routine shop tests and any other additional operational test to insure the workability and reliable operation of the equipment.

B. Factory test equipment and test methods shall conform with the latest applicable requirements of ANSI, IEEE, UL, and NEMA standards.

C. The operational test shall include the proper connection of supply and control voltage and, as far as practical, a mockup of simulated control signals and control devices shall be fed into the boards to check for proper operation.

D. Factory test equipment and test methods shall conform to the latest applicable requirements of ANSI, IEEE, UL, and NEMA standards, and shall be subject to the Owner/Engineer's approval.

PART 3 - EXECUTION

3.1 INSTALLER'S QUALIFICATIONS

A. Installer shall be specialized in installing this type of equipment, with minimum 5 years documented experience. Experience documentation shall be submitted for approval prior to beginning work on this project.

3.2 EXAMINATION

A. Examine installation area to assure there is enough clearance to install the equipment.

B. Housekeeping pads shall be included for the floor mounted motor controllers as detailed on the Drawings with the exception of motor controllers which are to be installed adjacent to an existing unit. Housekeeping pads for these (if used) should match the existing installation.

C. Check concrete pads and baseplates for uniformity and level surface.

D. Verify that the equipment is ready to install.

E. Verify field measurements are as instructed by manufacturer.

3.3 INSTALLATION

A. The Contractor shall install all equipment per the manufacturer's recommendations and Contract Drawings.

B. Install required safety labels.

C. All wiring shall be neatly installed, and wire ways shall be used wherever possible. All wiring shall be identified at all terminating locations by Tag ID as identified in Drawings.

3.4 FIELD QUALITY CONTROL

A. Inspect installed equipment for anchoring, alignment, grounding, and physical damage.

B. Check tightness of all accessible electrical connections. Minimum acceptable values are specified in manufacturer's instructions.

C. Provide one set of as-built panel drawings laminated, in each panel pocket.

3.5 FIELD ADJUSTING

A. Adjust all circuit breakers, switches, access doors, operating handles for free mechanical and electrical operation as described in manufacturer's instructions.

3.6 FIELD TESTING

A. Perform all electrical field tests recommended by the manufacturer. Disconnect all connections to solid-state equipment prior to testing.

B. Megger and record phase to phase and phase to ground insulation resistance. Megger, for 1 minute, at minimum voltage of 1000 VDC. Measured Insulation resistance shall be at least 100 megohms. In no case shall the manufacturer’s maximum test voltages be exceeded.

C. Test each key interlock system for proper functioning.

D. Test all control logic before energizing the motor or equipment.

3.7 CLEANING

A. Remove all rubbish and debris from inside and around the motor controllers. Remove dirt, dust, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint free rags. Do not use compressed air.

3.8 EQUIPMENT PROTECTION AND RESTORATION

A. Touch-up and restore damaged surfaces to factory finish, as approved by the manufacturer. If the damaged surface cannot be returned to factory specification, the surface shall be replaced.

END OF SECTION

SECTION 40 68 63 – PLC AND HMI PROGRAMMING

PART 1 - GENERAL

1.1 SUMMARY

A. The specification describes the PLC and HMI programming work to be performed by the Control System Specialist, consisting of labor, licensing, software, and incidentals for the programming of all PLCs, OITs, HMI servers and workstations, and other hardware that make up the process control system. The work shall include every item of programming and configuration necessary for a complete and functioning installation as shown on the drawings and as specified herein.

B. Related Sections:
   1. Section 40 61 96 – Process Control Descriptions.

1.2 REFERENCES

A. ANSI/ISA-18.2-2016 – Management of Alarm Systems for the Process Industries.

B. Definitions: Symbols, Definitions, and Abbreviations: All symbols, definitions, and engineering unit abbreviations utilized shall conform to IEEE 100-84, S50.1, and S51.1, where applicable.
   1. SCADA – Supervisory Control and Data Acquisition
   2. HMI – Human Machine Interface
   3. OIT – Operator Interface Terminal
   4. PLC – Programmable Logic Controller
   5. I/O – Input/Output
   6. VFD – Variable Frequency Drive
   7. SSRVS – Solid State Reduced Voltage Starter (“Soft Starter”)
   8. RTU – Remote Telemetry Unit
   9. MTU – Master Telemetry Unit
   10. MCC – Motor Control Center
   11. ETM – Elapsed Time Meter
   12. IOP - Integrated Operating Platform – System of installed, connected, and configured hardware, operating programs, and networking equipment.
   13. PLC and HMI Programming – Software configuration of operating programs to implement plant control strategies.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 SCOPE

A. The Control System Specialist shall be responsible for design of the PLC and HMI programs to achieve process control as described by the drawings and specifications. The Control System Specialist shall fully coordinate all components and details of the control system with all other equipment on the project.

B. The Control System Specialist shall coordinate all PLC and HMI programming, testing, and startup activities throughout the duration of the project.

C. Before final acceptance, the Control System Specialist shall configure all control loops to achieve stable process control in all conditions and perform a thorough test of all system functions.

D. The system shall include custom PLC programming and process screen displays developed by the Control System Specialist. The screens will provide the major vehicle for operators to monitor and interact with the treatment process. These displays shall enable speedy access and provide the capability to manipulate process control variables along with performing standard operator tasks such as ramping values and responding to alarms. User defined graphics displays shall depict specific views of the process operations and control. They shall be created and configured for monitoring and managing the process through the software.

E. Prior to finalizing graphic screens, the Control System Specialist shall submit screen captures of the proposed HMI screens to the Engineer and Owner for review. The submitted screen captures shall be sufficient to display the contents of the system, and to determine visual conformance with the Owner's standards. The Control System Specialist shall modify the screen contents based on the Owner and Engineer review prior to functional system testing. Review of the screens at this stage is preliminary and is not a final approval of all HMI content and functionality as required by the contract documents.

3.2 GENERAL

A. All server and workstation programs required for the IOP shall be automatically started during the boot sequence.

B. All calculations shall be performed in the PLC, including but not limited to analog control point values, unit conversions, timers, and numeric manipulations.

C. All set points shall test for minimum and maximum values and shall be operator adjustable via the operator interface software.

D. Each PLC shall be configured to provide the system a heartbeat function that will enable the system to periodically check for proper communications. The HMI application shall issue an alarm if communication fails. A PLC monitoring screen shall be configured to indicate the alarm conditions and log any occurrence of an alarm with a date/time stamp and description.

E. Inputs/Outputs
   1. P&ID and I/O list sheets in the drawings show the expected I/O points. Some I/O points on the input/output list may be existing and therefore not shown on the P&IDs.
   2. All analog I/O shall be trended on the associated HMI.
   3. Analog Inputs: Analog inputs shall be scaled, summed, logged, provided with high and low alarming with adjustable dead-bands, and integrated against time for totalization as required.
   4. Analog Outputs: Analog outputs shall be scaled as required.
   5. Digital Inputs: Digital inputs shall be configured as status indicators or as alarms as required. As an alarm indicator, the digital indicator shall record a descriptive alarm message with the date and time of the occurrence.
   6. Digital Outputs: Digital outputs shall be configured as either normally open or normally closed contacts with maintained or momentary action as may be required.

F. HMI Graphic Displays
   1. Layout:
      a. Header or sidebar display containing city logo, alarm indicator, and non-process related navigation objects.
      b. Main process overview screens will display major equipment statuses, analog values, and alarms in a graphical P&ID format.
      c. Equipment popups will allow the operator to drill down to specific motors, valves, and instruments, displaying detailed information and allowing for equipment and device control.
      d. A trending screen will display up to four trend charts for analog process values.

e. An alarming screen will display an alarm log history with description, date and timestamp, and acknowledgement status of alarm.
f. An event log screen will display system event history such as user logins with date and timestamps.
g. A PLC diagnostic screen will display PLC module statuses, as well as any communication alarms. This screen will also depict the local control panel network and any connected devices (OIT, PLC, Ethernet Switches, etc.)

2. Navigation tools will be intuitive and consist of a navigation ribbon, as well as process links to adjacent displays and complexes.

G. Package Systems
1. Control and status data transmitted to and/or received from peer devices via a communications network must be performed using peer-to-peer messaging or similar method requiring only the peer devices. Peer-to-peer control data shall not be conveyed to a peer device via HMIs, OIT, servers, or workstations.
2. Coordinate control and status data interface between IOP and packaged systems with manufacturer.

H. The Control System Specialist shall furnish the Owner final as-built copies of documented PLC and OIT programs, on electronic media, suitable for future troubleshooting or modifications by others.

3.3 SECURITY

A. OIT applications shall employ security configurations to prevent unauthorized changes to control and alarm parameters.

B. At a minimum, the security configuration shall consist of the following four access levels: View, Operator, Maintenance, and Engineer. Coordinate additional access levels and restrictions with Owner.
1. Engineer: Unrestricted access to all system features and parameters.
2. Maintenance:
a. Start and stop servers, workstations, and programs.
b. Control loop tuning
c. Run diagnostic programs.
d. Process troubleshooting and repair.
e. IOP troubleshooting and repair.
f. Adjust process parameters.
g. Bypass interlocks and permissives configured with bypass option.
h. Enable and disable equipment control from PLC.
3. Operator:
a. Start and stop HMI applications.
b. Adjust process parameters.
4. View:
a. HMI navigation privileges only.

C. User management shall utilize a User Configuration pop-up display with features to support adding, modifying, and deleting users. User management displays and features shall be restricted to users with Engineer privileges.

D. Password management shall utilize a pop-up display to allow users to manage their respective passwords.

E. A user shall be automatically logged out after periods of inactivity. Coordinate the time span a user must be inactive with the owner.

3.4 ALARM MANAGEMENT

A. At a minimum, each alarm in the PLC shall have the following attributes.
   1. Alarm description
   2. Alarm setpoint or logical condition
   3. Alarm priority
   4. Deadband (analog alarms)
   5. On delay
   6. Off delay
   7. Area or group
   8. Alarm message. Alarm messages shall be consistent in wording.
   9. Alarm shelving by operator
   10. Alarm suppression by program.

B. Disabled, suppressed-by design, or shelved alarms shall not impact other logic functions, such as interlock actions.

C. At a minimum, each alarm record will include the following attributes.
   1. Alarm source tag name
   2. Alarm description
   3. Alarm state
   4. Alarm Priority
   5. Alarm group
   6. Process value at time of occurrence.
   7. Time and date of alarm occurrence change of state.

D. The following alarm states will be used when displaying alarms on the HMI.
   1. Normal: No indication.
   2. Unacknowledged Alarm: Audible and visual indication of alarm condition. Indication will be easily distinguishable from other alarm states.
   3. Acknowledged Alarm: Visual indication of alarm condition. Indication will be easily distinguishable from other alarm states.
   4. Return-to-Normal Unacknowledged Alarm. Visual indication of alarm condition. Indication will be easily distinguishable from other alarm states.

E. All alarm configurations, controls, and states will be handled in the PLC. Alarm configurations and settings will be selectable and/or adjustable via the HMI.

F. Coordinate self-healing and reset required alarms with Owner. All alarms shall be acknowledged via the HMI.

G. All alarm setpoints shall be adjustable from the HMI.

H. Pre-configure analog device feedback high-high, high, low, low-low, rate-of-change, and out-of-range alarms.

I. Other specific alarms are designated in the control loop descriptions.

3.5 PROCESS EQUIPMENT AND DEVICES

A. HMI graphic objects shall use color and text to indicate remote control mode, software mode, and operating states.
   1. Remote control modes will include Remote and Not in Remote.
   2. Software modes shall include Manual/Off/Auto modes.

a. Manual: Operator is control owner. If equipment and/or device is in remote control, ready for operation in any mode, and interlocks are satisfied the equipment operation shall follow operator commands.
b. Off: Equipment and/or device operation from IOP is disabled.
c. Auto: Program is control owner. If equipment and/or device is in remote control, ready for automatic operation, interlocks are satisfied, and permissives are satisfied, the equipment operation shall follow program commands.

3. States:
   a. Machine, pump, and blower operating states shall include stopped, stopping, starting, running.
   b. Valve and gate operating states shall include closing, closed, opening, and opened.
   c. Unique colors shall be used for stopped/closed, running/closed, starting/opening, and stopping/closing states. Coordinate colors with the Owner.
4. Variable speed and variable position devices shall include actual speed and/or position as applicable.
5. Alarm indications for process objects will include an alarm border and alarm priority symbol in the color of the highest priority active, unacknowledged alarm. Additionally, the alarm symbol shall include the priority value for said alarm.

B. Pop-up faceplate displays will be included for monitoring, controlling, and configuring equipment and/or devices capable of control from the HMI. Faceplates shall be accessed by a click event on the graphic object. At a minimum, faceplates shall include the following features and configured with the applicable access levels.
1. Operator:
   a. General display with 1) mode selector 2) manual speed (position) setpoint (if applicable); 3) cumulative interlocks, permissives, unit ready for automatic control status, actual state, and actual speed (if applicable).
   b. Diagnostics displays with status indications for each interlock trip, permissive trip, unit not ready trip, and fault trip.
   c. Operating statistics, such as elapsed time meters and operation cycle counts. This display shall also include a reset button to reset total values.
2. Maintenance:
   a. Include diagnostic features including the ability to disable operation separate from any operator-adjustable features.
   b. Provide a means to bypass interlocks and permissives that are configured with a bypass feature.
3. Engineer:
   a. Include all configuration settings required to fully control unit, including but not limited to default modes, bump-less transfer, operating range, individual interlock, and permissive bypassing.

C. All actuated or driven units shall include PLC logic and HMI features to calculate and display operating statistics, such as cycle counts and ETMs.
1. ETMs and cycle counters shall totalize the time and the number of times a unit is in the operating state, such as running or opened.
2. ETMs and cycle counters shall capture starts per hour, daily totals, monthly totals, and running totals for display on OIT. Running totals shall maintain values until reset via an operator-selectable reset button on the respective faceplate. Daily totals are reset at engineer-adjustable time-of-day.
3. Each ETM and cycle counter shall include provisions for users with Maintenance permissions to restore or set totalized values to a new value.

D. Equipment and/or devices with state feedback and remote control from the PLC, such as machines, valves and pumps, shall include a timeout alarm to indicate the commanded state was not achieved. Alarms for this type of failure must be reset by initiating an alarm reset from the HMI, achieving commanded state, local mode change, or software mode change.

E. Equipment and/or devices with remote control feedback to the HMI shall include an alarm to indicate when the field mode selector is not set for remote control.

3.6 PROCESS MONITORING AND CONTROL

A. Each process shall include Manual/Off/Auto modes for automatic control, overriding automatic control, and disabling HMI control.

B. Each process shall have an associated pop-up display that uses symbols, text, and color to indicate the actual process state. The following states shall be included. In some cases, not all states are required, and may be omitted as needed.
   1. Resetting, Idle, Starting, Executing, Completing, Complete
   2. Holding, Held, and Un-holding
   3. Suspending, Suspended, and Un-suspending
   4. Stopping and Stopped
   5. Aborting, Aborted, and Clearing

C. A PID pop-up display shall be provided for configuring, adjusting, and monitoring closed-loop process controls. At a minimum, PID displays shall include maintenance adjustable PID loop parameters, operator-adjustable set-point, and real time trend with set-point, process variable and control variable pens.

D. Provide alarms as required to indicate when a closed-loop process is out of control.

E. Calculate daily and monthly minimum, maximum, average, and total values for each flow process variable and display values on HMI.

F. Process overview displays shall indicate the highest priority, active, unacknowledged alarm for the area. The indication shall include the following features.
   1. Alarm border with a priority symbol around the area or unit in alarm.
   2. Alarm border and priority symbol shall reflect the color associated with the alarm priority.
   3. The priority symbol shall include the priority value.

3.7 SYSTEM FUNCTIONALITY

A. The process control system shall be setup initially with the basic functionality as described in Specification 40 61 96 – Process Control Descriptions. These descriptions shall be used as a guide for controlling various items by location and the Control System Specialist shall be expected to continually refine the system functionality throughout the execution of the project. Each automatic, manual and operator-initiated set point shall be configured with upper and lower limits to keep the process operating within an expected operating range. The Control System Specialist shall coordinate the functionality of each item in the control description with the Contractor, Owner and Operator. The Control System Specialist shall provide support for all functions in the HMI screens.

END OF SECTION

SECTION 40 70 00 – INSTRUMENTATION FOR PROCESS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. The work to be included under this section shall consist of furnishing all materials, labor, equipment, tools, supplies, and incidentals for installation of all instrumentation equipment. The work shall include every item of construction necessary for a complete and acceptable installation as shown on the Drawings and as specified herein.

B. Related Requirements:
   1. Section 40 61 13 – Process Control System General Provisions.
   2. Division 40 – Series Instrument Specifications.

1.2 REFERENCE STANDARDS

A. ISA S20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves

B. ISA S50.1 - Compatibility of Analog Signals for Electronic Industrial Process Instruments

C. ISA S51.1 - Process Instrumentation Terminology
   1. ISA S51.1; Sec. 5 - Test Procedures

1.3 COORDINATION

A. Section 01 30 00, ADMINISTRATIVE REQUIREMENTS.

B. Coordinate Work of this Section with piping Work.

1.4 SUBMITTALS

A. Section 01 33 00, SUBMITTAL PROCEDURES: Requirements for submittals.

B. Product Data: Submit manufacturer information for system materials and component equipment, including connection requirements.

C. Shop Drawings:
   1. Indicate system materials and component equipment.
   2. Submit installation requirements and other details.

D. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

E. Source Quality-Control Submittals: Indicate results of factory tests and inspections.

F. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

G. Manufacturer Reports: Certify that equipment has been installed according to manufacturer instructions.

H. Qualifications Statement:
   1. Submit qualifications for manufacturer.

1.5 CLOSEOUT SUBMITTALS

A. Section 01 77 00, CLOSEOUT PROCEDURES: Requirements for submittals.

B. Project Record Documents: Record actual locations and final orientation of equipment and accessories.

1.6 QUALITY ASSURANCE

A. Ensure that materials of construction of wetted parts are compatible with process liquid.

B. Materials in Contact with Potable Water: Certified to NSF 61 and NSF 372.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified with minimum three years' documented experience.

1.8 SOURCE QUALITY CONTROL

A. Section 01 40 00, QUALITY REQUIREMENTS, for testing, inspection, and analysis.

B. Certificate of Compliance:
   1. If manufacturer is approved by authorities having jurisdiction, submit certificate of compliance indicating Work performed at manufacturer's facility conforms to Contract Documents.

C. Similar instruments shall be by the same Manufacturer to the extent practical.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Section 01 60 00, PRODUCT REQUIREMENTS: Requirements for transporting, handling, storing, and protecting products.

B. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.

C. Store equipment according to manufacturer instructions.

D. Protection:
   1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
   2. Provide additional protection according to manufacturer instructions.

1.10 WARRANTY

A. Refer to Section 01 78 36, WARRANTY AND BONDS, and individual instrument sections for additional or longer warranty requirements.

PART 2 - PRODUCTS

2.1 EQUIPMENT

A. Furnish instruments as specified in the individual instrument specifications. Instruments for services not listed shall be equal in quality, performance, and environmental and functional characteristics as instruments listed and shall be approved in writing by the Owner.

2.2 INSTRUMENT ACCESSORIES

A. Instrument and Control Device Tags: Each field mounted field device shall be identified by its unique tag number as it appears on the original P&I diagrams and the Instrument Loop Diagram. The tag number shall be stamped on a 1" x 2" stainless steel tag permanently attached to the instrument by braided stainless steel wire which has been sealed by an approved method such that the wire must be cut, or the seal broken to remove the tag. The tag number shall not be stamped on the nameplate of the instrument. This requirement shall be documented on the Instrumentation Specification Sheet.

B. Sunshades: Furnish stainless steel sunshades for all outdoor instruments not shaded by adjacent or integral equipment.

C. Process Tubing: Stainless Steel, ASTM A 269, TP316, seamless, annealed, 1/2" x 0.065" W.T. minimum.

D. Pneumatic Supply Tubing: Stainless Steel, ASTM A 269, TP316, seamless, annealed, 1/2" x 0.065" W.T., 3/8" x 0.049" W.T. and 1/4" x 0.035" W.T. minimum.

E. Fittings: 316 Stainless Steel ferrule type, SWAGELOCK or equal.

F. Pipe Stand Type Supports for Instrumentation: Pipe stands shall be stainless steel using welded fabrications with 2” schedule 40 pipe, 2” square tube x 0.188” thick, 3/8 zinc/cadmium plated hardware, 1/2” expansion anchors, 12 gauge mounting channel and 1/4” thick stainless steel plate as a minimum. Supply u-bolts or cable mounts, as necessary. Acceptable alternatives include engineered pipe stand systems such as O'Brien Saddlepak.

G. Enclosures for outdoor locations: Furnish and install NEMA 4X enclosures. All outdoor enclosures with instrumentation accessible in enclosure door shall have a stainless steel sunshade.

2.3 INSTRUMENTATION CABLING

A. Instrumentation signal wiring shall meet the following requirements:
1. 18AWG minimum stranded tinned copper twisted pairs and triads as applicable for the application.
2. Color code shall be black/red pair (black/red/white triad).
3. Individually shielded with shield drain wires.
4. Insulation to be polyethylene PE or PVC.
5. Outer jacket to be black polyvinyl chloride PVC.

2.4 CALIBRATION

A. Order instruments factory calibrated to the range indicated with calibration sheets indicating certification of traceability to National Institute of Standards and Technology (NIST). Instruments shall be ranged as indicated in the specification or as directed by Engineer.

2.5 FABRICATION
1. Materials of Construction: Provide 316 Stainless Steel for wetted and other parts unless otherwise specified.

2.6 HAZARDOUS LOCATION APPROVALS
1. Where installed within a hazardous location, instruments shall bear agency approvals for the identified class, division, and group of the hazardous location.
2. Hazardous location boundaries shall be as defined by NFPA 820 – Standard for Fire Protection in Wastewater Treatment and Collection Facilities. Consult the Engineer or

Authority Having Jurisdiction for a determination when hazardous location identification is uncertain.

3. Provide intrinsically safe wiring methods for connection of instruments located within a hazardous location.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Section 01 77 00, CLOSEOUT PROCEDURES: Requirements for installation and examination.

B. Verify that items provided by other Sections of Work are ready to receive Work of this Section.

3.2 INSTALLATION

A. Coordinate location and orientation of instrumentation with final equipment installations.

B. Ensure that instruments are located to be easily accessible for maintenance.

C. Install sensing elements at the point of measurement and route sensing line or cable to the transmitter. Install the transmitters 4'-6" above grade or platform in an easily accessible location adjacent to the sensor location. Mount on pipe stanchion or support designed for the purpose individually or grouped with other transmitters.

D. Surge Protection
1. 2-wire Loop Powered Instruments: Furnish and install surge protector, Emerson EDCO SS65 or equal, in each 4-20 mA current loop, adjacent to each respective instrument.
2. 4-wire Separately Powered Instruments: Furnish and install 120VAC/24VDC combination surge protector, EDCO SLAC-12036 or equal, adjacent to each respective instrument.

E. Steel supports shall be in accordance with this Section, and all other sections and specification requirements.

F. Process connections for instrumentation shall be in accordance with piping sections and all other specification requirements.

G. Provide block valves at taps for pressure or sampling sensor lines. Provide plugged tees at taps suitable for rodding or blowing out taps. Make pipe taps with weld-o-let type fittings or equal. Install block valves suitable for the service and rated as the pipe at each tap, generally use NPT threaded ball valves. Use materials rated for the service and transition to tubing for sensor runs. Use 1/2” OD 316 SS tubing or as shown on the Drawing details.

H. Tubing and Fittings:
1. Install tubing and fittings in a neat, orderly, and functional manner; level and plumb except as required, noted on approved drawings, or specified. Make offsets required for fittings or equipment level in the horizontal plane to prevent high or low spots.

I. Conduit and fittings:
1. Install conduit as required. Provide a cast body tee fitting at the instrument connections at the low point of all conduit runs below the instrument with a drain fitting for condensate. Make connections from instrument to tee with liquid-tight flexible conduit and use sealing compound inside the conduit and shrink-fit tubing over the outside of the connection to prevent entry of water into the instrument. Heat trace and insulate all liquid filled lines and the sensing body of all instruments connected to liquid service in exterior locations.

J. Calibration
   1. Calibrate each and every instrument connected to the work of this contract in its range, whether furnished under this contract, Owner-furnished, or existing, and fill out a signed and dated five point calibration sheet and install an initialed and dated calibration sticker. Notify the Owner in writing immediately of any instrument which will not calibrate. Instruments that do not calibrate will require the on-site services of a factory authorized representative at no cost to the Owner.

3.3 FIELD QUALITY CONTROL

A. Section 01 40 00, QUALITY REQUIREMENTS for inspecting and testing.

B. Testing:
   1. Test and calibrate instruments to demonstrate that they meet specified accuracy requirements.

C. Manufacturer Services: Furnish services of manufacturer's representative experienced in installation of products furnished under this Section for not less than 1 days on Site for installation, inspection, startup, field testing, and instructing Owner's personnel in operation and maintenance of equipment.

D. Equipment Acceptance:
   1. Adjust, repair, modify, or replace components failing to perform as specified and rerun tests.
   2. Make final adjustments to equipment under direction of manufacturer's representative.

E. Furnish installation certificate from equipment manufacturer's representative attesting that equipment has been properly installed and is ready for startup and testing.

3.4 DEMONSTRATION

A. Section 01 75 00, STARTUP TESTING AND TRAINING.

B. Demonstrate equipment startup, shutdown, routine maintenance, and emergency repair procedures to Owner's personnel.

SECTION 40 73 13 - PRESSURE AND DIFFERENTIAL PRESSURE GAUGES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Pressure gauges.

1.2 REFERENCE STANDARDS

A. ASME International:
   1. ASME B40.100 - Pressure Gauges and Gauge Attachments.

1.3 COORDINATION

A. Refer to Section 40 70 00, INSTRUMENTATION FOR PROCESS SYSTEMS, for requirements.

1.4 SUBMITTALS

A. Refer to Section 40 70 00, INSTRUMENTATION FOR PROCESS SYSTEMS, for requirements.

1.5 CLOSEOUT SUBMITTALS

A. Refer to Section 40 70 00, INSTRUMENTATION FOR PROCESS SYSTEMS, for requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 40 70 00, INSTRUMENTATION FOR PROCESS SYSTEMS, for requirements.

1.7 WARRANTY

A. Furnish a five-year manufacturer's warranty from final acceptance by the Owner and Engineer for the pressure gauges.

1.8 SPARE PARTS

A. Gauges Other Than Diaphragm Protected: Furnish 20 percent spare gauges, with a minimum of one gauge for each range used.

B. Diaphragm-Protected Gauges: Furnish 20 percent spare gauges, with a minimum of one gauge for each range used, complete with diaphragm seals.

PART 2 - PRODUCTS

2.1 PRESSURE GAUGES

A. Manufacturers:
   1. Ametek U.S. Gauge
   2. Ashcroft, Inc.
   3. Omega Engineering, Inc.
   4. Wika
   5. Winters Gauges

B. Dials:
   1. Nominal Diameter: 6 inches.

2. Face: White, laminated plastic dials with black graduations.
3. Scale: Extend over arc not less than 270 degrees.
4. Ranges and Graduation Units: As indicated on pressure gauge schedule.

C. Cases:
1. Liquid filled.
2. Material: Aluminum.
3. Type: Blowout protected.
4. Provide removable rear plate.
5. Windows:
a. Material: Clear, shatterproof glass.
b. Thickness: 1/8 inch.
c. Provide gasket.

D. Connection:
1. Location: Bottom.
2. Socket:
a. 1/4-inch or ½-inch NPT male thread.
b. Material: Brass forging.
c. Extend minimum 1-1/4 inches below gauge cases.
d. Provide wrench flats.
3. Mounting: As indicated on Drawings.

E. Measuring Element:
1. Bourdon Tubes:
a. Material: Phosphor bronze, to brass socket.
b. Provide welded, stress-relieved joints.
2. Movement:
a. Rotary geared.
b. Material: Stainless steel.
3. Accuracy:
a. Comply with ASME B40.100.
b. Plus and minus 0.5 percent of full-scale range.

F. Adjustment:
1. Provide for zero-reading adjustment.
2. Adjusting Screws: Accessible from rear of case without need for disassembly.

G. Accessories:
1. Pressure Snubber:
a. Material: Type 316 stainless steel.
b. Provide isolation valve.
2. Shutoff Cocks: Furnished by gauge manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Refer to Section 40 70 00, INSTRUMENTATION FOR PROCESS SYSTEMS, for requirements.

3.2 INSTALLATION

A. Coordinate location and orientation of gauges and seal assemblies with final piping and equipment installations.

B. Ensure that gauges are located to be easily read during operation and easily accessible for maintenance.

C. Where a 90-degree fitting is required, install a tee-fitting with a plug.

D. Refer to Section 40 70 00, INSTRUMENTATION FOR PROCESS SYSTEMS, for additional requirements.

3.3 FIELD QUALITY CONTROL

A. Refer to Section 40 70 00, INSTRUMENTATION FOR PROCESS SYSTEMS, for requirements.

3.4 DEMONSTRATION

A. Refer to Section 40 70 00, INSTRUMENTATION FOR PROCESS SYSTEMS, for requirements.

3.5 ATTACHMENTS

A. Pressure Gauge Schedule:

Sensor Tag	**Application**	**Measurement Range**
31PI1	Mixing Pump #1 Discharge Pressure	0 – 30 psi
31PI2	Mixing Pump #2 Discharge Pressure	0 – 30 psi
31PI3	Mixing Pump #3 Discharge Pressure	0 – 30 psi

END OF SECTION

SECTION 40 73 36 - PRESSURE AND DIFFERENTIAL PRESSURE SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Pressure switches.
   2. Differential pressure switches.

1.2 REFERENCE STANDARDS

A. National Electrical Manufacturers Association:
   1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
   2. NEMA ICS 1 - Industrial Control and Systems: General Requirements.

1.3 COORDINATION

A. Refer to Section 40 70 00, INSTRUMENTATION FOR PROCESS SYSTEMS, for requirements.

1.4 SUBMITTALS

A. Refer to Section 40 70 00, INSTRUMENTATION FOR PROCESS SYSTEMS, for requirements.

1.5 CLOSEOUT SUBMITTALS

A. Refer to Section 40 70 00, INSTRUMENTATION FOR PROCESS SYSTEMS, for requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 40 70 00, INSTRUMENTATION FOR PROCESS SYSTEMS, for requirements.

1.7 WARRANTY

A. Furnish a five-year manufacturer's warranty from the final acceptance by the Owner and Engineer for the pressure switches.

PART 2 - PRODUCTS

2.1 PRESSURE SWITCHES

A. Manufacturers:
   1. Ashcroft Inc.
   2. Dwyer Instruments, Inc.
   3. Omega Engineering, Inc.
   4. Winters Gauges

B. Type: Diaphragm actuated.

C. Materials:
   1. Diaphragm: Buna-N Stainless steel.
   2. Housing: Brass.

D. Accuracy: Plus or minus 5 percent of operating range.

E. Dead Band: Adjustable to 60 percent of full scale.

F. Set Points: Adjustable between 20 and 80 percent of adjustable range.

G. Connection:
1. Location: Bottom.
2. Size: 1/4 inch.
3. Furnish taps for sensing lines.

H. Electrical:
1. Contacts:
a. Two.
b. SPDT.
c. Type: Snap action, according to NEMA ICS 1.
2. Ampacity: 5 A at 120-V ac.

I. Enclosures: NEMA 250 Type 4X.

J. Differential Pressure Switches:
1. Type: Adjustable diaphragm.
2. Differential Range:
a. Adjustable.
b. Maximum: 0.50 inch water at low end.
c. Minimum: 6 inches water at high end.
3. Accuracy: Plus or minus 2.0 percent of full-scale range.
4. Maximum Operating Pressure: Up to 300 percent of rated pressure.
5. Transmitter: Operable with low-pressure connection disconnected.

K. Operation:
1. Control Power Wiring: As specified in Section 26 27 26, WIRING DEVICES.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Refer to Section 40 70 00, INSTRUMENTATION FOR PROCESS SYSTEMS, for requirements.

3.2 INSTALLATION

A. Refer to Section 40 70 00, INSTRUMENTATION FOR PROCESS SYSTEMS, for requirements.

3.3 FIELD QUALITY CONTROL

A. Refer to Section 40 70 00, INSTRUMENTATION FOR PROCESS SYSTEMS, for requirements.

3.4 DEMONSTRATION

A. Refer to Section 40 70 00, INSTRUMENTATION FOR PROCESS SYSTEMS, for requirements.

3.5 ATTACHMENTS

A. Pressure Switch Schedule:

Sensor Tag	Application	Measurement Range
31PSL1	Mixing Pump #1 Low Suction Pressure	TBD
31PSL2	Mixing Pump #2 Low Suction Pressure	TBD
31PSL3	Mixing Pump #3 Low Suction Pressure	TBD

END OF SECTION

SECTION 40 92 16 – MANUAL VALVE AND GATE OPERATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Valve and Gate Operators.
   2. Handwheel Operators.
   3. Key Operated Valves.
   4. Bench Stands.
   5. Floor Stands.
   6. Accessory Equipment and Floor Boxes.

B. Related Sections:
   1. Section 01 33 00 – Submittal Procedures.
   2. Section 01 40 00 – Quality Requirements.
   3. Section 01 60 00 – Product Requirements.
   4. Section 01 77 00 – Closeout Procedures.
   5. Section 40 23 43 – Process Valves.

1.2 GENERAL

A. Certain valve operators are specified in Division 44 to be furnished by equipment manufacturer as part of their equipment package and/or system. These valve operators are to be installed by the Contractor as specified herein. In addition to installation, the Contractor shall be responsible for test, inspection, and assisting the equipment suppliers in startup services as required to the place the valve operators into continuous, reliable operation.

1.3 SCHEDULES

A. Operator schedules are combined with Process Valve Schedules in Section 40 23 43, PROCESS VALVES.

1.4 REFERENCES

A. Aluminum Association
   1. DAF-45 – Design for Aluminum Finishes

1.5 SUBMITTALS

A. Submittals shall be made as required in Section 01 33 00, SUBMITTALS. The following specific information shall be provided:
   1. Shop Drawings:
      a. Product data sheets for make and model.
      b. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
      c. Power and control wiring diagrams, including terminals and numbers.
      d. Complete motor nameplate data.
      e. Open/close and throttle actuators sizing calculations including factor of safety used and final torques used for actuation selection.
      f. Refer to specific valve type for additional submittal requirements.
   2. Quality requirements Submittals:
      a. Special shipping, storage and protection, and handling instructions.

b. Suggested spare parts list to maintain the equipment in service for a period of 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
c. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.

1.6 OPERATION AND MAINTENANCE DATA

A. O&M Manuals: Content, format, and schedule for providing as specified in Section 01 77 00, CLOSEOUT PROCEDURES.

B. Maintenance Summary Forms: As specified in Section 01 77 00, CLOSEOUT PROCEDURES.

1.7 QUALITY ASSURANCE

A. Provide valve operators integral with the valve or gate, except for valve operators utilizing T-wrenches or keys, and portable operators intended to operate more than one valve.

B. Provide all similar operators by one manufacturer.

C. Provide gates and hand operating lifts by one manufacturer.

D. Provide hydraulic gate lifts by one manufacturer.

E. Provide hydraulic valve operators and motorized operators by one manufacturer.

1.8 MAINTENANCE

A. Extra Materials:
1. Key Operated Valve Keys or Wrenches: Furnish a minimum of four keys with 4-foot shafts and 3-foot pipe handles or wrenches with 4-foot shafts and 3-foot handles for operating key operated valves.

PART 2 - PRODUCTS

2.1 GENERAL

A. Size operator to operate valve for the full range of pressures and velocities.

B. Valve to open by turning counterclockwise.

C. Factory-mount the operator, actuator, and accessories.

2.2 VALVE OPERATORS

A. Manual Operator:
1. General:
a. Operator force not to exceed 40 pounds under any operating condition, including initial breakaway, and gear reduction operator when force exceeds 40 pounds.
b. Operator self-locking type or equipped with self-locking device.
c. Position indicator on quarter-turn valves.
d. Worm and gear operators one-piece design worm-gears of gear bronze material. Worm hardened alloy steel with thread ground and polished. Traveling nut type operators, threader steel reach rods with internally threaded bronze or ductile iron nut.

2. Exposed Operator:
    a. Galvanized and painted hand wheels.
    b. Lever operators allowed on quarter-turn valves 8” and smaller.
    c. Cranks on gear type operators.
    d. Chain wheel operator with tiebacks, extension stem, floor stands, and other accessories to permit operation from normal operation level.
    e. Valve handles to take a padlock and wheels a chain and padlock.
3. Buried Operator:
    a. Buried service operators on valves larger than 2-1/2 inch shall have a 2-inch AWWA operating nut. Buried operators on valves 2 inch and smaller shall have cross handle for operation by forked key. Enclose moving parts of valve and operator in housing to prevent contact with the soil.
    b. Design buried service operators for quarter-turn valves to withstand 450 foot-pounds of input torque at the FULLY OPEN or FULLY CLOSED positions, grease packed and gasketed to withstand a submersion in water to 10 psi.
    c. Buried valves shall have extension stems, bonnets, and valve boxes.

2.3 VALVE AND GATE OPERATORS

A. Stem Covers: Aluminum pipe; threaded cap on top; bolted aluminum flange on bottom; 1 by 12-inch slots cut at 18 inches on center in front and back of pipe; capable of covering threaded portion of greased stems that project above operators when gates or valves are opened or closed.

B. Stem Cover Flanges, Pipes and Caps: Etched and anodized to produce chemical finishes in accordance with AA C 22, medium matte finish, and AA A 41 clear anodic coating, or described in AA publication 45, after fabrication.

C. Gate Stem Covers: Concentric with stem

D. Position Indicators: Tail rods on hydraulic cylinders, or dial indicators with clear full-open and closed position indicators, calibrated in number of turns or percentage of opening.

E. Manual or Power Operator Size: Sized to deliver maximum force required under most severe specified operating condition, including static and dynamic forces, seat and wedge friction, and seating and unseating forces with safety factor of 5, unless otherwise specified.

F. Operator Size: Capable of supporting weight of suspended shafting unless carried by bottom thrust bearings; shaft guides with wall mounting brackets.

G. Provisions for Alternate Operation: Where specified or indicated on the Drawings, position and equip crank- or handwheel-operated geared valve operators or lifts for alternate operation with tripod mounted portable gate operators.

H. Operation: Counterclockwise to open with suitable and adequate stops, capable of resisting at least twice normal operating force to prevent overrun of valve or gate in open or closed position.

I. Open Direction Indicator: Cast arrow and legend indicating direction to rotate operator on handwheel, chain wheel rim, crank, or other prominent place.

J. Buried Operator Housing: Oil and watertight, specifically designed for buried service, factory packed with suitable grease, completely enclosed space between operator housing and valve body so that no moving parts are exposed to soil; provide operators with 2-inch square AWWA operating nut.

K. Worm Gear Operators: Provide gearing on worm gear operators that is self-locking with gear ratio such that torque in excess of 160 foot-pounds will not need to be applied to operate valve at most adverse conditions for which valve is designed.

L. Traveling Nut Operators: Capable of requiring maximum 100 foot-pounds of torque when operating valve under most adverse condition; limit stops on input shaft of manual operators for fully open and closed positions; non-moving vertical axis of operating nut when opening or closing valve.

2.4 HANDWHEEL OPERATORS

A. Manufacturers:
1. Rodney Hunt Company.
2. Waterman Industries, Incorporated.

B. Mounting: Floor stand or bench stand. Unless otherwise indicated on the Drawings position operator 36-inches (nominal) above top of walkway surface.

C. Bearings above and below Finished Threaded Bronze Operating Nut: Ball or roller.

D. Wheel Diameter: Minimum 24-inch.

E. Indicator: Counterclockwise opening with arrow, and word OPEN cast on top of handwheel indicating direction for opening.

F. Pull to Operate: Maximum 40 pounds pull at most adverse design condition.

G. Stem Travel Limiting Device: Setscrew locked stop nuts above and below lift nut.

H. Grease Fittings: Suitable for lubrication of bearings.

2.5 HAND-CRANKED GEARED OPERATORS

A. Type: Single removable crank; fully enclosed.

B. Mounting: Floor and Bench Stand. Unless otherwise indicated on the Drawings, position the operator 36-inches (nominal) above the top of the walkway surface.

C. Operating Nut: When scheduled for portable operators.

D. Geared Lifts: 2-speed with minimum ratio of 4 to 1.

E. Teeth on Gears, Spur Pinions, Bevel Gears, and Bevel Pinions: Cut.

F. Lift Nuts: Cast manganese bronze.

G. Exterior Surfaces on Cast Iron Lift Parts: Smooth.

H. Bearings above and below Flange on Lift Nuts: Ball or roller; capable of taking thrust developed by opening and closing of gates under maximum operating head; with bronze sleeve bearings and sufficient grease fittings for lubrication of moving parts, including bearings and gears.

I. Crank Rotation Indicator: Cast arrow with word OPEN in prominent, readily visible location indicating correct rotation of crank to open gate.

J. Hand Cranks: 15-inch radius; requiring maximum 25 pounds pull to operate gate at maximum operating head with:
   1. Revolving brass sleeves.
   2. Gears, spur pinions, bevel gears, and bevel pinions with cut teeth.
   3. Cast manganese bronze lift nuts.
   4. Cast iron lift parts with smooth exterior surfaces.

K. Indicator: Dial position type mounted on gear operator; enclosed in cast iron or aluminum housing with clear plastic cover; marked with fully open, 3/4, 1/2, 1/4, and closed positions.

2.6 FLOOR BOX AND STEM

A. Manufacturers:
   1. Waterman Industries, Inc.
   2. Neenah Foundry; R 7506.
   3. Clow; No. F5690.

B. Floor Boxes: Cast iron with:
   1. Plain type, for support of nonrising type stem.
   2. Complete with stem, operating nut, and stem guide brackets.
   3. Stem Guide: Space such that stem UR ratio does NOT exceed 200.
   4. Anchor Bolts: Type 304 SST.
   5. Counter type indicator.
   6. Hinged, lockable lid with directional arrow.
   7. 2-inch square AWWA operating nut.
   8. Packing gland providing drip-tight seal around valve shaft.

2.7 FLOOR STAND AND EXTENSION STEM

A. Manufacturers:
   1. Clow; Figure F-5515.
   2. Mueller, Figure A-26426.
   3. Rodney Hunt Company.
   4. Waterman Industries, Incorporated.

B. Floor Stand Assemblies: Heavy-duty cast iron, suitable for mounting specified operator.
   1. Nonrising, indicating type.
   2. Complete with stem, coupling, hand wheel, stem guide brackets, and yoke attachment.
   3. Stem Guide: Space such that stem UR ratio does NOT exceed 200.
   4. Anchor Bolts: Type 304 SST.

2.8 BENCH STANDS

A. Manufacturers:
   1. Rodney Hunt Company.
   2. Waterman Industries, Incorporated.

B. Bench Stands: Handwheel operators or hand crank, geared operators conforming to hand-cranked geared operator requirements, except capacity to be mounted on haunch, wall bracket, or self-contained gate yoke.

2.9 ACCESSORY EQUIPMENT

A. T-Handled Operating Wrench:
   1. 2 each galvanized operating wrenches, 4 feet long.

2. Manufacturers and Products:
    a. Mueller; No. A-24610.
    b. Clow No.; F-2520.
3. 2 each galvanized operating keys for cross handled valves.

B. Extension Bonnet for Valve Operator: Complete with stem and accessories for valve and operator.
1. Manufacturers and Products:
    a. Metallic Valves:
        1) Pratt.
        2) Allis-Chalmers.
    b. Plastic Valves:
        1) ASAHI/America.

C. Chain Wheel and Guide:
1. Install chain wheel and guide assemblies or chain lever assemblies on manually operated valves over 6.75-feet above finished floor. Use appropriate “L” type tie-back anchors where chains hang in normally traveled areas. Hand wheel direct-mount type.
2. Complete with chain.
3. Galvanized or cadmium-plated.
4. Manufacturers and Products:
    a. Clow Corp.; Figure F-5680.
    b. Walworth Co.; Figure 804.
    c. DeZurik Corp.; Series W or LWG.

D. Wall Brackets or Haunches: As indicated on the Drawings.

E. Stems: Stainless steel; sized to match output of operator; minimum gate or valve operating stem diameter; maximum 200 slenderness ratio.

F. Stem Couplings: Stainless steel; internally threaded to match stem; lockable to stem by set screw.

G. Stem Guides: Cast iron with silicon bronze bushing; maximum 200 slenderness ratio; capable of being mounted with a wall bracket; adjustable in two directions.

H. Wall Brackets: Cast iron, capable of withstanding the output of the operator; adjustable in two directions.

I. Stem Stuffing Boxes: Cast iron, with adjustable gland and packing.

J. Fasteners and Anchor Bolts: 316 stainless steel.

K. Geared Valve Operators: Provided with cut gears, either spur or worm; sized to operate valves at most adverse design condition; with maximum 40-pound pull at handwheel or chain wheel rim.

L. Geared Valve Traveling Nut Operators: Acceptable only where specified or indicated on the Drawings.

M. Accessory Equipment for Valves and Gates Requiring Remote Operators: Operating stems, stem couplings, stem guides, wall brackets, and stem stuffing boxes.

PART 3 - EXECUTION

3.1 SHIPPING, STORAGE, HANDLING, AND PROTECTION

A. As specified in Section 01 60 00, PRODUCT REQUIREMENTS.

3.2 INSTALLATION

A. Install floor boxes in concrete floor with lid flush with floor.

B. After installation of gate and stem covers, mark stem covers at point where top of stems are at full-open position and at closed position.

C. Attach floor stand to structure with anchor bolts.

D. Install stem stuffing boxes where operating stems pass through intermediate concrete floor slabs.

3.3 SCHEDULES

A. Provide Geared Operators for:
   1. Butterfly valves larger than 6 inches, nominal size, on liquid service.
   2. Butterfly valves larger than 10 inches, nominal size, on gas and air service.
   3. Plug valves 6 inches, nominal size, and larger.

B. Handwheel operators: Provide handwheel operators for valves mounted at 6 feet or less above floors.

C. Chain Wheel Operators: Provide chain wheel operators for valves mounted more than 6 feet to centerline above floors.

END OF SECTION

DIVISION 41

MATERIAL PROCESSING AND HANDLING EQUIPMENT

SECTION 41 10 01 DIGESTER GAS SAFETY EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Work necessary to furnish all labor, materials, equipment, and incidentals required to manufacture, completely install, adjust, protect, put in operation, and test the digester gas safety equipment as shown on the Drawings and as specified herein.

B. Related Sections:
1. Section 01 14 00 – Work Restrictions.
2. Section 01 33 00 – Submittals Procedures.
3. Section 01 40 00 – Quality Requirements.
4. Section 01 60 00 – Product Requirements.
5. Section 01 75 00 – Startup Testing and Training

1.2 GENERAL

A. Like items of equipment provided hereinafter shall be the end products of one Manufacturer to achieve standardization of appearance, operation, maintenance, spare parts, and Manufacturer's services.

B. General Requirements: See Division 01, GENERAL REQUIREMENTS, which contains information and requirements that apply to the Work specified herein and are mandatory for this project.

C. Unit Responsibility: The Work requires the digester gas safety equipment, complete with all accessories and appurtenances, be the end product of one responsible Manufacturer. The Manufacturer shall furnish all components and accessories of the system to enhance compatibility, ease of operation and maintenance, and as necessary to place the equipment in operation in conformance with the specified performance, features and functions without altering or modifying the Contractor's responsibilities under the Contract Documents.

D. The equipment specified herein is included in form ATTACHMENT B – LIST OF MANUFACTURERS provided in the front-end documents. Contractor shall identify the proposed manufacturer of the equipment specified on this form with the submitted bid.

1.3 SUBMITTALS

A. General: Administrative, shop drawings, samples, quality control, and contract close-out submittals shall conform to the requirements of Section 01 33 00, SUBMITTAL PROCEDURES.

B. In addition to the requirements of Section 01 33 00, SUBMITTAL PROCEDURES, submit the following additional information:
1. Shop Drawings:
    a. Make, model, weight, and horsepower of each component.
    b. Manufacturer's catalog information, descriptive literature, specifications, and identification of materials of construction.
    c. Performance Affidavit
    d. Complete design data and pressure drop information for each size and type of gas safety and control accessory provided.
    e. Design and manufacturing certification documentation, to substantiate compliance with the specifications.

1.4 OPERATION AND MAINTENANCE DATA

A. O&M Manuals: Content, format, and schedule for providing as specified in Section 01 77 00, CLOSEOUT PROCEDURES.

B. Maintenance Summary Forms: As specified in Section 01 77 00, CLOSEOUT PROCEDURES.

1.5 WARRANTY

A. Provide warranty for a period of 12 months after the final acceptance of the equipment by the Owner and Engineer. The warranty shall stipulate that the equipment furnished is suitable for the purpose intended and free from defects of material and workmanship for the duration of the warranty. In the event the equipment fails to perform as specified, the Manufacturer will promptly repair or replace the defective equipment without additional cost to the Owner.

B. Spare parts identified within this specification shall not be used to address warranty repairs.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Where a Manufacturer's standard equipment name and/or model number is listed, the digester gas safety equipment shall be provided to conform to the performance, functions, features, and materials of construction as specified herein.

B. Manufacturer of components and accessories specified herein shall be as follows:
1. Varec Biogas.
2. Shand & Jurs.

2.2 GENERAL REQUIREMENTS

A. See Section 01 60 00, PRODUCT REQUIREMENTS, for specific requirements related to the equipment specified herein.

B. All equipment shall be supplied complete. Parts shall have liberal strength, stability and stiffness and shall be especially adapted for the intended service. Ample room and facilities shall be provided for inspection, repairs, and adjustments.

C. Stainless steel nameplates giving the name of the Manufacturer, the serial number, model number, horsepower, speed, and any other pertinent data shall be attached to the item.

D. All gas safety and control devices shall be constructed of first quality materials which have strength, wearing, and corrosion resistance characteristics entirely suitable for the types of service for which the individual devices are designated. All gas safety and control equipment provided under this Contract shall be designed and manufactured in accordance with ISO 9001.

E. All body castings shall be clean, sound, and without defects of any kind. No plugging, welding, or repairing of defects will be allowed.

F. All bolt heads and nuts shall be hexagonal of American Standard size. All hardware shall be 316 stainless steel. The Contractor shall be responsible for coordinating connecting piping. Gas safety and control devices with screwed ends shall be made tight with Teflon tape. Unions are required at all screwed joint valves within a run of pipe.

G. Unless otherwise specified, all equipment to be installed in piping less than 4 inches shall have NPT connections and equipment installed in piping 4 inches and larger shall have flanged connections. Unless otherwise specified, flanges shall be flat faced with ANSI B16.1, Class 125 diameter and drilling.

2.3 SERVICE CONDITIONS

A. Digester gas safety and control equipment shall be designed for digester gas service with saturated gas composed of approximately 61% methane and 33% carbon dioxide, 5% water vapor, and 1% hydrogen sulfide having a heating value between 550 and 650 Btu per cubic foot, temperature between 40°F and 110°F, and a specific gravity of approximately 0.80-0.90.

B. Gas control systems shall include all safety devices specified, indicated on the Drawings, or otherwise required to ensure continuous protection against fire, explosion, and gas hazard.

2.4 FLAME ARRESTERS

A. The contractor shall provide flame arresters in the gas piping as shown on the Drawings to prevent the passage of flame by means of a removable flame-arresting bank arranged for easy removal for cleaning, inspection, and replacement without disturbing adjacent piping.

B. Flame arresters shall be Varec Biogas 5000/5010 Series or Shand & Jurs Model 94309.

C. Flame arresters shall be provided with Underwriters Laboratory (UL) and/or Factory Mutual (FM) approved elements, or elements of similar design and configuration as elements approved by UL and/or FM for similar service conditions.

D. Net free area through the bank assembly shall be not less than three times the corresponding size standard pipe. The entire bank assembly shall slide out of the arrester housing to facilitate inspection and cleaning.

E. The bank assembly shall be filled with corrugated rectangular shaped sheets. The flame sheets shall be arranged to facilitate removal for inspection and cleaning.

F. Flame arresters for vertical installation shall be self-draining. Flame arresters for horizontal service shall include an offset housing with a 1/2-inch NPT drip trap connection at the low point.

G. Housing construction shall be 356-T6 low copper cast aluminum. Bank assembly shall include a low copper aluminum frame and low copper aluminum bank sheets.

H. Flame arrester shall be leakproof to 10 psig.

I. Drain piping with drip traps shall be provided from the inverts of all horizontally installed flame arresters which do not completely drain to adjacent piping.

J. Flame arresters shall be provided in accordance with the following minimum free air capacity (FAC = 60°F at 14.7 psia) and maximum pressure drop requirements.

Size (inches)	Minimum FAC (CFH)	Maximum ΔP (inches w.c.)
4	15,000	2.0
6	30,000	2.0
8	50,000	2.0
10	90,000	2.0
12	120,000	2.0

2.5 PRESSURE RELIEF AND VACUUM BREAKER VALVE

A. Pressure relief and vacuum breaker valves shall be provided at the locations shown on the drawings.

B. The pressure relief and vacuum breaker valves shall be Varec Biogas Model 2011B or Shand & Jurs 94020.

C. The pressure relief and vacuum breaker valves shall provide both over-pressure and over-vacuum protection for the anaerobic digester. The valve shall be suitable for installation in an exterior location and operation in all-weather conditions.

D. The pressure relief and vacuum breaker valve shall have a 356-T6 low copper cast aluminum body with Type 316 stainless steel pallet assembly and seating ring. Pallet seats shall be PTFE.

E. The pressure relief and vacuum breaker valve shall be weight loaded with removable lead weights to allow adjustment of the pressure relief pallet. Pallet weights shall be lead. The pressure pallet shall be adjustable from +2-inches to +15-inches water column. The vacuum pallet shall be set at -2-inches water column.

F. The pressure and vacuum breaker valve provided shall have the following minimum free air capacity (FAC = 60°F at 14.7 psia) at the indicated over-pressure and over-vacuum operating conditions.

Size (inches)	Minimum FAC (CFH)	Set Pressure (inches w.c.)	Over-Pressure (of Set Pressure)
4	60,000	+12.0	50%
6	140,000	+12.0	50%
8	180,000	+12.0	50%
10	300,000	+12.0	50%
12	500,000	+12.0	50%

Size (inches)	Minimum FAC (CFH)	Set Pressure (inches w.c.)	Over-Vacuum (of Set Pressure)
4	20,000	-2.0	100%
6	40,000	-2.0	100%
8	80,000	-2.0	100%
10	120,000	-2.0	100%
12	180,000	-2.0	100%

2.6 PRESSURE RELIEF AND VACUUM BREAKER WITH FLAME ARRESTER – DIGESTER COVERS

A. Pressure relief and vacuum breaker valves with flame arresters shall be provided at the locations shown on the Drawings.

B. The pressure relief and vacuum breaker valves with flame arrester shall provide both over-pressure and over-vacuum protection for the anaerobic digester. The valve shall be suitable for installation in an exterior location and operation in all-weather conditions.

C. The pressure and vacuum breaker valves with flame arrester shall be Varec Biogas 5811B or Shand & Jurs 97571. The pressure and vacuum breaker valves shall meet the materials of construction requirements specified in Paragraph 2.5. The flame arrester shall meet the materials of construction requirements specified in Paragraph 2.4.

D. The pressure and vacuum breaker valve with flame arrester provided shall have the following minimum free air capacity (FAC = 60°F at 14.7 psia) at the indicated over-pressure and over-vacuum operating conditions.

Size (inches)	Minimum FAC (CFH)	Set Pressure (inches w.c.)	Over-Pressure (of Set Pressure)
4	60,000	+12.0	50%
6	140,000	+12.0	50%
8	180,000	+12.0	50%
10	300,000	+12.0	50%
12	500,000	+12.0	50%

Size (inches)	Minimum FAC (CFH)	Set Pressure (inches w.c.)	Over-Vacuum (of Set Pressure)
4	60,000	-2.0	100%
6	140,000	-2.0	100%
8	180,000	-2.0	100%
10	300,000	-2.0	100%
12	500,000	-2.0	100%

2.7 SAFETY SELECTOR VALVE – DIGESTER COVERS

A. Safety selector valves shall be provided at each pair of pressure relief and vacuum breaker with flame arrester assemblies at the digester covers as shown on the drawings.

B. Safety selector valves shall be of aluminum body with stainless steel internal components and hardware. Minimum C_V values shall be 1,000 (4-inch size), 2,700 (6-inch size), 4,500 (8-inch size).

C. Safety Selector Valves shall be Varec Biogas Model SVR or Shand & Jurs 97190.

2.8 TOOLS AND SPARE PARTS

A. None.

PART 3 - EXECUTION

3.1 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Comply with Section 01 60 00, PRODUCT REQUIREMENTS.

B. No shipment shall be made until the Contractor has an approved shop drawing submittal.

C. Delivery of Materials: Products shall be delivered in original, unbroken packages, containers, or bundles bearing the name of the manufacturer.

D. Storage: Products shall be carefully stored in a manner that will prevent damage and in an area that is protected from the elements.

E. 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 at all times. Pumps, motors, drives, electrical equipment, and other equipment with anti-friction or sleeve bearings shall be stored in weathertight and heated storage facilities prior to installation. For extended storage periods, plastic equipment wrappers shall not be used to prevent accumulation of condensate in gears and bearings.

3.2 INSTALLATION

A. All equipment shall be installed in accordance with the Manufacturer's instructions and as shown on the Drawings.

B. Before installation, all gas safety and control equipment shall be lubricated where applicable, manually operated to check operation and the interior of the gas safety and control devices shall be thoroughly cleaned.

C. The gas safety and control devices shall be so located that they are easily accessible for operating purposes and shall bear no stresses due to loads from the adjacent pipe. The Contractor shall be responsible for coordinating connecting piping.

D. Any leakage or "sweating" of joints shall be stopped, and all joints shall be tight.

3.3 FIELD QUALITY CONTROL

A. Field testing shall be performed in accordance with Section 01 75 00, STARTUP TESTING AND TRAINING.

B. Certified factory testing shall be provided for all gas safety and control devices. Gas safety and control devices shall be shop tested, including performance tests, leakage test, and proof-of-design tests. The manufacturer through the Contractor shall submit certified copies of the reports covering the test for acceptance by the Engineer.

C. Functional Test: After the installation of all equipment, the equipment shall be subject to field acceptance tests as specified herein.
   1. The Contractor shall conduct field tests to check and adjust system components, and to test and adjust operation of the overall system.
      a. Preliminary field tests shall be conducted prior to start-up with final field tests conducted during start-up.
      b. The factory service representative shall assist the Contractor during all field testing and prepare a written report describing test methods, and changes made during the testing, and summarizing test results.
      c. The service representative shall certify proper operation of the valve operator system upon successful completion of the final acceptance field testing.
   2. Preliminary field tests shall be conducted prior to start-up and shall include a functional check of all gas safety and control devices and all system components.
      a. Preliminary field tests shall demonstrate that the gas safety and control devices perform according to specifications and that all equipment, valves, controls, alarms, interlocks, etc., function properly.
      b. The preliminary field tests shall include all leakage testing.
      c. The preliminary field test report much be approved by the Engineer prior to conduction final field acceptance tests.
      d. Based on results of preliminary field tests, the Contractor shall make any adjustments required to settings, etc., to achieve the required operation specified or otherwise directed by the Engineer.

3. Final field acceptance tests shall be conducted simultaneously with the start-up and field testing of the digesters, gas holders, gas compressors, gas drying and conditioning system, engines, boilers, etc. Field tests shall be conducted for the full range of operating modes and conditions specified and as directed by the Engineer. Each of the gas safety and control devices shall be tested at minimum, maximum, and normal head/flow conditions, and under all specified conditions of opening and closing.
4. Field testing shall include optimization of opening and closing times of the applicable gas safety and control devices. The Contractor shall provide the means for accurate measurement of pipeline pressures. Valve and vent opening and closing times shall be adjusted based on process requirements to optimize their operation. Final valve and vent opening and closing times as determined by field tests shall be approved by the Engineer prior to final acceptance of the system.

3.4 MANUFACTURER'S SERVICES

A. A Manufacturer's representative for the equipment specified herein shall be present at the jobsite for the minimum person-days listed for the services here under, travel time excluded:
1. (1) person-day for installation assistance, inspection, and certification of the installation. Provide Certificate.
2. (1) person-day during operational field testing.
3. (1) person-day for pre-startup classroom or jobsite training of Owner's personnel.

B. Training of Owner's personnel shall be at such times and at such locations as required and approved by the Owner.

C. See Section 01 75 00, STARTUP TESTING AND TRAINING.

3.5 MANUFACTURER'S CERTIFICATES

A. Provide Manufacturer's certificate(s).

END OF SECTION

SECTION 41 20 00 – HYDROGEN SULFIDE REMOVAL EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Work necessary to furnish all labor, materials, equipment, and incidentals required to manufacture, completely install, adjust, protect, put in operation, and test the hydrogen sulfide removal equipment as shown on the Drawings and as specified herein.

B. Related Sections:
   1. Section 01 33 00 – Submittals Procedures.
   2. Section 01 40 00 – Quality Requirements.
   3. Section 01 60 00 – Product Requirements.
   4. Section 01 75 00 – Startup Testing and Training.
   5. Section 40 23 43 – Process Valves.

1.2 GENERAL

A. General Requirements: See Division 01, GENERAL REQUIREMENTS, which contains information and requirements that apply to the Work specified herein and are mandatory for this project.

B. Like items of equipment provided hereinafter shall be the end products of one Manufacturer to achieve standardization of appearance, operation, maintenance, spare parts, and Manufacturer's services.

C. Unit Responsibility: The Work requires the hydrogen sulfide removal equipment, complete with all accessories and appurtenances, be the end product of one responsible Manufacturer. The Manufacturer shall furnish all components and accessories of the system to enhance compatibility, ease of operation and maintenance, and as necessary to place the equipment in operation in conformance with the specified performance, features and functions without altering or modifying the Contractor's responsibilities under the Contract Documents.

D. The equipment specified herein is included in form ATTACHMENT B – LIST OF MANUFACTURERS provided in the front-end documents. Contractor shall identify the proposed manufacturer of the equipment specified on this form with the submitted bid.

1.3 SUBMITTALS

A. General: Administrative, shop drawings, samples, quality requirements, and contract closeout submittals shall conform to the requirements of Section 01 33 00, SUBMITTAL PROCEDURES.

B. In addition to the requirements of Section 01 33 00, SUBMITTAL PROCEDURES, submit the following additional specific information:
   1. Complete assembly and installation drawings, together with detailed specifications and data covering materials used and accessories forming a part of the equipment furnished. The data and specifications shall include, but shall NOT be limited to, the following, where applicable:
      a. Manufacturer and model.
      b. Performance data, including flow curves.
      c. Electrical schematics.
      d. Dimensions.
      e. Connection sizes and locations.
      f. Pressure drop through each vessel.

g. Weight, shipping and operating.
h. Clearance requirements.
i. Temperature rise and insulation rating
j. Type of bearings and method of lubrication
k. Efficiency at nameplate rating and at operating point.

2. Structural design calculations and drawings for vessels including ladder signed and sealed by a professional engineer licensed in the State of Alabama.
3. Controls
   a. Wiring Diagram, if applicable
4. Quality requirements Submittals:
   a. Certified copies of the results of all Factory Functional and field Performance Test reports.
      1) Submit for the Engineer's approval a copy of the proposed startup testing log sheet.
   b. Special shipping, storage and protection and handling instructions.
   c. Manufacturer's printed installation instructions.
   d. List special tools, materials and supplies furnished with equipment for use prior to and during startup and for future maintenance.
   e. Special tools/spare parts shall NOT be used during the warranty period.
5. Contract Closeout Submittals: Service records for maintenance performed during construction.

1.4 QUALITY REQUIREMENTS

A. Where practical, factory performance tests shall be conducted for each item furnished under this Section. Each shall be operated to test the functionality.

B. Tests shall be in accordance with the latest applicable codes and standards, including by ASHRAE, ASME, AMCA, AHRI, ASTM, IBC, and NFPA.

C. Submit six copies of certified test results to the Engineer for approval.

1.5 OPERATION AND MAINTENANCE DATA

A. O&M Manuals: Content, format, and schedule for providing as specified in Section 01 77 00, CLOSEOUT PROCEDURES.

B. Maintenance Summary Forms: As specified in Section 01 77 00, CLOSEOUT PROCEDURES.

1.6 WARRANTY

A. Provide warranty for a period of 12 months after the final acceptance of the equipment by the Owner and Engineer. The warranty shall stipulate that the equipment furnished is suitable for the purpose intended and free from defects of material and workmanship for the duration of the warranty. In the event the equipment fails to perform as specified, the Manufacturer shall promptly repair or replace the defective equipment without additional cost to the Owner.

B. Spare parts identified within this specification shall not be used to address warranty repairs.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Where a Manufacturer's standard equipment name and/or model number is listed, the equipment shall be provided as modified to conform to the performance, functions, features, and materials of construction as specified herein.

B. The basis of design for the hydrogen sulfide removal system is the proposed system by Unison Solutions. Contractor shall be responsible for any modifications required for use of an alternative manufacturer including coordination of interconnecting piping, equipment pad size, ancillary connections, and any other differences between systems at no additional cost to Owner.

C. Manufacturers of components and accessories specified herein shall be as follows:
   1. Unison Solutions.
   2. MARCAB.

2.2 GENERAL REQUIREMENTS

A. See Section 01 60 00, PRODUCT REQUIREMENTS, for specific requirements related to the equipment specified herein.

B. All equipment shall be supplied complete. Parts shall have liberal strength, stability and stiffness and shall be especially adapted for the intended service. Ample room and facilities shall be provided for inspection, repairs, and adjustments.

C. Stainless steel nameplates giving the name of the Manufacturer, the serial number, model number, horsepower, speed, and any other pertinent data shall be attached to the item.

2.3 SERVICE CONDITIONS AND DESIGN REQUIREMENTS

A. The hydrogen sulfide removal equipment shall remove hydrogen sulfide from digester gas produced by an anaerobic digestion process and shall meet the following design requirements:
   1. Number of Vessels: 1
   2. Design Flow: 350 SCFM
   3. Maximum Pressure Drop: 1-inch water column
   4. Maximum Outlet Hydrogen Sulfide Concentration: < 10 ppmv
   5. Gas: Saturated anaerobic digester gas
   6. Inlet Pressure Range: 2 to 14-inches water column
   7. Average Inlet Pressure: 5 inches water column
   8. Gas Temperature Range: 0 to 120-degree F
   9. Media: Pelletized iron hydroxide
   10. Average Media Life: 12 months
   11. Vessel Diameter: 10-feet
   12. Minimum Media Depth: 12-feet
   13. Maximum Allowable Working Pressure: 5 psig
   14. Maximum Allowable External Working Pressure: 1 psig

2.4 MATERIALS

A. Scrubber Vessel
   1. The vessel shall be fabricated of minimum 1/4-inch Type 304L stainless steel. Vessel shall be designed and hydrostatically tested to 10 psig before shipment.
   2. All stainless steel surfaces shall be precleaned, descaled, passivated, and inspected.

3. The vessel shall be provided with 6-inch diameter ANSI Class 125 flanged inlet and outlet for connection to digester gas piping.
4. All fasteners and anchor bolts shall be Type 316 stainless steel.
5. Vessel shall be provided with ladder and platform to access accessories on top of the vessel. Platform shall be designed for dead load plus live load of 100 psf over the entire span with a maximum live load deflection of L/360. Both platform and ladder shall be aluminum construction and di-electrically separated from the stainless steel vessel. Platform shall have handrail on all sides with spring loaded gate.
6. Vessel shall have the following additional accessories:
    a. Pressure/vacuum relief valve with flame arrester.
    b. Minimum 30-inch diameter flanged top manway.
    c. Minimum 30-inch diameter flanged side manway.
    d. Bottom manual condensate drain with stainless steel ball valve.
    e. Dual top vents with flame arresters.
    f. Inlet/discharge pressure gauges.
    g. Inlet/discharge temperature gauges.

B. Piping
1. Piping shall be Type 304L stainless steel, minimum Schedule 10S. Threaded pipe shall be minimum Schedule 40S.
2. Flange connections shall be ANSI Class 150.
3. Gaskets shall be 1/16-inch nitrile bound non-asbestos ring gaskets.

C. Scrubber Media
1. Scrubber media shall be pelletized iron hydroxide.

2.5 TOOLS AND SPARE PARTS

A. None.

PART 3 - EXECUTION

3.1 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Comply with Section 01 60 00, PRODUCT REQUIREMENTS.

B. No shipment shall be made until the Contractor has an approved shop drawing submittal.

C. Delivery of Materials: Products shall be delivered in original, unbroken packages, containers, or bundles bearing the name of the manufacturer.

D. Storage: Products shall be carefully stored in a manner that will prevent damage and in an area that is protected from the elements.

E. 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 at all times. Pumps, motors, drives, electrical equipment, and other equipment with anti-friction or sleeve bearings shall be stored in weathertight and heated storage facilities prior to installation. For extended storage periods, plastic equipment wrappers shall not be used to prevent accumulation of condensate in gears and bearings.

3.2 INSTALLATION

A. All equipment shall be installed in accordance with the Manufacturer's instructions and as shown on the Drawings.

B. All piping, valves, fittings, conduit, wiring, etc. required to interconnect system components shall be furnished and installed by the Contractor. Unless otherwise noted, piping shall be Type 304L stainless steel.

C. Care shall be exercised to ensure that piping stresses are not transmitted to the equipment. Contractor shall provide supports, as necessary.

D. Each item shall be operated, adjusted, and tested after installation as required to ensure proper adjustment and operation of all controls.

E. Each item shall be leveled, plumbed, aligned, and wedged into position to fit connecting piping.

3.3 FIELD QUALITY CONTROL

A. Field testing shall be performed in accordance with Section 01 75 00, STARTUP TESTING AND TRAINING.

B. One month after start-up, the Manufacturer shall sample inlet and outlet hydrogen sulfide concentrations to confirm performance requirements are achieved. All costs for sampling and sample analysis shall be included in the Manufacturer's scope of supply. If outlet concentrations are not achieved as specified herein, modifications to the system shall be performed at no additional cost to the Owner and new samples shall be taken until the performance requirements are achieved.

3.4 MANUFACTURER'S SERVICES

A. A Manufacturer's representative for the equipment specified herein shall be present at the jobsite for the minimum person-days listed for the services here under, travel time excluded:
   1. (1) person-day for installation assistance, inspection, and certification of the installation. Provide Certificate.
   2. (1) person-day during operational field testing.
   3. (1) person-day for pre-startup classroom or jobsite training of Owner's personnel.

B. Training of Owner's personnel shall be at such times and at such locations as required and approved by the Owner.

C. See Section 01 75 00, STARTUP TESTING AND TRAINING.

END OF SECTION

DIVISION 44

POLLUTION CONTROL EQUIPMENT

SECTION 44 10 00 – DIGESTER CLEANING AND COVER INSPECTION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Work necessary to furnish all labor, materials, equipment, and incidentals required to remove and dispose of contents of each anaerobic digester and to clean the inside of the digesters such that inner surfaces are free of waste and other foreign debris and in condition acceptable to facilitate modification of existing piping and equipment and to complete the requirements of the improvements. Additionally, the Contractor shall pay for the cover manufacturer (Ovivo) to travel to the project site and to assess the condition of each digester cover, following cleaning.

B. Work included: Furnish labor, services, materials, equipment, transportation, permits, fees, applicable taxes, and other items as necessary to complete cleaning of all anaerobic digesters and to facilitate inspection of the cover systems by the Manufacturer, as specified in this Section, including but not limited to the following:
   1. Remove, properly dewater, and dispose of all interior contents within each anaerobic digester.
   2. Payment of all applicable fees for tipping, disposal, monitoring, certifications, testing, permits, and licenses, as required to complete the Work.
   3. Weigh vehicles utilizing a certified scale approved by the Owner at, or as close as possible to, the project site.
   4. Provide adequate purging and ventilation of the digesters for safe access and explosion hazard mitigation prior to draining tank, during anaerobic digester cleaning, and during inspection by Owner and Engineer in accordance with OSHA requirements.
   5. Provide adequate ventilation during all confined-space activities and on-person gas monitors.
   6. Once all solids have been removed, Contractor shall washdown all interior walls and floors of the digesters, including all piping and appurtenances located within, and the removal of debris generated from these washdown activities.

C. Related Sections:
   1. Section 01 14 00 – Work Restrictions.
   2. Section 01 33 00 – Submittal Procedures.

1.2 REFERENCES

A. Occupational Safety and Health Administration (OSHA)

1.3 SUBMITTALS

A. General: Administrative, shop drawings, samples, quality requirements, and contract closeout submittals shall conform to the requirements of Section 01 33 00, SUBMITTAL PROCEDURES.

B. In addition to the requirements of Section 01 33 00, SUBMITTAL PROCEDURES, submit the following additional specific information:
   1. Details of removal and disposal plan including, but not limited to, equipment, materials, and methods proposed by Contractor for removal and disposal operations including:
      a. Name of removal subcontractor (if applicable).
      b. A description of how the materials will be removed from each digester.
      c. A description of the equipment to be used.
      d. An estimated quantity of solids to be hauled to the landfill.
      e. Work schedule.

2. Transportation Plan, including the following:
    a. Name of hauling subcontractor (if applicable).
    b. Description of hauling equipment.
    c. Copy of license for hauling subcontractor (if applicable) for proof of acceptability.
3. Copies of all certified weight tickets from the weigh station and sanitary landfill(s) receiving the biosolids, residuals, and debris for all material disposed.
4. Spill response contingency plan
5. Electrical and utility water requirements and proposed schedule for disposal of wash water.
6. Digital photo documentation of interior of digester before, during, and after cleaning in sufficient detail to document the interior condition of the digester structure.
7. Sludge disposal method.
8. Schedule of digester cleanout.
9. Required Permits.
10. Required Licenses.
11. Safety plan.

C. Digester Cover Inspection Report
1. Submit a summary report prepared by the cover manufacturer detailing the findings of the cover inspections along with general recommendations regarding the condition of the protective coating system and structural steel panels on the underside of the existing covers.

1.4 SAFETY REQUIREMENTS

A. General:
1. Contractor shall be solely and completely responsible for the safety of all persons and property during the contract period.
2. Contractor shall take all necessary safety precautions and comply with all applicable OSHA, local, State and Federal laws, codes, ordinances, and regulations.
3. Contractor shall meet the following safety requirements, and any additional measures necessary to ensure protection of health and safety:
    a. Interior air quality shall be tested continuously once hatches are opened for ventilation, cleaning, and follow-up inspection.
        1) Log all air sampling information.
        2) Test all confined-space interior air for all explosive gases and lower explosion limit.
        3) Test all confined-space interior air for oxygen level requirements.
        4) If readings do not meet OSHA standards do not enter any confined space.
        5) Provide proper ventilation to maintain OSHA air quality standards.
    b. Explosive gas safety measures shall be followed while working on digesters.
    c. Do not allow flammable materials (petroleum products, etc.) in or near the digesters.
    d. Do not allow any ignition source within a safe distance of the digesters including, but not limited to:
        1) Sparking equipment or tools including boots with nails and tacks on soles.
        2) Welding equipment.
        3) Cigarettes and lighters.
        4) Non-explosion proof electrical equipment and motors.
    e. Ensure each digester is removed from the gas system(s) before any Work begins. If necessary, temporary measures may be taken to ensure complete isolation from the primary gas system.
4. Contractor is responsible for opening digester manways and for ventilating hazardous gases from the digesters prior to and during all Work at the digesters.
5. Contractor is responsible for determining if each digester is a permit required or non-permit required confined space prior to entering the digester to perform the Work. Should

Contractor determine that the digester and Work is a permit required confined space, all entries into the digester and work to be performed must meet the requirements of OSHA 29 CFR 1910.146 Permit-required Confined Spaces.

B. Hazardous Classified Areas:
   1. Areas inside and around the anaerobic digestion facility are classified as Class I, Division I, Group D hazardous areas as shown on the Contract Drawings and as specified in NFPA 820.

C. Safety equipment:
   1. Safety equipment provided shall include but not be limited to the following items:
      a. Explosion and oxygen deficiency meters.
      b. Ladders, with safety apparatus, as needed.
      c. Explosion proof lights.
      d. Explosion proof ventilation fans.
      e. Non-sparking tools.
      f. Safety harness, tethers, and retrieval devices.
      g. “No Smoking” signage and other cautionary signage.
      h. All necessary PPE in accordance with all OSHA, Federal, State, and Local requirements.
      i. Biosolids Pumps: Positive displacement or centrifugal pumps with special impellers or explosion proof motors if used near or lowered into digester.
      j. Dewatering Equipment: Explosion proof pumps and motors if used near digested biosolids atmosphere.

1.5 UTILITIES

A. Water Service: The Owner will provide, at no charge, a one firehose connection that will be available near the digester facility to facilitate removal and washdown operations. Contractor shall provide a backflow preventer and any hoses, nozzles, etc. necessary to convey water from the Owner’s existing system to the point of use. A temporary flow meter must be obtained from the Owner by Contractor and total water usage submitted to the Owner.

B. Power: The Owner will provide, at no charge, a location to connect temporary 480V power necessary to operate the equipment used to remove biosolids from the digesters. Contractor shall be responsible for assessing all necessary connections to existing electrical gear at the digester facility and for providing all temporary equipment and tie-ins.

1.6 ANAEROBIC DIGESTERS DESCRIPTION

A. The digesters are circular, concrete tanks with sloped bottoms. The configurations of the digesters are as follows:

Digester No.	1	2	3
Diameter, feet	75	75	75
Side Water Depth, feet	24	24	24
Effective Volume (approximate), gallons	930,000	937,000	937,000
Cover Type	Fixed	Floating	Floating

B. Contents/History of Operation:

1. The contents of each digester include anaerobically digested biosolids, organic and inorganic materials, nonvolatile materials, debris, rags, grit, and other materials that have accumulated over time.

PART 2 - PRODUCTS

2.1 TEMPORARY MATERIALS

A. Provide temporary pumping, piping, valves, and equipment required for cleaning, safety measures, and other Work as specified.

B. All other materials not specifically described in the contract documents but required for proper completion of the Work specified shall be provided by Contractor.

PART 3 - EXECUTION

3.1 GENERAL

A. Prior to starting the Work, Contractor shall coordinate with the Owner and Engineer to develop and submit an approved work schedule. Work should be caried out with minimum interference to plant operations.

B. Any operational functions of the existing facility that are required to be done to facilitate Contractor's Work shall be done by plant personnel only.

C. Prior to beginning removal and disposal operations at a specific digester, Contractor shall block off all storm drain inlets in the vicinity that would receive flow in the event of a failure of Contractor's equipment or as directed by the Engineer.

D. Except as specified herein, Contractor may not use the Owner's existing process equipment and drains for dewatering or removing biosolids, residuals, and debris from the digesters.

E. Contractor shall be responsible for all purging and safety requirements for opening the hatches and/or manways before entry.

3.2 REMOVAL OF THE DIGESTER CONTENTS

A. Dewatering processes such as (but not limited to) belt filter presses or centrifuges may be used. Other methods will be evaluated by Owner and Engineer. Filtrate or centrate may be transferred to the plant drain system at a rate not to exceed the capacity of the existing piping and with a solids concentration no greater than 200 mg/L.

B. Location of the tie-in point to the plant drain system shall be determined by Owner and Engineer with Contractor based on the proposed dewatering system characteristics and location of equipment. The returned water shall be monitored and screened with a 1/2-inch maximum opening before entering the drain. No trash is to be re-introduced into the yard piping system.

C. After completing removal operations in a specific digester, Contractor shall hydro-jet all drains as applicable from the drain location to the first downstream manhole.

D. Following removal of the contents of each digester, washdown all interior surfaces including, but not limited to, walls, floors, piping, fittings, brackets, pipe supports, and any other items to remain in place to remove any rags, debris, sand, solid waste, and other matter that is stuck to these interior surfaces. Extend of washdown shall be as needed so the entire digester interior

surface is left in a clean condition and its existing bare or coated concrete surface is exposed as directed and approved by the Owner and Engineer.

1. Contractor to exercise care if using pressure washing to prevent damage to the concrete surface or any protective coatings.

3.3 INSPECTION

A. Upon completion of cleaning, Contractor shall notify the Owner in writing that the digester is ready for inspection. Within 10 business days from the date of notification the Owner and Contractor shall jointly inspect the digester interior and attached equipment. If quality of cleaning is not accepted, Contractor shall take required steps to complete cleaning to satisfaction of Owner.

3.4 TRANSPORTATION

A. Contractor shall transport the waste material directly from the Project site to the designated disposal site. No additional payload may be added at any time. A manifest shall accompany each load with copies provided to the Owner. Contents of the wasteload may be checked at the disposal site to assure conformance with the manifest.

B. Contractor shall dispose of all waste material daily at a disposal site permitted by the State. Contractor shall locate the disposal site, arrange for disposal, and acquire permission to dispose of digester contents. The disposal site shall be permitted to handle the grade of material removed from the digester or Contractor shall be permitted to dispose of the grade of material on a designated site. Contractor shall comply with all applicable local, State and Federal laws, codes, ordinances, and regulations concerning removal, hauling, and disposal of sludge contents.

C. Hauling Vehicles:

1. Contractor shall furnish water-tight trucks for hauling biosolids, residuals, and debris. Hauling vehicles shall not permit contents to leak, splash, or spill onto roads during loading or transportation. Contractor shall be responsible for cleaning up any leaked, splashed, or spilled digester contents on roads or other areas at or away from Project site.
2. All trucks used for hauling of biosolids, residuals, and debris shall have an empty weight certificate.
3. All trucks shall be marked in large lettering with the name, truck number, and phone number for clear identification by the public and Owner.
4. Contractor shall wash/clean all trucks off site.
5. Maintenance of vehicles/hauling equipment shall not be performed on site.

3.5 PAYMENT

A. Contractor shall take a minimum of two total solids samples of the contents of each container/truckload sent to the disposal location. Samples are to be representative of the materials within the container/truck and be sampled from different locations and depths at locations approved by Owner and Engineer. Each sample shall be labeled to identify which container samples were taken for calculating payment. The total solids results for each container/truck shall be averaged to estimate the total solids concentration of the contents in the container/truck. Sample collection time shall be coordinated with the Owner and Engineer. All sampling shall be witnessed by the Owner or Engineers Resident Project Representative.

1. If a dewatering process is being provided, such as a belt filter press, and the dewatered cake is immediately loaded onto a container/truck for disposal, then three freshly dewatered samples shall be taken from the cake conveyor during each day of dewatering operation and the average of the samples be used for all containers/truckload filled on that day.

2. At any time, should dewatered cake characteristics appear to change, the Owner or Engineer may direct Contractor to take additional samples to capture the total concentration.

B. The total solids samples shall be either delivered to the Owner's in-house laboratory or sent to a third-party laboratory to determine the total solids concentration of each sample. Owner will provided analyses at no cost to Contractor. Any third-party analyses shall be paid by Contractor at no additional cost to the Owner.

C. Contractor shall obtain weight tickets from the landfill to determine the wet tons of material disposed.

D. The dry tons for payment shall be calculated by multiplying the average total solids concentration in decimal format (40% TS in decimal is 0.40) by the wet tons stated on the landfill weight ticket.

E. Contractor shall keep a log of containers/truck load weights, solids concentration, disposal location, and calculated total dry tons disposed to at each disposal location. Each month, Contractor shall submit a log with copies of landfill weight tickets and total solids sample results for each container/truck load for payment with partial pay application.

3.6 COVER INSPECTION

A. Upon completion of the digester cleaning effort, the Contractor shall coordinate and pay for the cover manufacturer (Ovivo) to travel to the project site and to perform a condition assessment of the underside of each anaerobic digester cover. Because only one digester may be out of service at any given time, three separate trips and assessments must be performed following the cleanout of each digester.

B. Contractor shall be responsible for all costs associated with the inspection effort including, but not limited to, travel costs and the necessary preparatory work required by the cover manufacturer to perform the assessment. This includes providing means to access the inside of the digester tank, installing scaffolding or other means of accessing the underside of the cover from the inside of the digester tank to the expectations of the cover manufacturer, and setting up and maintaining adequate ventilation, atmospheric monitoring, and other safety measures.

C. The cover manufacturer shall make formal recommendations as to the condition of the existing cover and what, if any, rehabilitation items should be considered. Specifically, this should include recommendations pertaining to the existing protective coating system and for the structural integrity of each cover.

D. Any costs to address the recommendations made by the manufacturer shall be covered by the contingency allowances included in the bid form and are not to be included in the base bid.

3.7 CLEAN-UP

A. Maintain the Project site in a clean and orderly condition at all times.
1. Any spillage, debris, or excess materials shall be cleaned up and removed from the plant site.
2. Under no circumstances shall spillage, debris, or excess materials be washed into storm drains. Plant drains may be used only following approval from Owner and Engineer.
3. Walkways, driveways, and passways shall be maintained in a manner that will not be a safety hazard to plant staff or become an obstruction or interfere with performance of normal and routine tasks.

B. Upon completion of the Work, remove all materials and equipment from the plant site.

END OF SECTION

SECTION 44 42 00 – HYDRAULIC MIXING SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Work necessary to completely furnish and install the hydraulic mixing system, complete with mixing nozzles, and including all related equipment, materials, and appurtenances.

B. Related Sections:
   1. Section 01 33 00 – Submittal Procedures.
   2. Section 01 60 00 – Product Requirements.
   3. Section 01 75 00 – Startup Testing and Training.
   4. Section 05 50 00 – Metal Fabrications.
   5. Section 09 90 00 – Painting and Protective Coatings.
   6. Division 26 – Electrical.

1.2 GENERAL

A. General Requirements: See Division 01, GENERAL REQUIREMENTS, which contains information and requirements that apply to the work specified herein and are mandatory for this project.

B. Equipment Numbers: See Supplement Data Sheets at end of section.

C. Like items of equipment provided hereinafter shall be the end products of one Manufacturer to achieve standardization of appearance, operation, maintenance, spare parts, and Manufacturer's services.

D. Unit Responsibility: The Work requires that the hydraulic mixing system, local control panel, instruments, and components, complete with all accessories and appurtenances, be the end product of one responsible Manufacturer. The Manufacturer shall furnish all components and accessories of the system to enhance compatibility, ease of operation and maintenance, and as necessary to place the equipment in operation in conformance with the specified performance, features and functions without altering or modifying the Contractor's responsibilities under the Contract Documents.

E. The equipment specified herein is included in form ATTACHMENT B – LIST OF MANUFACTURERS provided in the front-end documents. Contractor shall identify the proposed manufacturer of the equipment specified on this form with the submitted bid.

1.3 SUBMITTALS

A. General: Administrative, shop drawings, samples, quality control, and contract closeout submittals shall conform to the requirements of Section 01 33 00, SUBMITTAL PROCEDURES.

B. In addition to the requirements of Section 01 33 00, SUBMITTAL PROCEDURES, submit the following additional specific information:
   1. Shop Drawings
      a. Make, model, weight, and horsepower of each component.
      b. Manufacturer's catalog information, descriptive literature, specifications, and identification of materials of construction.
      c. Detailed mechanical, and electrical drawings showing the equipment fabrications and interface with other items. Include dimensions, size, and details of anchorage and of connections to other work, and weights of associated equipment.

d. External utility requirements (quantity and connection details) such as air, water, power, drain etc., for each component.
e. Motor nameplate data, motor manufacturer, and any motor modifications.

2. Wiring diagrams for motors, including terminals and numbers.
3. Suggested spare parts list to maintain the equipment in service for a period of 1 year and 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
4. List of special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
5. Instrumentation and Control Submittals: In conformance with Division 26.
6. System design calculations, including:
   a. Design basis, with respect to regulatory and industry standard design guidelines. Include design recirculation flow rate.
   b. Nozzle selections, with jet velocity and connection size. Calculations shall show that adequate mixing conditions are provided under the maximum nozzle velocity conditions specified herein.
   c. Pipe size selections, and anticipated range of flow velocities through each selected pipe size.
   d. Hydraulic calculations, leading to pump sizes, motor sizes, and pump selections.
   e. Verification of sufficient available net positive suction head at solids concentrations up to eight percent, assuming normal digester operating level, mixed liquor operating temperature of 100 °F, and accounting for jobsite elevation.
7. CFD Results: Submit a CFD model analysis for the mixing system proposed on this project in a tank of identical size and geometry as the digesters shown in the bid drawings for this project. The CFD analysis shall show how manufacturer's equipment with the number of nozzles provided, in conjunction with nozzle orientation, nozzle flow and heat conditions, will create a mixing pattern suitable to mix the primary digester contents while not exceeding the maximum 25 ft/sec nozzle discharge velocity specified for this project. The CFD model shall indicate what type of mixing pattern is created by the mixing system, when installed.
8. Pumps
   a. Assembly drawing, nomenclature and material list, and parts list.
   b. Type, manufacturer, model numbers, location and spacing of bearings.
   c. Impeller type, diameter, through-let dimensions, sphere size, number of vanes and identification number.
   d. Hydraulic calculations for the head required by the pump.
   e. Complete motor performance data including: rating, voltage/phase/frequency; design type; service factor; insulation class; motor pole number; actual rotation speed when combined with the specified pumps; current, power factor and active input power (KW) as a continuous function of shaft power from no load to at least 115 percent load; start (max. inrush) current; locked rotor current; NEC code letter; and motor torque as a continuous function through the motor start cycle from no rotation to synchronous speed.
   f. Complete performance test curve(s) showing full range (shutoff to run-out) head vs. capacity, NPSHR, hydraulic efficiency, motor active (KW) input power, motor total (KVA) input power (based on measured current and voltage), and shaft power (BHP).
   g. Location and description of Service Centers and spare parts stock.
   h. Factory Test Reports (Balance & Vibration)
   i. For each pump, the manufacturer shall indicate, by arrows to points on the Q/H curves, limits recommended for stable operation, between which the pumps are to be operated to prevent surging, cavitation, and vibration. The stable operating range shall be as large as possible, and shall be based on actual hydraulic and mechanical characteristics of the units and shall meet the hydraulic performance requirements of the proposed system
9. Setting plans, including:

a. Anchor bolt layout
b. Anchor bolt dimensions
c. Outline dimensions and weights of pumps, bases, motors, and control enclosures.

10. Quality Control Submittals:
    a. Manufacturer's Certificate of Compliance: Commercial products, including painting/coating systems.
    b. Certified copies of the results of all Factory Functional and field Performance Test reports.
        1). Submit for the Engineer's approval a copy of the proposed start-up testing log sheet.
    c. Special shipping, storage and protection and handling instructions.
    d. Test procedures.
    e. Test results, reports, and certifications.
    f. Manufacturer's Certificate of Proper Installation.
    g. Operation and maintenance manual.
    h. Manufacturer's printed installation instructions.
11. Contract Closeout Submittals: Service records for maintenance performed during construction.

1.4 QUALITY CONTROL

A. A performance affidavit shall be supplied to the Contractor, Engineer and Owner certifying that the system as provided will meet or exceed the performance requirements for the specific application.

B. Pumps shall be factory tested per the test code of the American Hydraulic Institute, and sound Engineering practice. All pump performance documentation, including flow/head curves, shall adhere to the Hydraulic Institute Standards and shall allow no negative tolerance on flow, head, hydraulic efficiency or any other criteria deemed by the Engineer to be necessary to evaluate pumping system performance. All equipment herein shall be designed and installed in accordance with current OSHA standards.

C. Submit six copies of certified test results to the Engineer for approval.

1.5 OPERATION AND MAINTENANCE DATA

A. O&M Manuals: Content, format, and schedule for providing as specified in Section 01 77 00, CLOSEOUT PROCEDURES.

B. Maintenance Summary Forms: As specified in Section 01 77 00, CLOSEOUT PROCEDURES.

1.6 WARRANTY

A. Provide warranty for a period of 12 months after the final acceptance of the equipment by the Owner and Engineer. The warranty shall stipulate that the equipment furnished is suitable for the purpose intended and free from defects of material and workmanship for the duration of the warranty. In the event the equipment fails to perform as specified, the Manufacturer will promptly repair or replace the defective equipment without additional cost to the Owner.

B. All performance and warranty requirements shall be the sole responsibility of the approved mixing system manufacturer. Deferral or warranties to suppliers and subcontractors is not permitted.

C. Spare parts identified within this specification shall not be used to address warranty repairs.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Where a Manufacturer's standard equipment name and/or model number is listed, the equipment system shall be provided as modified to conform to the performance, functions, features, and materials of construction as specified herein.

B. The naming of a manufacturer in this specification section is not an indication that the manufacturer's standard equipment is acceptable in lieu of the specified component features. Naming is only an indication that the manufacturer may have the capability of Engineering and supplying the mixing system and pumps as specified herein. The manufacturer shall clearly note on his bid proposal to the Contractor and submittal data to the Engineer any and all deviations to this specification. Deviations to this specification shall be cause for rejection of the equipment at the discretion of the Engineer and Owner.

C. An extensive parts inventory shall be maintained by the manufacturer such that all pump parts are available for overnight delivery during the life expectancy of the pump.

D. The hydraulic mixing system including materials, equipment, components, and accessories specified in this section shall be products of:
   1. Vaughan Co., Inc. - Rotamix System.
   2. Hayward Gordon - Hydromix System.

2.2 GENERAL REQUIREMENTS

A. See Section 01 60 00, PRODUCT REQUIREMENTS, for specific requirements related to the equipment specified herein.

B. Noise Level: When in operation, no piece of equipment shall exceed the OSHA noise level requirements for a 1 hour exposure, 105 dBA.

C. Service Factors: Service factors shall be applied in the selection and design of components where so indicated in individual sections. When not indicated there, minimum service factors shall be 1.25, except for gears and gear drives as specified herein.

D. Safety Devices: The completed work shall include all necessary permanent safety devices, such as machinery guards, emergency stops and similar items required by OSHA, and other federal, state, and local health and safety regulations.

E. Flanges and Pipe Threads: Comply with ANSI B 16.1, Class 125; or B 16.5, Class 150, unless otherwise indicated. Threaded flanges and fittings shall have standard taper pipe threads complying with ANSI/ASME B 1.20.1.

F. Bearings:
   1. Conform to the standards of the Anti-Friction Bearing Manufacturers Association, Inc. (AFBMA).
   2. Except where otherwise indicated, bearings of process equipment shall have a minimum L-10 life expectancy of 100,000 hours.

G. Anchor bolts shall be specified in Section 05 50 00, METAL FABRICATIONS. Number and size as recommended by Manufacturer.

H. Stainless Steel: Stainless steel components shall be 304 stainless steel, or higher, as specified.

I. Nameplates: Equipment nameplates of stainless steel shall be engraved or stamped and fastened to the equipment in accessible locations with 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.

2.3 SERVICE CONDITIONS

A. See supplements to this section for additional equipment system product, component or accessory information.

2.4 PERFORMANCE REQUIREMENTS

A. Maximum Nozzle Discharge Velocity: The digester hydraulic mixing system shall be designed such that the nozzle velocity does not exceed 25 ft/sec under any operating condition.

B. The pumps shall be suitable for pumping digested sludge and shall be designed and fully guaranteed for this use. The fluid temperature range shall be from 40 degrees to 115 degrees F.

C. The pumps shall be specifically designed to pump and mix waste solids at heavy consistencies without plugging or dewatering of the solids. Materials shall be chopped/macerated and conditioned by the pump as an integral part of the pumping action. Each pump must have demonstrated the ability to chop through and pump high concentrations of solids such as plastics, heavy rags, grease and hair balls, wood, paper products and stringy materials without plugging, both in tests and field applications.

D. The mixing nozzles shall be designed to produce a rotational mixing pattern within the tank, while also producing flow across the middle portion of the tank thereby preventing solids from migrating towards the center. The mixing pattern shall effectively prevent mounding in the center of the process. The vendor shall be responsible for determining mixing assembly quantity, location and appropriate nozzle angles.

E. Solids shall be drafted by the nozzle discharge to the outer 30% of the tank where the peripheral rotation will create a homogeneous state throughout the tank, suspending both organic and inorganic solids.

F. Distance and location of Digester Mixing suction piping shall be a minimum of 50% of the digester radius from the center or as recommended by Manufacturer of digester mixing system based upon CFD model results.

G. A minimum of 90% active mixing will occur within thirty minutes or less.

H. The Manufacturer shall size the pipe network connecting the pump and nozzle assemblies, to prevent solids deposition during periods of minimum mixing flow.

2.5 EQUIPMENT AND/OR MATERIALS

A. Mixing Nozzle System
   1. Nozzles
      a. Shall be ASTM A536 glass-lined cast ductile iron with 1.0-inch nominal wall thickness to protect against abrasive conditions, and a long straight taper length of at least 12-inches. Nozzles lined with rubber will not be allowed. Alternatively, mixing nozzles shall be cast of ASTM 532 Class II, Type C chrome iron with a minimum hardness of 450 - 550 Brinell throughout the entire nozzle wall.
      b. Assembly fittings shall be ASTM A536 glass-lined cast ductile iron, with 150-pound flanged piping connection.

c. Nozzles shall have a van Stone style flange connection allowing for adjustment in alignment of 360 degrees.

2. Number of Nozzles per Digester:
   a. Per manufacturer recommendation to meet mixing performance requirements.
   b. Minimum of 6 nozzles.
3. Base shall be fabricated carbon steel, with 3/4-inch mounting holes for 5/8-inch anchor bolts.
4. Anchor bolts shall be 5/8-inch diameter, and of sufficient length to support thrust loads from nozzles. Construction shall be 316 stainless steel.

B. Mixing Pumps
1. Pump Casing
   a. The pump casing shall be of semi-concentric design, ASTM A536 ductile cast iron or ASTM A48 cast iron construction.
   b. Provide a single piece casing with integrally cast discharge flange.
   c. Design to withstand a design working pressure not less than 1.10 times the maximum shutoff total dynamic head with the maximum diameter impeller at the maximum operating speed plus the maximum suction static head.
   d. Design to withstand a 5-minute hydrostatic test pressure not less than 1.5 times the design working pressure.
   e. Provide suction and discharge flanges with ASME B16.1 Class 125 bolt patterns.
   f. Provide a cast cleanout to permit inspection and cleaning of the pump suction area.
      1) The cleanout shall have a bolted cover with inner contour that matches contour of suction piece.
   g. Provide casings with both 1/4-inch NPT high point vent and 2-inch low point drain taps on suction side; install pipe nipples with threaded gate valves.
   h. Provide 1/4-inch NPT taps for pressure gauges on the suction and discharge flanges.
2. Back Plate:
   a. Adapter plate shall be ASTM A536 ductile cast iron or ASTM A48 cast iron construction with all water passages to be smooth, and free of blowholes and imperfections for good flow characteristics.
   b. The back pullout adapter plate shall be a separate component part and shall allow removal of the pump components from above the casing.
   c. The back pullout adapter plate shall allow external adjustment of the impeller to cutter bar clearance.
   d. The pump shall include a rear cutting mechanism designed to cut against the pump out vanes and the impeller hub, reducing and removing stringy materials from the mechanical seal.
3. Impeller:
   a. Impeller and impeller cutter nut shall be ASTM A148 cast alloy steel, hardened to minimum Rockwell C 60 and dynamically balanced.
   b. Shall be single-passage, semi-open chopper-centrifugal impeller with smooth water passages to reduce clogging by rags, stringy or fibrous materials on impellers or shafting.
   c. Provide static, dynamic, and hydraulic balance of impeller and complete rotating element.
   d. Provide for external adjustment of impeller to cutter bar clearances without pump disassembly of suction or discharge piping.
4. Cutter Bar:
   a. Cutter bar shall be T1 alloy steel hardened to minimum Rockwell C 60.
   b. Cutter bar plate shall be designed to prevent blockage of intake and binding of debris at the shaft and impeller vanes.
   c. Cutter bar shall be replaceable without replacement of the suction flange or suction plate. Cutter bars which are integral to the suction flange or suction plate are not acceptable.

5. Pump Shafting:
    a. Material:
        1) Shaft shall be steel, Grade 4140.
        2) Hard faced or with hardened sleeve where shafts pass through bearings. Harden to 550 Brinell hardness number minimum per ASTM E10.
        3) If mechanical seals cannot be installed on hardened shaft, shaft is not to be hardened in the mechanical seal area.
        4) If sleeve provided, sleeve to be renewable and key locked in place.
    b. Strength: Able to withstand minimum 1.5 times maximum operating torque and other loads.
    c. Deflection: Maximum 0.002 inches under operating conditions.
    d. Impeller Attachment: Readily removable without use of special tools.
    e. Shaft Seal Type: Mechanical seal system specifically designed to require no seal flush. The mechanical seal shall be located immediately behind the impeller hub to eliminate the stuffing box and maximize the flushing available from the impeller pumpout vanes. The seal shall be cartridge-type mechanical seal with Viton O-rings and silicon carbide faces. This cartridge seal shall be pre-assembled and pre-tested so that no seal settings or adjustments are required from the installer. Any springs used to push the seal faces together must be shielded from the fluid to be pumped. The cartridge shall also include a 17-4PH, heat-treated seal sleeve and a ductile iron seal gland or CF8M stainless steel gland.
6. Bearings and Bearing Frame:
    a. Bearing Type: Back-to-back mounted single-row angular contact ball bearing and radial bearings, self-aligning spherical roller type radial bearings, angular contact ball type, or tapered roller for thrust bearings.
    b. Bearing Life: Bearings shall be rated with a minimum L10 bearing life of 100,000 hours at rated design point or 24,000 hours in accordance with ABMA 9 or 11 at bearing design load imposed by pump shutoff with maximum sized impeller at rated speed, whichever provides longest bearing life in intended service.
    c. Pump bearing frames shall be one-piece rigid construction with bearing housing.
    d. Bearing Housing:
        1) Shall be A536 ductile cast iron or ASTM A48 cast iron, and machined with piloted bearing fits for concentricity of all components.
        2) Bearing housing shall have oil bath lubrication using ISO Gr. 100 turbine oil and a side mounted site glass to provide a permanently lubricated assembly or fitted with grease nipples for grease lubrication.
        3) Viton® double lip seals riding on stainless steel shaft sleeves are to provide sealing at each end of the bearing housing.
7. Supports, Pedestals, and Baseplates
    a. Pump Base: Minimum 3/8-inch fabricated structural steel base and support system for the drive arrangement indicated herein and shown on the drawings.
    b. Pump, driver, and bearing support strength: Able to withstand minimum 1.5 times maximum imposed operating loads.
    c. Configuration: Allow easy access to stuffing boxes, bearing frames, and couplings.

2.6 ELECTRICAL COMPONENTS AND ACCESSORIES

A. General:
1. Conform with Division 26, ELECTRICAL.
2. Provide all necessary electrical components and wiring for a complete, functional system.
3. Where indicated, motor starters shall be provided in a separate motor control center specified in Division 26, ELECTRICAL. Provide all necessary control functions to properly interface with this motor starter.

B. Wiring: The Drawings and Specifications indicate the anticipated wiring for the equipment provided under this section. If additional wiring is required, or if required wiring does not match

what is indicated, the Contractor shall make the necessary modifications to the electrical wiring and documentation as part of the lump sum price. Wiring shall meet the requirements of Division 26, ELECTRICAL, and NFPA 70. Insulation shall be rated 600 volts, minimum. Low-voltage (24V) signals shall be run in twisted, shielded pair cable.

C. Provide breather drain units in the bottom of all electrical enclosures to allow moisture to exit the enclosure.

D. Motors:
   1. Provide squirrel-cage ac induction motors meeting the requirements of Division 26, ELECTRICAL, and as specified herein.
   2. For additional specific requirements on motors, refer to the Motor Data Sheets at the end of the Section.

2.7 INSTRUMENTATION AND CONTROLS

A. All instrumentation and control components shall be provided in accordance with the requirements of Division 26.

2.8 TOOLS AND SPARE PARTS

A. Tools: The work includes one complete set of special tools recommended by the manufacturer for maintenance and repair of each separate type of equipment; tools shall be stored in tool boxes, and identified with the equipment number by means of stainless steel or solid plastic name tags attached to the box.

B. Spare Parts:
   1. Spare parts shall be tagged by project equipment number and identified as to part number, equipment manufacturer, and subassembly component (if appropriate). Spare parts subject to deterioration such as ferrous metal items and electrical components shall be properly protected by lubricants or desiccants and encapsulated in hermetically sealed plastic wrapping. Spare parts with individual weights less than 50 pounds and dimensions less than 2 feet wide, or 18 inches high, or 3 feet in length shall be stored in a wooden box with hinged wooden cover and locking clasp. Hinges shall be strap type. The box shall be painted and identified with stenciled lettering stating the name of the equipment, equipment numbers, and the words "spare parts." A neatly typed inventory of spare parts shall be taped to the underside of the cover.

C. Provide the following spare parts and special tools:

Qty	Item
1	Complete Shelf-Spare Pump and Motor
1	Seal assembly, complete, for each type supplied.
1 set	Radial and thrust bearings
1 set	Impeller cutter bar
1	Complete set of special tools necessary to perform maintenance

2.9 FINISHES

A. Factory Applied Finishes: Prepare surfaces and apply finishes as specified in Section 01 60 00, Product Requirements.

B. Field Applied Finishes:
   1. The pump unit shall conform to the requirements of Section 09 90 00, PAINTING AND PROTECTIVE COATINGS, System No. 4.
   2. Nozzle Assemblies shall conform to the requirements of Section 09 90 00, PAINTING AND PROTECTIVE COATINGS, System No. 2.

PART 3 - EXECUTION

3.1 GENERAL

A. Coordination shall include space and structural requirements, clearances, utility connections, signals, outputs and features required by the manufacturer including safety interlocks.

3.2 ASSEMBLY AND PREPARATION FOR SHIPMENT

A. Each drive unit, including motor, shall be completely factory assembled, aligned, and securely crated for shipment. Accessory equipment which cannot be shipped assembled to the unit, such as shafts, baseplates, impellers, spare parts, and anchorage materials, shall be separately crated, clearly marked as to the contents, and shipped on the same shipment as the drives.

B. For shipment, exposed surfaces subject to rust, such as mounting flange faces, etc., shall be covered with a rust-preventive compound such as Kendall No. 5, or equal.

3.3 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Comply with Section 01 60 00, PRODUCT REQUIREMENTS.

B. No shipment shall be made until the Contractor has an approved shop drawing submittal.

C. Delivery of Materials: Products shall be delivered in original, unbroken packages, containers, or bundles bearing the name of the manufacturer.

D. Storage: Products shall be carefully stored in a manner that will prevent damage and in an area that is protected from the elements.

E. 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 at all times. Pumps, motors, drives, electrical equipment, and other equipment with anti-friction or sleeve bearings shall be stored in weathertight and heated storage facilities prior to installation. For extended storage periods, plastic equipment wrappers shall not be used to prevent accumulation of condensate in gears and bearings.

3.4 INSTALLATION

A. Install in accordance with manufacturer’s written instructions and approved submittals.

B. At each tank, the mix nozzles shall mount to the tank floor. Locations shall be as shown on the Drawings. The Contractor will supply the interconnecting piping, and the pump suction piping, which shall draw from the center of each tank floor. The Contractor shall provide all pipe supports, including sloped, vertical, and horizontal.

C. Lubricants: Include oil and grease for initial operation.

D. Each unit shall be operated, adjusted, and tested after installation as required to ensure proper adjustment and operation of all controls.

E. Pump bases shall be grouted after initial fitting and alignment, but before final bolting of connecting piping.

F. After final alignment and bolting, pump connections shall be tested for applied piping stresses by loosening the flange bolts. If any movement or opening of the joints is observed, piping shall be adjusted to proper fit.

3.5 FIELD QUALITY CONTROL

A. Field testing shall be performed in accordance with Section 01 75 00, STARTUP TESTING AND TRAINING.

B. Digester Mixing System Performance Test:
   1. The Contractor shall validate performance of the mixing system following installation and start-up of the digester. Testing shall be performed on each digester of varying size.
   2. When the digester has been filled to at least the minimum water level and has been in operation for at least 14-days, the Manufacturer or their designated representative, shall collect samples from each of the two cover mounted sampling locations at four depths as selected by the Engineer. A minimum of eight samples will be collected and analyzed. Samples shall be collected a minimum of 36-inches from the floor and wall.
   3. The samples shall be analyzed for total solids concentration.
   4. Acceptance Criteria: A uniform concentration of total solids shall be defined as 75% of the samples (6 out of 8) being within plus or minus 10 percent of the arithmetic average of the total solids concentration for all samples taken during the test.
   5. Should the system not yield a mixed tank as specified, Contractor will be required to make system modifications such as additional nozzles, additional horsepower, or piping modifications as necessary to adequately mix tank at no additional cost to Owner.

C. Mixing Pump Performance Testing:
   1. The Contractor shall complete the following field acceptance tests upon installation of the complete pumping assembly.
      a. Alignment: Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation.
      b. Operating Temperature: Monitor bearing areas on pump and motor for abnormally high temperatures.
      c. Performance: In accordance with Hydraulic Institute Standards.

3.6 MANUFACTURER'S SERVICES

A. A manufacturer's representative for the equipment specified herein shall be present at the job site for the minimum person-days listed for the services hereinunder, travel time excluded.
   1. Installation, Startup, and Testing Services (for each digester mixing system)
      a. 1 person-days for installation assistance, inspection, and Certificate of Proper Installation.
      b. 1 person-day for functional and performance testing.
      c. Provide Qualifications of Manufacturer's Representative.
   2. Training Services (total)
      a. 1 person-day of prestart classroom or jobsite training of Owner's personnel.
      b. Training of Owner's personnel shall be at such times and at such locations as required and approved by the Owner.

B. See Section 01 75 00, STARTUP TESTING AND TRAINING.

3.7 MANUFACTURER'S CERTIFICATES

A. Provide Manufacturer's certificate(s).

3.8 SUPPLEMENTS

A. The supplements listed below and following end of section are part of this Specification:
   1. Digester Mixing System.

END OF SECTION

Section 44 42 00.1 – DIGESTER MIXING SYSTEM

PROJECT: HILLIARD N. FLETCHER WRRF PHASE II IMPROVEMENTS
OWNER: CITY OF TUSCALOOSA WATER AND SEWER
EQUIPMENT NAME(S): DIGESTER MIXING SYSTEMS
EQUIPMENT TAG NUMBER(S): 20MP01, 20MP02, 20MP03, 20MP04
CONTROL PANEL TAG(S):

MANUFACTURERS / MODEL

MANUFACTURERS	MODEL
Vaughan Co., Inc.	Rotamix
Hayward Gordon	Hydromix

SERVICE CONDITIONS

Liquid Handled:	Digested Sludge
% Solids:	2% - 8%
Liquid Temperature:	40 – 115 °F
Elevation:	See Drawings

EQUIPMENT DESCRIPTION

Digester Number:	1	2	3
Tank Diameter:	75'-0"	75'-0"	75'-0"
Side Wall Depth (at Normal WSE):	24'-0"	24'-0"	24'-0"
Floor Slope (H:V)	12:3	12:3	12:3
Nozzle Assembly:	Double	Double	Double
Number of Assemblies, min.:	5	5	5
Total Nozzles, min.:	8	8	8

PERFORMANCE REQUIREMENTS

Minimum Pump Efficiency: 60%
Maximum Nozzle Velocity: 25 ft/sec
Variable Frequency Drive: Y

Design Condition	Condition No. 2	Condition No. 3
Flow: 4600 GPM	Flow: N/A GPM	Flow: N/A GPM
TDH: 40(4) ft.	TDH: N/A ft.	TDH: N/A ft.

MOTOR DATA

Type: Squirrel-cage induction meeting the requirements of NEMA MG1.
Manufacturer: For multiple units of the same type of equipment, furnish motors and accessories of a single manufacturer.
Hazardous Location: ☐ Furnish motors for hazardous (classified) locations that conform to UL 674 and have an applied UL listing marking.

Motor Horsepower: 75 (Max)
Voltage: 460
Phase: 3
Frequency: 60
Synchronous Speed: 1,000 rpm
Service Factor: ☐ 1.0 ☒ 1.15

Mounting Type: ☒ Horizontal ☐ Vertical
Enclosure Type: TEFC
Material: Cast Iron, A48 35B
Load Class: Constant Torque
☐ Multispeed, Two Speed: _____ rpm

☒ Adjustable Speed Drive: See Division 26, ELECTRICAL. Provide Inverter Duty Rated Motors.
Windings: ☐ One ☐ Two ☒ Thermal protection embedded in windings.
Provide: ☐ Space Heater ☒ Oversize main terminal (conduit) box for motors ☐ Moisture detection switches.

SPECIAL FEATURES / NOTES

1. Each manufacturer shall confirm system sizing based on project drawings and their inherent mixing system characteristics. Detailed calculations documenting system sizing shall be submitted as specified.
2. Motor nameplate horsepower shall not be exceeded at any operational point.
3. Each pump must be capable of meeting the flow ranges specified above, however, mixing performance is for the specified design condition only.
4. Design operating head shall be as determined by the digester mixing system manufacturer. Value indicated was used for initial design purposes only.

SECTION 44 42 13 – FINE BUBBLE FIXED-GRID AERATION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Work necessary to furnish all labor, materials, equipment and incidentals required to completely install, adjust, protect, put in operation and test the fine bubble fixed-grid aeration system as shown on the Drawings and as specified herein.

B. Related sections:
1. Section 01 14 00 – Work Restrictions.
2. Section 01 33 00 – Submittals Procedures.
3. Section 01 60 00 – Product Requirements.
4. Section 01 78 23 – Operation and Maintenance Data.
5. Section 01 75 00 – Startup Testing and Training.

1.2 GENERAL

A. Like items of equipment provided hereinafter shall be the end products of one Manufacturer to achieve standardization of appearance, operation, maintenance, spare parts, and Manufacturer's services.

B. General Requirements: See Division 01, GENERAL REQUIREMENTS, which contains information and requirements that apply to the Work specified herein and are mandatory for this project.

C. Unit Responsibility: The Work requires the fine bubble fixed–grid aeration system, complete with all accessories and appurtenances (including, but not necessarily limited to, fine-bubble membrane diffusers, all distribution and manifold piping including connecting piping to existing drop pipes as indicated on the Drawings, adjustable piping supports, couplings, moisture blow offs, anchor bolts and expansion anchors), be the end product of one responsible Manufacturer. The Manufacturer shall assume all responsibility for mating the fine bubble fixed–grid aeration system to the existing dropleg piping to obtain the performance specified. The Manufacturer shall furnish all components and accessories of the system to enhance compatibility, ease of operation and maintenance, and as necessary to place the equipment in operation in conformance with the specified performance, features and functions without altering or modifying the Contractor's responsibilities under the Contract Documents.

D. The equipment specified herein is included in the MANUFACTURER/ SUBCONTRACTOR Form. Refer to the Bid Form and the Instructions to Bidders for additional requirements.

1.3 SUBMITTALS

A. General: Administrative, shop drawings, samples, quality control, and contract closeout submittals shall conform to the requirements of Section 01 33 00, SUBMITTAL PROCEDURES.

B. In addition to the requirements of Section 01 33 00, SUBMITTAL PROCEDURES, submit the following additional specific information:
1. Shop Drawings and Product Data:
a. Descriptive literature and dimensional drawings for all equipment proposed, including views of the air manifold and diffuser assemblies indicating materials of construction, material product specification for all components, and number, location, and spacing of diffusers, and size and layout of air piping. Include weights, center of gravity and lifting diagrams, as required.

b. Methods for compensating for thermal expansion and construction and design criteria employed.
c. Product technical data including:
    1) Acknowledgement that products submitted meet requirements of standards referenced.
    2) Manufacturer's installation instructions.
        a) Include description of the Contractor's proposed method for ensuring a level installation of all equipment and methods of tightening of bolts, diffuser hold-down rings, etc.
d. Fabrication and/or layout drawings:
    1) Diffusers:
        a) Manufacturer.
        b) Type and model.
        c) Dimensional information.
        d) Stable airflow rate range and corresponding headloss.
        e) Oxygen transfer efficiency (clean water) for design conditions.
        f) Mounting arrangement.
        g) Mounting instructions.
        h) Number and distribution per basin.
        i) Acceptable air flow range per diffuser.
        j) Testing plan as specified herein.
        k) Engineering calculations documenting number of diffusers, SOTR achieved, mixing achieved, and uniform distribution of air throughout each dropleg basin grid so that the air flow per diffuser does not vary by more than five-percent at any specified air flow rate condition.
    2) Air distribution system
        a) Dimensional information including size and spacing of all piping. Drawings to scale showing installation in existing aeration basins and effluent channels.
        b) Materials.
        c) Joint restraint.
        d) Expansion compensation.
        e) Moisture blow-off details.
        f) Pipe support details including layout for manifolds and distribution laterals.
        g) Installation instructions.
        h) Engineering calculations documenting thrusts due to pressurized pipes, forces due to expansion of pipes, forces on pressurized pipe due to sudden loss of air pressure, temperature of pipe walls for site conditions in air distribution piping, headloss calculations (from diffuser to top of dropleg over the specified air flow range) and performance curves (headloss versus diffuser air flow over the specified air flow range).
    3) Moisture Blow-off Systems:
        a) Complete materials list and specifications and dimensions of all parts of the system.
        b) Location of the system and layout of the piping, including joints, pipe supports and valves.
    4) Pipe Supports:
        a) Complete design criteria, materials list and specifications, and dimensions of all parts of the pipe supports and extensions.
        b) Include drawings showing proposed support design including anchor locations and details.
        c) Description of methods for supporting and preventing uncontrolled movement of the air manifold and diffuser lateral grid piping resulting from flotation dynamic forces and thermal expansion.

2. Quality Control Submittals:
    a. Design Calculations:
        1) Design calculations documenting air headloss from the top of the dropleg to the farthest diffuser for all conditions specified herein.
        2) Design calculations verifying uniform air distribution through the manifold, distribution laterals, and diffusers under all conditions specified herein.
        3) Design calculations showing loading conditions on piping and support components.
    b. Performance Test Data (results and reports):
        1) Certified copies of all Factory Functional and Field Performance Test reports after tests have been completed including, but not limited to:
            a) Dynamic wet pressure (DWP) test report prior to delivery of diffusers.
            b) Oxygen transfer efficiency (OTE) test report.
            c) Manufacturer's internal quality control testing including permeability, uniformity, strength, and chemical resistance tests demonstrating compliance with these specifications and service environment.
        2) Reports to include:
            a) Description of the test facility.
            b) Description of the sampling procedures.
            c) Engineering calculations.
            d) Summary of test results.
    c. Contract Closeout Submittals:
        1) Service records for maintenance performed during construction.
        2) Warranty.
        3) Certificate of Proper Installation.

1.4 FACTORY TESTING

A. Prior to initiation of production, the Contractor shall submit for the Engineer's review a testing plan to ensure consistently good quality and uniformity of the diffuser assemblies. A sampling plan shall be included. After testing, test results for all diffusers tested shall be submitted for approval and tested diffusers shall be identified.

B. Oxygen Transfer Testing:
1. Submit certified oxygen transfer performance curves to demonstrate capability of the aeration system to meet the specified oxygen transfer requirements.
2. Perform shop test with air rate and mass rate of oxygen transfer equivalent to the proposed diffuser design at the first and last aeration grid.
3. A 5-percent variance on the allotted air at each condition shall be allowed.
4. Use a testing and data analysis procedure equivalent to the ASCE Standard for the Measurement of Oxygen Transfer in Clean Water.
5. The ratio of the total diffuser surface area (AD) to the tank surface area (AT) used for testing will be the actual ratio of the installation.
6. Perform a minimum of 3 tests at each design air flow rate. Test results shall not vary more than 10-percent from the mean.
7. The cobalt catalyst used shall not raise the cobalt ion concentration in the test tank above 0.5 mg/l.
8. Base the amount of technical grade sodium sulfite added for each test on the stoichiometric quantity of chemical required plus a suitable additional amount to completely deoxygenate the test water for at least one minute before the dissolved oxygen level increase from zero.
9. Test may be conducted using the same test water up to a TDS level of 2,000 mg/L.
10. Determine dissolved oxygen values using properly calibrated probes with recorders.
11. Collect at least one sample per test and analyze for dissolved oxygen using the Azide modification of the Winkler Method as specified by Standard Methods.
12. Use a minimum of four D.O. probes during the test.

13. Before the first test and after the last test of each water change, take samples and test for total suspended solids, total dissolved solids, total hardness, alkalinity, iron, manganese, residual chlorine, pH, cobalt and temperature.
14. If testing results do not meet full scale design requirements as specified, one (1) retest will be allowed prior to manufacturer disqualification.

1.5 OPERATION AND MAINTENANCE DATA

A. O&M Manuals: Content, format, and schedule for providing as specified in Section 01 77 00, CLOSEOUT PROCEDURES.

B. Maintenance Summary Forms: As specified in Section 01 77 00, CLOSEOUT PROCEDURES.

1.6 WARRANTY

A. For all aeration equipment components and accessories, provide warranty for a period of 12 months after the final acceptance of the equipment by the Owner and Engineer. The warranty shall stipulate that the equipment furnished is suitable for the purpose intended and free from defects of material and workmanship for the duration of the warranty. In the event the equipment fails to perform as specified, the Manufacturer will promptly repair or replace the defective equipment without additional cost to the Owner.

B. In addition, the Manufacturer shall warrant the following:
1. The membrane diffuser elements shall not fail for a period of five (5) years after the final acceptance of the equipment by the Owner and Engineer.
a. Failure is defined as one or more of the following measured or observed changes on diffusers in a cleaned condition:
1) Any rupture or tear of the membrane.
2) Any measured durometer exceeding 80 Shore A.
b. If one or both of the above changes occurs, the Manufacturer shall provide replacement membranes for the failed membranes to the Owner for replacement by the Owner.
c. If more than 60-percent of the membranes in a tank fail, all membranes shall be replaced with new membranes.

C. Spare parts identified within this specification shall not be used to address warranty repairs.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Where a Manufacturer's standard equipment name and/or model number is listed, the fine bubble fixed-grid aeration system shall be provided as modified to conform to the performance, functions, features, and materials of construction as specified herein.

B. Manufacturer of components and accessories specified herein shall be as follows:
1. Sanitaire – Xylem.
2. SSI.

2.2 GENERAL REQUIREMENTS

A. See Section 01 60 00, PRODUCT REQUIREMENTS, for specific requirements related to the equipment specified herein.

B. All equipment shall be supplied complete. Parts shall be proportioned to have liberal strength, stability and stiffness and shall be especially adapted for the intended service. Ample room and facilities shall be provided for inspection, repairs, and adjustments.

C. All equipment furnished herein is intended to be submerged. No part shall be of any material other than membrane, plastic, PVC, Type 304 or higher stainless steel, or gasket material.

D. The number of diffusers, distribution laterals, and manifolds shown on the Drawings shall be considered the minimum acceptable and is provided primarily for Contractor's informational purposes. It shall be the responsibility of the Manufacturer to ensure the actual equipment furnished meets all requirements specified herein.

E. PVC
   1. Unless noted otherwise, fabricate all PVC moldings and extrusions from PVC compound conforming to ASTM D1784, compound cell classification 12454-B with a minimum tensile strength of 7,000 psi. PVC parts shall be suitable for long term exposure to compressed air at temperatures indicated in service conditions.
   2. Fabricate all PVC droplegs, manifolds, and distribution laterals piping from PVC material conforming to ASTM D1785 or ASTM D3034, with a hydrostatic design stress rating of 2,000 psi.
   3. PVC fittings shall be provided as shown on the Drawings and conforming to ASTM D2466.
   4. Shop fabricate all solvent welded PVC joints in accordance with ASTM D2855, except edges need not be chamfered. All solvent welding shall be with solvent cements specifically formulated for use with PVC in compliance with ASTM D2564. No field solvent welding will be permitted.

F. All anchor bolts shall be epoxy type, insensitive to moisture, Type 316 stainless steel, and a minimum diameter of 3/8". Manufacturers shall be as follows:
   1. Hilti, Inc. HIT Doweling Anchor System, Tulsa, OK.

G. The grids shall be designed and installed so the operator can readily access and maintain the diffuser elements.

2.3 FINE BUBBLE FIXED-GRID AERATION SYSTEM SERVICE CONDITIONS

A. All fine bubble fixed-grid aeration system shall be designed to operate satisfactorily in two separate activated sludge aeration basin trains as shown on the Drawings.

B. The range of mixed liquor suspended solids (MLSS) in the aeration basin trains will be 1,000 to 5,000 mg/l.

C. The supplied diffuser system shall be capable of providing the oxygen rates and efficiencies given the following site conditions:
   1. Maximum Ambient Air Temperature: 105°F.
   2. Minimum Ambient Air Temperature: 24°F.
   3. Site Elevation: 150 – 160-ft MSL.

D. The entire system, including the dropleg, manifold, distribution laterals, drain lines and moisture purge system shall allow for expansion and contraction under the following conditions:
   1. Winter conditions, empty aeration basin trains (24°F).
   2. Summer conditions, empty aeration basin trains (105°F).
   3. Operation with air supply at 225°F and aeration basin trains full.
   4. Operation with air supply at 225°F and water level in aeration basin trains 1-ft above diffusers for short-term testing and start up periods.

E. Side Water Depth:
   1. Anoxic Zones:
      a. Peak Hour Flow Conditions, One Basin out of Service = 21.1-ft
      b. Maximum Month Flow Conditions = 20.4-ft
   2. Aeration Basins:
      a. Peak Hour Flow Conditions, One Basin out of Service = 20.9-ft
      b. Maximum Month Flow Conditions = 20.0-ft
   3. Effluent Channels:
      a. Peak Hour Flow Conditions, One Basin out of Service = 18.8-ft
      b. Maximum Month Flow Conditions = 17.3-ft

F. Diffuser Mounting Distance Above Basin Floor:
   1. Match existing.

G. Clean water oxygen transfer efficiencies shall be measured at Standard Conditions, at the specified average submergence during maximum month flow conditions, and by test procedures and conditions as specified herein. Standard Conditions are defined as 14.7 psia, 20°C/68°F and 36-percent relative humidity.

H. The available air pressure at the top of each dropleg shall be as follows:
   1. Denitrification Mode (anoxic zone diffusers not in operation) = 8.8 – 9.5 psig
   2. Conventional Nitrification Mode (anoxic zone diffusers in operation) = 8.7 – 8.9 psig
   3. Effluent Channel = 8.9 psig

2.4 FINE BUBBLE FIXED-GRID AERATION SYSTEM DESCRIPTION

A. The aeration basins are divided into two trains with each train consisting of one anoxic zone, three aerobic zones, and an effluent channel. Each zone/channel requires varying diffuser arrangements. The existing coarse bubble diffuser systems installed in the anoxic zones are not included in the Work and shall remain in place.

B. The following components are part of this system and shall be installed in each aeration basin train as shown on the Drawings and as specified herein:
   1. Piping: Manifolds, distribution lateral pipes, piping supports and couplings.
   2. Diffusers: Fine bubble membrane diffusers, diffuser holders, retainers, gaskets, and orifices.
   3. Diffuser Accessories:
      a. Diffuser pressure monitoring panel (one panel per aeration grid).
      b. Fixed joints.
      c. Type 316 stainless steel bolts, nuts and gaskets for flange joints.
      d. Type 316 stainless steel anchor bolts.
      e. Accessory piping, taps, and valves as specified.
   4. Other equipment as required for completely operational aeration system.

C. The membrane diffusers and piping grid shall be laid out on the bottom of the aeration basin trains as shown on the Drawings utilizing the existing dropleg locations. If necessary, increase the number of diffusers provided over the amount specified to comply with the performance requirements specified.

D. Diffuser Layout:
   1. Number of Aeration Basin Trains / Effluent Channels = 2
   2. Provide the following minimum number of diffusers (per aeration basin):

Aerobic Zones and Effluent Channels Diffuser Requirements (Minimum, per Aeration Basin Train / Effluent Channel)				
	Zone 1	**Zone 2**	**Zone 3**	**Effluent Channel**
Grids per Zone	2	1	3	1
Dropleg Diameter, in.	8	6	6	4
Distribution Laterals per Grid	17	7	17	4
Lateral Size, in.	4	4	4	4
Nominal Lateral Length, ft.	55.75	89.5	63.17	84.75
Lateral Spacing, ft.	Var.	Var.	Var.	3
Diffusers per Lateral	43	55	31	30
Diffusers per Grid	731	385	527	120
Diffusers per Zone	1,462	385	1,581	120
Nominal Length, ft.	115	91.3	200.3	92.1
Nominal Width, ft.	45	20	45	12

2.5 FINE BUBBLE FIXED-GRID AERATION SYSTEM PERFORMANCE REQUIREMENTS

A. The fine bubble fixed-grid aeration system shall be designed to transfer the required amount of oxygen to meet biological process demands and shall have sufficient mixing capacity to thoroughly mix the entire contents and to keep all solids in suspension.

B. The fine bubble fixed-grid aeration system shall be designed and orifices sized so that at minimum and maximum airflows, the airflow rate output of any two diffusers in the system shall not differ by more than five percent. The Manufacturer shall furnish calculations to verify this requirement. The distribution and balancing of air shall be controlled by the use of orifices and proper distribution lateral pipe size selection only. The use of flow distribution control devices requiring automatic and/or manual operation shall not be permitted.

C. Airflow Distribution Summary, All Basins in Service:

Flow Condition	**Available Air Flow Volume (SCFM/grid)**				**Total (SCFM)**
	Zone 1	Zone 2	Zone 3	Effluent Channel	
Minimum	388(1)	270(1)	450(1)	325(1)	5,442(1)
Average	981	517	707	325(1)	9,850
Design	1,727	910	1,245	325(1)	16,848
Maximum	2,542	1,339	1,832	325(1)	24,488
Notes: 1. Mixing controls.					

D. Standard Oxygen Transfer Rate Distribution Summary:

Flow Condition	Standard Oxygen Transfer Rate (lbs O2/day /grid)				Total (SCFM)
	Zone 1	Zone 2	Zone 3	Effluent Channel	
Minimum	3,938(1)	2,686(1)	4,393(1)	2,616(1)	52,714(1)
Average	9,157	4,645	5,996	2,616(1)	87,126
Design	15,252	7,741	9,985	2,616(1)	141,632
Maximum	21,055	10,687	13,771	2,616(1)	193,452
Notes: 1. Mixing controls.					

E. Mixing Requirements:
   1. Ensure mixing over the air flow range specified prevents deposition of solids in or near basin corners and behind columns, supports and incidental structural components.
   2. The system shall provide air flow rates as required to adequately suspend solids (0.12 scfm/ft^2).

2.6 FINE BUBBLE MEMBRANE DIFFUSERS AND ASSEMBLIES

A. Furnish diffuser assemblies including diffuser, gasket, holder, retaining ring and air flow control orifice.

B. Membrane Diffusers and Gaskets:
   1. Circular membrane diffuser discs of 9-in diameter with integral O-ring of EPDM synthetic rubber compound with precision die formed slits.
   2. Design diffuser as one-piece injection molded part with minimum thickness of 0.08-in.
   3. Produce diffusers free of tears, voids, bubbles, creases, or other structural defects.
   4. Rated diffuser air flow rate for continuous and intermittent operation:
      a. Minimum: 0.5 scfm per diffuser
      b. Average: 1.25 – 2.0 scfm per diffuser
      c. Maximum: 3.5 scfm per diffuser
   5. Diffuser membrane material shall meet the following criteria:
      a. Base Polymer: EPDM, ASTM D573.
      b. UV Resistance: Carbon Black.
      c. Specific Gravity: 1.25, or less.
      d. Durometer: Minimum 58 durometer, +5 percent, ASTM D2240.
      e. Modulus of Elasticity: 500 psi, ASTM D412.
      f. Ozone Resistance (72 hours; 104°F; 50 pphm): No cracks at 2x magnification, ASTM D1171, Test Method A.
      g. Tensile Strength (Unperforated): 1200 psi, min., ASTM D573.
      h. Elongation Percentage:
         1) Percent Retained (70 hours; 104°F): 75 percent maximum, ASTM D573.
         2) Minimum at Break: 350-percent, ASTM D412.
      i. Accelerated Aging: 40-percent, max., ASTM D395.

C. Diffuser Assemblies:
   1. Furnish diffuser assemblies including diffuser, diffuser gasket, holder, retaining ring and air flow control orifice.
   2. Furnish diffuser membranes with uniform distribution of air bubble release across the active surface of the diffuser element when submerged in water. Manufacture membrane discs with integral sealing gasket.
   3. Membrane Diffusers:
      a. Diffuser membranes shall collapse and seal onto support plate when aeration system air is turned off.
      b. Incorporate an integral check valve into the membrane diffuser.

c. Design and test diffusers for a DWP of 6-in +/- 20-percent water column at 1.0 scfm/diffuser and 2-in submergence.

4. Diffuser Support Plate: Provide a PVC or glass filled polypropylene support plate to form an air plenum under the diffuser and support for the membrane when the air is off.
5. PVC Diffuser Element Holders
   a. Element holders shall provide complete peripheral edge support for the diffuser element.
   b. Element holders shall be solvent welded to air distribution piping. Mechanical attachment of assembly to air distribution piping is not allowed.
   c. Element holders shall be installed on the distribution lateral piping at the system supplier factory.
   d. Element holders shall resist dead load of 200-lbs applied vertically to the outer edge of the diffuser unit.
   e. Furnish retaining device to securely hold and seal the diffuser to the holder.
      1) Design diffuser assembly and retaining device to prevent air escape at the diffuser element-sealing gasket interface. Make gasket integral with diffuser.
      2) Provide a method to vary the applied sealing force between the sealing gasket and diffuser. Sealing method or retaining device shall generate a minimum of 50 pounds per inch of circumference of the sealing gasket to provide a long-term positive seal and prevent air escape, except through the active area of the diffuser.
   f. Provide screw on retainer rings with a positive O-ring seat and a minimum of 2-1/2 complete threads for engagement. Threads shall have a minimum cross-section of 1/8-in.

2.7 AIR DISTRIBUTION PIPING

A. General:
1. The air distribution piping includes the droplegs into the aeration basin, the manifolds that supply air from the dropleg to the distribution laterals, and the distribution laterals on which the diffusers are mounted.
2. Unless otherwise specified, all piping shall be in accordance with Division 40, PROCESS INTEGRATION.
3. All manifolds, distribution laterals, couplings, tees, joints, other piping and parts shall be manufactured of unplasticized PVC conforming to ASTM D3034, SDR-33.5, unless noted otherwise.
4. Fabricate all piping assemblies to be field installed using flange type joints or positive fixed threaded union joints. Push on, bell in spigot, or expansion type joints will not be acceptable. Use interlocking spines or equivalent to prevent rotation of union style joints.
5. Threaded union joints shall consist of a spigot section solvent welded to one end of the pipe, a threaded socket section solvent welded to the mating pipe, an O-ring gasket, and a threaded screw-on retainer ring. Flange joints shall have standard 125-pound drilling. Band couplings shall not constitute a fixed joint.
6. All joints, regardless of type, shall resist 80 ft-lbs, minimum, without rotation.
7. No field welding of pipe sections, fittings, or flanges is acceptable.
8. Install piping plumb with walls and make up all changes in direction using standard fittings.
9. Provide for any expansion or contraction of the diffuser piping resulting from temperature change. Each system shall allow for expansion and contraction over the specified Service Conditions. There shall be no thermally induced stresses due to expansion and contraction over Service Conditions specified. Joints shall be air-tight and not allow movement of the pipe at the joint. Expansion and contraction shall take place through the supports.
10. All piping gaskets shall be butyl rubber, neoprene, or a composition suitable for air to 230°F. Gasket material shall be suitable for long term immersion in wastewater.

B. Droplegs:
1. Existing droplegs shall remain in place and be reused with new air distribution system.

2. Connect new manifolds to existing droplegs with a Type 304 stainless steel flexible transition coupling.

C. Manifolds:
1. Furnish manifolds having the same nominal pipe diameter as the dropleg.
2. Fabricate manifolds with fixed joint connections to each distribution lateral. All underwater joints shall be positive locking type and anti-rotational.
3. Maintain a constant bottom elevation of the manifolds throughout the basin.
4. Provide removable blind flanges or threaded end caps at the ends of all manifolds to allow purging of debris prior to startup.
5. Shop fabricate the manifolds in sections of 20-ft or less to confirm with the accepted layout for the equipment supplied.
6. Manifolds shall be provided for long term exposure to 130°F near-wall temperature.

D. Distribution Laterals:
1. Furnish distribution laterals having a nominal diameter of 4-in size, minimum.
2. Distribution laterals shall be perpendicular to the air manifold.
3. The distribution laterals shall connect to the manifold by fixed joint connections. Required accessories shall be provided for each connection. Design connections and supports to resist thrust generated by expansion and contraction of the system.

2.8 PIPING SUPPORTS

A. General:
1. Attach supports to the tank floors using expansion type concrete anchors or epoxy-type anchor system. All pipe support anchors shall have a factor of safety of ten or greater against calculated buoyant forces when installed.
2. The diffusers shall be leveled for uniform distribution of air for oxygen transfer and mixing as specified herein. All diffuser piping and diffusers shall be capable of being leveled and remaining level under all conditions of operation whether the tanks are full, partially full, or empty.
3. Unless noted otherwise, supports shall be fabricated of Type 304 stainless steel using flat stock of at least 3/16-in by 2-in and rods of at least 3/8-in diameter.
4. Each air piping section shall have a minimum of two supports. Support height shall be sufficient to provide the diffuser elevation shown on the Drawings.
5. Allow for complete removal of supports from the basin to facilitate in-basin maintenance.

B. Manifold Supports:
1. Provide a minimum of two supports with a maximum spacing between supports of 8-ft.
2. Design support system to resist thrust generated by expansion or contraction of piping system.
3. Design the manifold supports to include a manifold hold-down, guide straps, anchor bolts and supporting structure. Use minimum 1-1/2-in wide guide straps. Provide supports with a mechanism allowing for ± 1.5-in adjustment for alignment of the manifold in the field.

C. Distribution Lateral Supports:
1. Provide supports with a mechanism allowing for a ± 2-in vertical adjustment for alignment of the distribution laterals in the field. Adjusting and aligning mechanism shall be infinitely adjustable within its limits to allow precise leveling of the distribution laterals and diffuser assemblies to within ± 1/8-in of a common horizontal plane without removing the distribution lateral from the support.
2. Each pipe section shall have at least two supports and support spacing shall not exceed 6-ft.
3. Distribution lateral piping shall include an expansion-contraction system consisting of fixed joints and guide supports.

a. Guide supports shall allow longitudinal movement for expansion and contraction of distribution lateral piping.
    1) Guide supports shall consist of a self-limiting hold down and sliding mechanism. Hold down and sliding mechanisms shall provide a full circumferential 1.5-in wide contoured bearing surface with chamfered leading edges to minimize binding of the distribution lateral.
    2) Sliding mechanism shall provide minimum resistance to movement of the distribution lateral under full buoyant uplift load. Mechanism shall provide 1/8-in clearance around the distribution lateral and be self-limiting if the mechanism is over tightened. Worm gear and radiator type clamps shall not be utilized for attaching distribution lateral pipe to supports.
    3) Expansion joints shall not be used for joining pipe sections.
b. Sections of distribution lateral piping shall be joined with fixed joints which prevent joint blow-apart and rotation of one pipe section with respect to another.
    1) Fixed Support straps shall have 1-1/2-in wide top and bottom contoured bearing surface with punched burrs to positively grip the air distributor when tightened.
    2) Design strap to be self-limiting to prevent stressing the distributor if the clamp is over tightened.

2.9 AIR PURGE SYSTEM

A. Provide one drain line, sump, and air lift purge system for each grid as specified and install as recommended by the Manufacturer and approved by the Engineer.
1. Furnish one PVC drainline, in-line sump and air lift purge system to drain the entire submerged aeration piping system for each aeration grid.
2. The sump shall be integral with the manifold line and its bottom elevation shall be lower than the invert of the manifold and air distribution laterals.
3. Connect sump to 1-in diameter airlift eductor line extending from the sump invert elevation to a point basin water level and terminate with a PVC ball valve.
4. Airflit eductor line shall utilize a purge hose between the drain sump and the vertical pipe run at the tank wall.
5. Extend the vertical airlift eductor line to a point above the tank water level and terminate with a horizontally mounted PVC ball valve at the top rail of the handrail.
6. Locate blowoff piping and valve at an easily accessible location above the water surface. Provide for operation of drain valves from the tank walkway.
7. Support air lift eductor piping from tank wall every 4.5-ft with stainless steel pipe clamps and expansion anchors.

2.10 DIFFUSER PRESSURE MONITORING SYSTEM

A. Each aeration grid shall be furnished with connecting box, bubbler tube, support brackets, polyethylene tubing and carrier pipe as shown on the Drawings. The connecting box shall be a handrail mounted fiberglass box capable of containing three 1/2-in PVC ball valves, quick coupling connectors accessible through a front access door. All mounting hardware shall be Type 316 stainless steel. The three ball valves shall connect to the air distribution header and diffuser element holder plenum with a 3/8-in diameter tubing and a 1/2-in bubble tube (for submergence pressure measurement at top of diffuser).

B. One portable monitoring panel shall be provided with at least one differential pressure gauge, quick coupling connectors, PVC ball valves, one set of calibration curves, and tubing and fittings as necessary to measure pressure differential between header and holder plenum and holder plenum and diffuser submergence.

2.11 ELECTRICAL COMPONENTS AND ACCESSORIES

A. General:
   1. Conform with Division 26, ELECTRICAL.
   2. Provide all necessary electrical components and wiring for a complete, functional system.

B. Wiring: The Drawings and Specifications indicate the anticipated wiring for the equipment provided under this section. If additional wiring is required, or if required wiring does not match what is indicated, the Contractor shall make the necessary modifications to the electrical wiring and documentation as part of the lump sum price. Wiring shall meet the requirements of Division 26, ELECTRICAL, and NFPA 70.

C. Electrical Raceways: Electrical wiring shall be installed in conduit meeting the requirements of Division 26, ELECTRICAL. Raceways shall be installed in accordance with Division 26, ELECTRICAL, and NFPA 70.

D. Provide breather drain units in the bottom of all electrical enclosures to allow moisture to exit the enclosure.

2.12 TOOLS AND SPARE PARTS

A. Tools: The work includes one complete set of special tools recommended by the manufacturer for maintenance and repair of each separate type of equipment; tools shall be stored in tool boxes, and identified with the equipment number by means of stainless steel or solid plastic name tags attached to the box.

B. Spare Parts:
   1. Spare parts shall be tagged by project equipment number and identified as to part number, equipment manufacturer, and subassembly component (if appropriate). Spare parts subject to deterioration shall be properly protected by encapsulated in hermetically sealed plastic wrapping. Spare parts with individual weights less than 50 pounds and dimensions less than 2-feet, or 18-inches high, or 3-feet in length shall be stored in a wooden box with hinged wooden cover and locking clasp. Hinges shall be strap type. The box shall be painted and identified with stenciled lettering stating the name of the equipment, equipment numbers, and the words "spare parts." A neatly typed inventory of spare parts shall be taped to the underside of the cover.

C. Provide the following spare parts and special tools:

Qty	Item
100	Membrane diffuser elements and gaskets
100	Membrane diffuser holder retainer rings
100	Membrane diffuser holders
1	Complete air purge system
1%	Pipe supports and accessories (% of each type and size installed)
1%	Flanged union joints (% of each type and size installed)
1%	Threaded union joints (% of each type and size installed)
1%	Expansion joints (% of each type and size installed)
1	Complete set of special tools necessary to perform maintenance

2.13 FABRICATION

A. Shop Assembly: The system shall be factory assembled and tested.

PART 3 - EXECUTION

3.1 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. No shipment shall be made until the Contractor has an approved shop drawing submittal.

B. Comply with Section 01 60 00, PRODUCT REQUIREMENTS.

C. No shipment shall be made until the Contractor has an approved shop drawing submittal.

D. All diffusers shall be packed in suitable strong cartons or boxes. Diffusers of the same permeability rating shall be stamped on each carton in legible numerals.

E. Delivery of Materials: Products shall be delivered in original, unbroken packages, containers, or bundles bearing the name of the manufacturer.

F. Storage: Products shall be carefully stored in a manner that will prevent damage and in an area that is protected from the elements. No equipment shall be stored on-site longer than 30 days from delivery to installation.

G. 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 at all times. Pumps, motors, drives, electrical equipment, and other equipment with anti-friction or sleeve bearings shall be stored in weathertight and heated storage facilities prior to installation. For extended storage periods, plastic equipment wrappers shall not be used to prevent accumulation of condensate in gears and bearings.

3.2 INSTALLATION

A. All equipment shall be installed in accordance with the Manufacturer’s instructions and as shown on the Drawings.

B. Clean existing sections of air mains and droplegs prior to installing diffuser elements.

C. Protect diffuser elements from freezing at all times.

D. Protect diffuser elements from un-pressurized submergence in wastewater.

E. Diffusers shall be leveled to within +/- 1/8-in of a common horizontal plane. Deforming of distribution laterals, diffuser connectors, diffusers, or pipe supports to align or level the system shall not be allowed.

3.3 FIELD QUALITY CONTROL

A. Field testing shall be performed in accordance with Section 01 75 00, STARTUP TESTING AND TRAINING.

B. Functional Test: After the installation of all aeration system equipment, the equipment shall be subject to field acceptance tests as specified herein.

C. Mounting Tests: Support and tie-down provisions of the piping shall be tested to ensure that they have a factor of safety of four against calculated buoyant forces. Anchor bolts for the piping system shall be tested to ensure that they have a factor of safety of ten against calculated buoyant forces.
   1. Upon installation of the supports and prior to installation of piping, all supports of each type and anchor bolts shall be tested. Testing shall include no less than 10-percent of the supports of each type, chosen at random to be witness tested by the Engineer. Each support chosen for test shall be attached to a lever which shall be placed on a fulcrum. A static load shall be applied to the opposite end producing a vertical extracting force on the support tie-down equal to four times the calculated maximum buoyant force to which the support tie-downs will be subjected in normal operation as detailed above. Anchor bolts shall be tested to a vertical extraction force of ten times the calculated maximum buoyant force. The application of the test load shall be such that the entire pipe support, including pipe hold down strap, is tested.
   2. Upon a test failure, the entire system will require testing under the above specified conditions. Repair and replace all equipment not meeting the test requirements.

D. Inspection of Piping: The piping shall be inspected for proper joints, supports and tie-downs, end plugs and drain relief valves.

E. Level Test: Each tank shall be filled with clear water to the top of the diffusers. The level of the diffusers shall then be checked to see that they are at an elevation differential that the Manufacturer has recommended. Should it be necessary to correct the elevation of any diffuser assembly as a result of this check, such action shall be taken prior to proceeding further.

F. Uniformity and Leakage Test: Each tank shall be filled with water to a depth of 1-ft above the diffusers. The air supply will be turned on to minimum and maximum air flow rates as specified herein and air supplied evenly to all distribution laterals. The surface of the water will then be visually inspected to see that air flow is uniformly distributed across the tanks and that no air leaks are present within the piping system. If, in the opinion of the Engineer, there are areas of consistently low or high air quantity release, or leaks within the piping system, make all necessary adjustments to correct these deficiencies.
   1. During the uniformity and leakage test, the aeration system pressure shall be monitored and recorded.

G. Cost of Testing: All of the above field tests, including the filling, dewatering, and cleaning of the aeration tanks, shall be conducted at the expense of the Contractor. The costs of all re-testing, if required, shall also be borne by the Contractor.

3.4 MANUFACTURER'S SERVICES

A. A Manufacturer's representative for the equipment specified herein shall be present at the jobsite for the minimum person-days listed for the services here under, travel time excluded:
   1. (4) person-days for installation assistance, inspection, and certification of the installation. Provide Certificate. These days may not necessarily run concurrently and might require separate trips.
   2. (2) person-days during operational field testing.
   3. (1) person-days for pre-startup classroom or jobsite training of Owner's personnel.

B. Training of Owner's personnel shall be at such times and at such locations as required and approved by the Owner.

C. See Section 01 75 00, STARTUP TESTING AND TRAINING.

3.5 MANUFACTURER'S CERTIFICATES

A. Provide Manufacturer's certificate(s).

END OF SECTION