

SPECIFICATIONS AND CONTRACT DOCUMENTS



ISSUED FOR BID

For the Construction of

MAWSS CC Williams Headworks Rehabilitation and Odor Control

MOBILE, ALABAMA

Garver Project No. 2402007

VOLUME 2 OF 4

TECHNICAL SPECIFICATIONS DIVISIONS 26 TO 46

PREPARED FOR

**Mobile Area Water and Sewer
System**

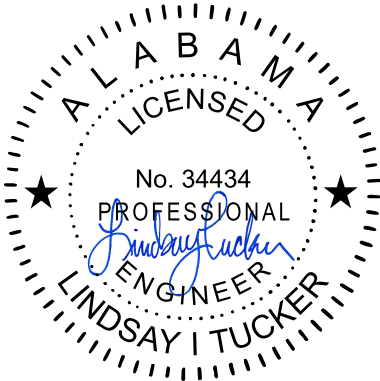
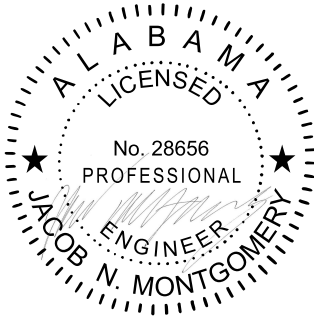
August 2026



CERTIFICATIONS

MAWSS CC WILLIAMS HEADWORKS REHAB AND ODOR CONTROL GARVER PROJECT NO. 2402007

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
Lindsay I. Tucker, PE  Digitally Signed 08/10/2026	Division 01
Jacob N. Montgomery, PE  Digitally Signed 08/10/2026	Division 02 Division 03 Division 05 Division 06 Division 07 Division 09

CERTIFICATIONS

Jack W. Dorminey, PE



Digitally Signed 08/10/2026

Division 22
Division 23

Jonathan C. White, PE



Digitally Signed 08/10/2026

Division 26
Division 40 61 13 thru 40 76 20

CERTIFICATIONS

Samuel K. Johnson, PE  Digitally Signed 08/10/2026	Division 31 Division 32 Division 33
Russell D. Tate, PE  Digitally Signed 08/10/2026	Division 40 05 00 thru 40 42 00 Division 44 Division 46

GARVER, LLC CERTIFICATE OF AUTHORIZATION:

AL ENGINEERING COA NO. ECA500

Expiration Date: 01/31/2028

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DIVISION 26
ELECTRICAL

SECTION 26 05 00 – COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. The basic requirements for electrical installations and includes requirements common to Division 26 – Electrical.
2. Expansion and supplementation of requirements specified in the General and Supplementary Conditions.
3. Construction of the new building structures, associated facilities, and all related electrical systems as defined in the plans and in these specifications.
4. 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.
5. The Contractor shall be responsible for the coordination of power, communication, and controls for the project.
6. 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.
7. 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.
8. 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.
9. 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.
10. 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 as specified in "Code" requirements as though specified in Drawings.
11. 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 in. 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 REFERENCES

A. NFPA (National Fire Protection Association):

1. 70 – National Electrical Code.
2. 70E – Standard for Electrical Safety in the Workplace.

3. 72 – National Fire Alarm Code.
 4. 101 – Life Safety Code.
 5. Internet Website: <http://www.nfpa.org>
- B. CFR (Code of Federal Regulations):
1. 29 CFR 1910 – Occupational Safety and Health Standards (OSHA).
 2. 29 CFR 1926 – Safety and Health Regulations for Construction.
 3. Internet Website: <http://www.gpo.gov/fdsys>
- C. ANSI/IEEE C2 – National Electrical Safety Code.
- D. Applicable Federal, State and Local:
1. Fire codes.
 2. Energy Codes.
 3. Building Codes.
 4. Environmental, Health, and Safety Laws and Regulations.
- E. Applicable City
1. Electrical Code.
 2. Ordinances pertaining to electrical work.
- F. 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. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Submittals shall be furnished by the Contractor for the work involved in sufficient time so that no delay or changes will be caused.
- 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 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 Division 26 – Electrical.
- 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 information of:
1. General Contractor.

2. Subcontractor.
3. Distributor and/or Supplier.
4. Sales Agency.
5. Submittals not supplying this information will be rejected.

I. Shop Drawings:

1. In addition to the above, submit shop drawings for major materials where called for and when requested by the Engineer.
2. Lockout/Tagout Program.
3. Switchboard, motor control centers, panelboards, surge arresters, and safety switches.
4. Motor starters and contactors including custom wiring diagrams for all motors.
5. Lighting fixtures and lamps including light pole foundation requirements.
6. Wire, cable, and conduit.
7. Dry type transformers including weight and dimensions.
8. Wiring devices and plates.
9. Dimensioned layout of electrical room drawn to scale, with equipment location specified. Clearances shall be as specified in NEC and local codes.
10. Dimensioned layout of all below grade conduit installations.
11. Grounding system and layout.
12. Lightning protection system layout.
13. Traffic control system layout and schematics.
14. Seismic protection materials and methods for all electrical equipment.
15. 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 Division 26 – Electrical 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 as specified in 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 apprenticeship program recognized and approved by the statutes of the State of the work being performed.

1.8 UTILITY TELECOM WORK

- A. The Contractor shall be responsible for coordinating all telecommunications services, including internet and telephone work, with the servicing utility, Owner, and Engineer. Provide all required equipment, connectors, and accessories to make all final communication system connections.

1.9 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 onsite master electricians and their contact information, including office and mobile telephone numbers.
- B. As specified in 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 – 1910.335.
- C. Implementation of the Lockout/Tagout Program and all other related safety requirements are the sole responsibility of the Contractor.

1.10 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.

1.11 EQUIPMENT CONNECTIONS

- A. General:
 - 1. 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.

1.12 GENERAL CONDITIONS

- A. The work under this paragraph 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 in this paragraph.

1.13 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.

1.14 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.

1.15 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.

1.16 LAYOUT

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

1.17 RELATED WORK SPECIFIED ELSEWHERE

- A. Mechanical Equipment:
 - 1. 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 what was previously 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.

1.18 LOCAL CONDITIONS

- A. Inspection of Sites:
 - 1. 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.

1.19 RECORD DOCUMENTS

- A. Refer to the General and Supplementary Conditions for requirements.
- B. Supplement 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.

1.20 OPERATION AND MAINTENANCE DATA

- A. Installation manual:
 - 1. 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.
- B. Operations manual:

1. Manufacturer's printed operating instructions and procedures to include startup, 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.
 - C. Maintenance manual:
 1. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
 - D. Service manual:
 1. 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 Division 26 – Electrical.
 - E. Final approved equipment shop drawings, clearly labeled.
 - F. Final test reports, clearly labeled, including motor certification tests.
 - G. Final certified calibration sheets for all equipment and instruments.
 - H. After approval of the O&M Manuals, the Contractor shall provide to the Owner and Engineer as specified in 01 77 00 – Closeout Procedures.
- 1.21 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 as specified in the intent of the specifications. The Contractor shall conduct complete tests required by the Engineer to demonstrate the ability of the various systems.
- 1.22 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.
- 1.23 WARRANTY
- A. See Section 01 78 36 – Warranties and Bonds for requirements.

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 offsite storage is authorized in writing. Protect stored equipment and materials from damage.
- C. Equipment and materials shall be stored as specified in 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 using auxiliary heaters as required to raise the temperature to 5°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 airconditioned 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 using auxiliary heaters as required to raise the temperature to 5°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 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 as specified in 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 as specified in 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 Division 26 – Electrical.
- 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, fireproofed, and waterproofed.
- D. Repairs to be performed with materials which match existing materials and to be installed as specified in appropriate sections.
- 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 Division 26 – Electrical.

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 Division 26 – Electrical.
- 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 make sure of 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:
 - 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 as specified in:
 - 1. The manufacturer's recommendations
 - 2. The contract drawings
 - 3. 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 as specified in requirements and to form the basis of record drawings.
 - 4. 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 V 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 V 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 V 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 hookups, 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 nonconforming 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 nonconforming 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:
 - 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 as specified in the NEC, 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. This Section includes furnishing, installing, terminating, identifying, and testing the following field-installed conductors and cables rated 600 V and less:
 - 1. Power conductors and cables for service entrance, feeder, and branch circuits.
 - 2. Discrete control conductors and cables.
 - 3. Analog signal instrumentation cables.
 - 4. Flexible cords.
- B. This Section does not include:
 - 1. Factory-installed wiring internal to listed equipment assemblies or packaged equipment. Such wiring shall comply with the listing requirements of the completed assembly.
 - 2. Ethernet, fiber-optic, and other data communication cabling.
 - 3. Proprietary cables between components of a packaged instrument or equipment assembly, except for installation requirements indicated in the Contract Documents.
- C. Related Sections:
 - 1. Section 26 05 53 – Identification for Electrical Systems
 - 2. Section 40 66 33 – Fiber Optic Data Communication Cabling
 - 3. Section 40 66 34 – Copper Data Communication Cabling

1.2 REFERENCES

- A. NETA (International Electrical Testing Association):
 - 1. ATS – Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
- B. NFPA (National Fire Protection Association):
 - 1. 70 – National Electrical Code.
 - 2. 262 – Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
- C. UL (Underwriters Laboratories, Inc.):
 - 1. 44 – Standard for Thermoset Insulated Wires
 - 2. 62 – Standard for Flexible Cords and Cables
 - 3. 83 – Standard for Thermoplastic Insulated Wires
 - 4. 1277 – Standard for Electrical Power and Control Tray Cables.
 - 5. 1581 – Standard for Electrical Wire Testing

1.3 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Product Data:
 - 1. Submit data for each conductor and cable type specified, including:
 - a. Conductor size, material, and stranding.
 - b. Number of conductors or pairs.
 - c. Insulation and jacket materials.
 - d. Voltage and temperature ratings.
 - e. Shielding construction.
 - f. Wet-location suitability.

- g. Flame, sunlight, and oil-resistance ratings.
 - h. UL Listing.
 - 2. Identify the proposed use of each conductor and cable type.
- C. Test Reports:
- 1. Specify procedures and values obtained.
- D. Closeout Submittals
- 1. Project Record Documents: Record actual locations of components and circuits.

1.4 QUALIFICATIONS

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

1.5 FIELD MEASUREMENTS

- A. Verify field measurements are as specified in Drawings.

1.6 COORDINATION

- A. Where wire and cable destination is specified and routing is not, determine routing and lengths required.
- B. Wire and cable routing specified is approximate unless dimensioned.

1.7 WARRANTY

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 SINGLE CONDUCTOR WIRING

- A. Available Manufacturers (Subject to compliance with requirements):
- 1. Southwire Company/ American Insulated Wire Corp.
 - 2. Prysmian/General Cable Corporation.
 - 3. Belden.
 - 4. Other Approved Equal.
- B. Conductor Material:
- 1. Copper unless indicated otherwise.
- C. Insulation Rating:
- 1. 600V, 90°C, suitable for wet locations.
 - 2. Insulation types shall be as required by Part 3.

2.2 MULTICONDUCTOR CONTROL CABLE

- A. Type TC-ER, listed for the installed location and wiring method.
- B. Conductor Material:
- 1. Stranded copper.

- C. Conductor Size:
 - 1. Not smaller than No. 14 AWG.
- D. Insulation Rating:
 - 1. 600V, 90°C, suitable for wet locations.
- E. Individual conductors shall be durably color coded or numbered for identification.
- F. Provide the number of insulated conductors and equipment grounding conductor indicated on the Drawings. Equipment grounding conductor shall have green insulation.
- G. Provide an overall sunlight-resistant, moisture-resistant PVC or thermoplastic elastomer jacket.

2.3 ANALOG SIGNAL INSTRUMENTATION CABLE

- A. Type TC-ER, listed for the installed location and wiring method.
- B. Conductor Material:
 - 1. Stranded tinned copper, arranged in twisted pairs or triads as required for the application.
- C. Conductor Size:
 - 1. Not smaller than No. 18 AWG.
- D. Insulation Rating:
 - 1. 600V, 90°C, suitable for wet locations.
- E. Shielding:
 - 1. Each pair or triad shall have an individual aluminum-polyester foil shield providing 100 percent coverage and a stranded tinned-copper drain wire not smaller than No. 20 AWG. Shields shall be electrically isolated from each other and from the overall cable jacket.
- F. Pair and triad conductors shall be durably color coded. Provide consistent color coding throughout the Project.
- G. Provide an overall sunlight-resistant, moisture-resistant PVC or thermoplastic elastomer jacket.

2.4 WIRING CONNECTORS

- A. Available Manufacturers (Subject to compliance with requirements):
 - 1. Atkore/AFC Cable Systems, Inc.
 - 2. Hubbell Power Systems, Inc.
 - 3. O-Z/Gedney; Appleton Electrical Co.
 - 4. 3M; Electrical Products Division
 - 5. TE Connectivity
 - 6. ABB Group
 - 7. ECM Industries/ILSCO
 - 8. Ideal Industries Inc.
 - 9. Leviton
 - 10. Other Approved Equal.

2.5 TERMINATIONS

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

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

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Material:
 - 1. All conductors shall be copper.
- B. Stranding:
 - 1. All conductors shall be stranded.
 - a. Solid conductors may only be used for lighting and receptacle branch circuits No. 12 AWG and smaller.

3.2 CONDUCTOR INSULATION APPLICATIONS

- A. Service Entrance:
 - 1. Type RHW-2 or XHHW-2, single conductors in raceway.
- B. Feeders and Branch Circuits:
 - 1. Below Grade: Type XHHW-2 single conductors in raceway.
 - 2. Above Grade: Type XHHW-2 or THWN-2, single conductors in raceway.
- C. Variable Frequency Drive Circuits:
 - 1. Shielded three conductor cable with symmetrical ground conductors, identified for use in VFD applications up to 2000V.
- D. Cord Drops and Portable Appliance Connection:
 - 1. Type SO, hard service cord with stainless steel wire mesh strain relief device at terminations to suit application.
- E. Discrete Control Circuits:
 - 1. Type THWN-2 or XHHW-2 in raceway for single conductors.
 - a. Provide multi-conductor cables in lieu of single conductors where specifically indicated on Drawings or required elsewhere in the Specifications.
- F. Cable Tray Applications:
 - 1. Type XHHW-2, single conductors for larger than 4/0 AWG; otherwise type TC tray cable.

3.3 CONDUCTOR SIZING

- A. Power circuits: not smaller than No. 12 AWG
 - 1. Increase conductor size where required to limit branch circuit voltage drop to 3 percent maximum and combined feeder and branch circuit voltage drop to 5 percent maximum.
- B. Discrete control circuits: not smaller than No. 14 AWG.

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 are 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, unless specifically indicated otherwise on Drawings.
- B. Route wire and cable to meet Project conditions.
- C. Neatly train and lace wiring inside boxes, equipment, and panelboards.
- D. For finished spaces, conceal cables in walls, ceilings, and floors unless otherwise specified.
- 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 specified.
- J. Special Techniques:
 - 1. Building Wire in Raceway:
 - a. Pull conductors into raceway at same time.
 - b. Install building wire 4 AWG and larger with pulling equipment.
 - 2. Wiring Connections:
 - a. Clean conductor surfaces before installing lugs and connectors.
 - b. Make splices, taps, and terminations to carry full ampacity of conductors with no perceptible temperature rise.

- c. Tape uninsulated conductors and connectors with electrical tape to 150% of insulation rating of conductor.
 - d. Install split bolt connectors for copper conductor splices and taps, 6 AWG and larger.
 - e. Install solderless pressure connectors with insulating covers for copper conductor splices and taps, 8 AWG and smaller.
 - f. Install insulated spring wire connectors with plastic caps for copper conductor splices and taps, 10 AWG and smaller.
- K. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not specified, use those specified in UL 486A and UL 486B.
- L. 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.
- M. Wiring at Outlets:
 - 1. Install conductor at each outlet, with at least 6 in. of slack.
- N. 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.
- O. Install crimp-on fork terminals or wire ferrules for device terminations with stranded wire. Do not place bare stranded conductors directly under screws.
- P. Install terminal lugs on ends of 600 V wires unless lugs are furnished on connected device, such as circuit breakers.
- Q. 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.
- R. 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.
- S. Discrete Control Conductors:
 - 1. Terminate each conductor at a numbered terminal block.
 - 2. Do not splice except at accessible terminal blocks in identified enclosures.
 - 3. Ground the equipment grounding conductor at each end as required for the circuit. Do not use shield drain wires as equipment grounding conductors.
- T. Analog Instrumentation Cable:
 - 1. Install in dedicated raceways separated from power and discrete control wiring. Where crossing cannot be avoided, cross power conductors at approximately 90 degrees.
 - 2. Do not splice except at identified terminal blocks in accessible instrument or control enclosures.
 - 3. Maintain pair twisting to within 1/2 in. of the termination.
 - 4. Maintain shield and drain-wire continuity through intermediate terminal enclosures. Ground each shield at the control panel or receiving system end only unless the instrument manufacturer specifically requires another arrangement. Insulate the shield and drain wire from ground at the field device end.
 - 5. Terminate and label spare pairs at terminal blocks at both ends. Do not leave spare conductors unterminated in raceways or enclosures.

- 6. Protect instrumentation cable from induced noise and physical damage. Do not exceed manufacturer pulling tension or bend-radius requirements.
- U. Do not modify, replace, or reroute factory-installed wiring within equipment assemblies except as required by the equipment manufacturer and approved through the applicable equipment submittal.
- V. Field-installed conductors shall terminate at manufacturer-designated field terminals or communications interfaces.

3.8 WIRE COLOR

- A. General:
 - 1. Refer to 26 05 53 – Identification for Electrical Systems for color requirements.
- B. Neutral Conductors:
 - 1. When two or more neutrals are in one conduit, individually identify each with proper circuit number.
- C. Branch Circuit Conductors:
 - 1. Install three or four wire home runs with each phase uniquely color coded.
- D. Service and Feeder Circuit Conductors:
 - 1. Uniquely color code each phase.

3.9 FIELD QUALITY CONTROL

- A. Perform each visual and mechanical inspection and electrical test recommended by NETA ATS. Certify compliance with test parameters.
- B. Perform each of the following visual inspections and prepare test reports:
 - 1. Inspect exposed sections of conductor and cable for conductor or insulation damage.
 - 2. Inspect compression-applied connectors for correct cable match and identification.
- C. Perform each of the following electrical tests and prepare test reports:
 - 1. Point to point continuity test of all control conductors.
 - 2. Test bolted connections for high resistance using a low-resistance ohmmeter, calibrated torque wrench, or thermographic survey.
 - 3. Insulation resistance test of each service, feeder, and branch circuit conductor (megger test) prior to connection to equipment. Perform phase to ground and phase to phase tests. Perform tests at voltage level and duration as recommended by NETA ATS for the associated voltage rating. Do not perform testing through connected sensitive electronic equipment.
- D. Test Reports:
 - 1. Prepare written reports to record the following:
 - a. Test procedures used.
 - b. Test results that comply with requirements.
 - c. 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 Includes:
 - 1. Electrical grounding and bonding as specified in Drawings and as specified. Grounding and bonding are defined as encompassing systems, circuits, and equipment.
 - 2. Applications of electrical grounding and bonding include:
 - a. Metal underground water pipe
 - b. Metal building frame
 - c. Underground structures
 - d. Concrete-encased electrode
 - e. Structural steel
 - f. Electrical power systems
 - g. Counterpoise grounding loops
 - h. Separately derived systems
 - i. Raceways
 - j. Service equipment
 - k. Equipment

1.2 REFERENCES

- A. IEEE (Institute of Electrical and Electronics Engineers):
 - 1. 81 – Guide for Measuring Ground Resistance, and Potential Gradient in the Earth.
 - 2. 42 – Recommended Practice for Grounding of Industrial and Commercial Power Systems.
 - 3. 1100 – Recommended Practice for Powering and Grounding Electronic Equipment.
- B. NETA (International Electrical Testing Association):
 - 1. ATS – Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
- C. NECA (National Electrical Contractors Association) Installation Standards.
- D. NFPA (National Fire Protection Association):
 - 1. 70 – National Electrical Code.
 - 2. 780 – Lighting Protection Code.
- E. UL LCC:
 - 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:
 - 1. 25 ohms maximum.

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

1.5 SUBMITTALS

- A. Subject to requirements of Section 01 33 00 – Submittal Procedures.
- B. Product Data:
 - 1. Submit data on grounding electrodes and connections.
- C. Test Reports:
 - 1. Specify overall resistance to ground.
- D. Manufacturer's Installation Instructions:
- E. Project Record Documents:
 - 1. 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:
 - 1. Company specializing in manufacturing Products specified in this section with minimum three years of documented experience.
- B. Installer:
 - 1. 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.

1.10 WARRANTY

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

- A. Subject to compliance with requirements, provide grounding and bonding products from ONE for each type of product.
- B. Acceptable Manufacturers:
 - 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 Approved Equal.

2.2 ROD ELECTRODES

- A. Product Description:
 - 1. Material: Copper-clad steel, sectional type or pointed rods.
 - 2. Diameter: 3/4 in.
 - 3. Length: 20 ft.

2.3 WIRE

- A. Insulated Conductors:
 - 1. Stranded copper wire insulated for 600V.
- B. Direct Buried Bare Conductors:
 - 1. Stranded tinned copper.
- C. Above Grade Bare Conductors:
 - 1. Stranded copper.
- D. Foundation Electrodes:
 - 1. Size per NEC or as specified in Drawings, minimum #4AWG.
- E. Grounding Electrode Conductor:
 - 1. Size per NEC or as specified in Drawings, minimum #4AWG.

2.4 GROUNDING BUS BARS

- A. Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, 1/4 in. by 4 in. 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:

1. Provide electrical bonding plates, connectors, terminals, lugs, and clamps as recommended by bonding plate, connector, terminal, and clamp manufacturers for specified applications.
2. 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.
3. 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.
4. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
5. 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:

1. Exothermic materials, accessories, and tools for preparing and making permanent field connections between grounding system components.

2.7 GROUND CLIPS:

- ### A.
- A 2 in. by 6 in. by 1/4 in. galvanized steel plate with hole for 1/2 in. hardware. Clip shall be welded to structural steel to facilitate bonding.

PART 3 - EXECUTION

3.1 EXAMINATION

- ### A.
- Verify final backfill and compaction have 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 specified.
- ### 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 specified.
 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 4. Connections to Structural Steel: Bolted connectors.

3.4 GROUNDING INSTALLATION

- ### A.
- Install as specified in 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 specified in 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 as specified in NEC, including service equipment, distribution panels, lighting panelboards, switch and starter enclosures, motor frames, grounding type receptacles, and other exposed noncurrent 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:
 - 1. Accomplish grounding of electrical system by using insulated grounding conductor installed with feeders and branch circuit conductors in conduits. Size grounding conductors as specified in 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:
 - 1. Route along shortest and straightest paths possible, unless otherwise specified 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:
 - 1. See 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:
 - 1. Drive rods until tops are 2 in. below finished floor or final grade, unless otherwise specified.
 - 2. Install rod electrodes at locations as specified in Drawings. Install additional rod electrodes to achieve specified resistance to ground.
 - 3. Interconnect ground rods with grounding electrode conductor below grade and as otherwise specified. Make connections without exposing steel or damaging coating, if any.
- L. Bonding Straps and Jumpers:
 - 1. Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
 - 2. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - 3. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
 - 4. 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:

1. 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:

1. Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 ft apart.

P. Ground Ring:

1. Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column and specified item, extending around the perimeter of building.
2. Install tinned-copper conductor not less than No. 4/0 AWG for ground ring and for taps to building steel.
3. Bury ground ring not less than 24 in from building foundation at a depth not less than 30 in. below finished grade.

Q. Ufer Ground (Concrete-Encased Grounding Electrode):

1. Fabricate as specified in NFPA 70, using a minimum of 20 ft of bare copper conductor not smaller than No. 4 AWG.
2. If concrete foundation is less than 20 ft 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. See ANSI/IEEE C2 grounding requirements.

B. Grounding Manholes:

1. Install a driven ground rod through manhole floor, close to wall, and set rod depth so 4 in. 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 in. above to 6 in. below concrete. Seal floor opening with waterproof, non-shrink grout.

- C. Grounding Connections to Manhole Components:
 - 1. 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:
 - 1. 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 in. 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. 3-phase motor and appliance branch circuits.
 - 6. Flexible raceway runs.
- B. Air-Duct Equipment Circuits:
 - 1. 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:
 - 1. 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:
 - 1. 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 as specified in NETA ATS.
- B. Perform ground resistance testing as specified in IEEE 142.
- C. Perform continuity testing as specified in 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 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 as specified in 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. This Section Includes:
 - 1. Conduit supports.
 - 2. Formed slotted support channel.
 - 3. Spring steel clips.
 - 4. Equipment bases and supports.
- B. Related Sections:
 - 1. Section 03 30 00 – Cast-In-Place Concrete.

1.2 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Shop Drawings:
 - 1. Specify 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:
 - 1. Specify 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:
 - 1. 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:
 - 1. 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.

1.6 WARRANTY

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 CONDUIT SUPPORTS

- A. Manufacturers:
 - 1. Atkore/Allied Tube & Conduit.
 - 2. Cooper B-Line, Inc, a division of Eaton Corp.
 - 3. ERICO International Corporation, a nVent brand.
 - 4. GS Metals Corp.
 - 5. Thomas & Betts Corporation, a division of ABB.
 - 6. Atkore/Unistrut.
 - 7. Wesanco, a Zsi-Foster brand.
 - 8. Other Approved Equal.
- B. Hanger Rods:
 - 1. Threaded high tensile strength with free running threads.
- C. Beam Clamps:
 - 1. With tapered hole in base and back to accept either bolt or hanger rod.
- D. Conduit clamps:
 - 1. For Trapeze Hangers:
 - a. Notched to fit trapeze with single bolt to tighten.
 - 2. General Purpose:
 - a. One hole for surface mounted conduits.

2.2 FORMED SLOTTED SUPPORT CHANNEL

- A. Manufacturers:
 - 1. Atkore/Allied Tube & Conduit.
 - 2. Cooper B-Line, Inc.; a division of Eaton Corp.
 - 3. ERICO International Corporation, a nVent brand.
 - 4. GS Metals Corp.
 - 5. Thomas & Betts Corporation, a division of ABB.
 - 6. Atkore/Unistrut.
 - 7. Wesanco, a Zsi-Foster brand
 - 8. Or equal.
- B. Product Description:
 - 1. Factory fabricated slotted support channels with holes 1 1/2 in. on center, as specified in MFMA-4.

2.3 SPRING CLIPS

- A. Manufacturers:
 - 1. Atkore/Allied Tube & Conduit.
 - 2. Cooper B-Line, Inc.; a division of Eaton Corp.
 - 3. ERICO International Corporation, a nVent brand.
 - 4. GS Metals Corp.
 - 5. Thomas & Betts Corporation, a division of ABB.
 - 6. Atkore/Unistrut.

7. Wesanco, a Zsi-Foster brand
8. Or equal.

- B. Product Description:
1. Mounting hole and screw closure.

PART 3 - EXECUTION

3.1 HANGERS AND SUPPORTS APPLICATION

- A. Outdoor Locations
1. Slotted support channels shall be type 316 stainless steel.
 2. Clips, clamps, threaded rods, and fastening hardware shall be type 316 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 type 316 stainless steel.
 2. Clips, clamps, threaded rods, and fastening hardware shall be type 316 stainless steel.

3.2 HANGERS AND SUPPORTS INSTALLATION

- A. See 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 in.
 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 as specified in 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 in. off wall.
 - 4. Support vertical conduit at every floor.
- I. Strength of Support Assemblies:
 - 1. Where not specified, 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 EQUIPMENT BASES AND SUPPORTS INSTALLATION

- A. Provide housekeeping pads of concrete, minimum 4 in. thick and extending 6 in. beyond supported equipment. See 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 as specified in 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:
 - 1. Surface raceways, fittings, outlet boxes, pull and junction boxes, and conduit sleeves for electrical systems.

1.2 REFERENCES

- A. ANSI (American National Standards Institute):
 - 1. C80.1 – Rigid Steel Conduit, Zinc Coated.
 - 2. C80.3 – Specification for Electrical Metallic Tubing, Zinc Coated.
 - 3. C80.5 – Aluminum Rigid Conduit – (ARC).
- B. NEMA (National Electrical Manufacturers Association):
 - 1. 250 – Enclosures for Electrical Equipment (1000 Volts Maximum).
 - 2. FB 1 – Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies.
 - 3. OS 1 – Sheet Steel Outlet Boxes, Device Boxes, Covers, and Box Supports.
 - 4. OS 2 – Nonmetallic Outlet Boxes, Device Boxes, Covers, and Box Supports.
 - 5. RN 1 – Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
 - 6. TC 2 – Electrical Polyvinyl Chloride (PVC) Tubing and Conduit.
 - 7. TC 3 – PVC Fittings for Use with Rigid PVC Conduit and Tubing.

1.3 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Product Data:
 - 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.
- C. Manufacturer's Installation Instructions:
 - 1. 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.
- D. Closeout Submittals:
 - 1. Project Record Documents:
 - a. Record actual routing of all conduits.
 - b. Record actual locations and mounting heights of outlet, pull, and junction boxes.

1.4 SYSTEM DESCRIPTION

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

1.5 DESIGN REQUIREMENTS

- A. Minimum Raceway Size:
 - 1. 3/4 in. unless otherwise specified.
- B. Flexible Conduit Connections:
 - 1. Use maximum of 36 in. of flexible conduit for equipment subject to vibration, noise transmission, or movement.

1.6 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.

1.7 COORDINATION

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

1.8 WARRANTY

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

- A. Manufacturers:
 - 1. Atkore/AFC Cable Systems, Inc.
 - 2. Southwire Co./Alflex Inc.
 - 3. Atkore/Allied Tube & Conduit.
 - 4. Anamet Electrical, Inc.; Anaconda Metal Hose.
 - 5. Electri-Flex Co.
 - 6. Manhattan/CDT/Cole-Flex, a brand for Alpha Wire.
 - 7. Tenaris.
 - 8. O-Z Gedney; a unit of General Signal.
 - 9. Wheatland Tube Company.
 - 10. EGS/Appleton Electric.
 - 11. Republic Conduit.
 - 12. Thomas & Betts Corporation; A Member of the ABB Group.
 - 13. Western Tube & Conduit Corporation.
 - 14. Other Approved Equal.
- B. Rigid Steel Conduit:
 - 1. ANSI C80.1 and UL 6.

- C. Rigid Aluminum Conduit:
 - 1. ANSI C80.5.
- D. Fittings and Conduit Bodies:
 - 1. NEMA FB 1; material to match conduit.
- E. Threaded Joint Compound:
 - 1. UL listed for use in conduit assemblies, to lubricate and protect threaded conduit joints from corrosion and to enhance conductivity.
 - 2. Eaton STL8 or equal.

2.2 PVC COATED METAL CONDUIT

- A. See Section 26 05 33.13 – PVC Coated Conduit for requirements.
- B. Available Manufacturers (Subject to compliance with requirements):
 - 1. Atkore/AFC Cable Systems, Inc.
 - 2. Anamet Electrical, Inc.; Anaconda Metal Hose.
 - 3. Dura-Line/Arnco Corp.
 - 4. Cantex Inc.
 - 5. CertainTeed Corp.; Pipe & Plastics Group
 - 6. Condux International, Inc.
 - 7. ElecSYS, Inc.
 - 8. Electri-Flex Co.
 - 9. Lamson & Sessions; Carlon Electrical Products.
 - 10. Manhattan/CDT/Cole-Flex, a brand for Alpha Wire.
 - 11. RACO; a Hubbell Company
 - 12. Thomas & Betts Corporation, a division of ABB.
 - 13. Other Approved Equal.

2.3 LIQUIDTIGHT FLEXIBLE METAL CONDUIT

- A. Available Manufacturers (Subject to compliance with requirements):
 - 1. Cooper Crouse-Hinds, a division of Cooper Electric.
 - 2. EGS/Appleton Electric.
 - 3. Erickson Electrical Equipment Company
 - 4. Hoffman, a division of nVent.
 - 5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division
 - 6. O-Z/Gedney; a unit of General Signal.
 - 7. RACO; a Hubbell company.
 - 8. Scott Fetzer Co./Adalet.
 - 9. Spring City Electrical Manufacturing Company.
 - 10. Stahlin Nonmetallic Enclosures.
 - 11. Carlon, a brand of Thomas & Betts Corporation.
 - 12. Thomas & Betts Corporation, a division of ABB.
 - 13. Legrand/Wiremold Co. (The)
 - 14. Daniel Woodhead Co, a subsidiary of Woodhead Industries, Inc.
 - 15. AFC Cable Systems: a part of Atkore International.
 - 16. Adamet Electrical, Inc.
 - 17. Southwire Company.
 - 18. Other Approved Equal.
- B. Product Description:
 - 1. Interlocked type 316 stainless steel construction with moisture, oil, and sunlight resistant PVC jacket and stainless steel fittings.

- C. Fittings:
 - 1. 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:
 - 1. NEMA TC 2; Schedule 40 or 80 PVC.
- C. Fittings and Conduit Bodies:
 - 1. 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:
 - 1. NEMA OS 1.
- C. Cast Outlet and Device Boxes:
 - 1. FEMA FB1, Type FD, material to match conduit type. Furnish gasketed cover.
- D. Wall Plates for Finished Areas:
 - 1. As specified in Section 26 27 26 – Wiring Devices.
- E. Wall Plates for Unfinished Areas:
 - 1. Furnish gasketed cover.

2.6 PULL AND JUNCTION BOXES

Manufacturers:

- 1. nVent Hoffman.
 - 2. Rittal.
 - 3. Eaton.
 - 4. Hubbell
 - 5. Or equal.
- B. Hinged-Cover Enclosures:
 - 1. Continuous-hinge cover with flush latch, unless otherwise specified. NEMA 250 rating as specified in Part 3.

2.7 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.

2.8 SLEEVE SEALING SYSTEM

- A. Available Manufacturers (Subject to compliance with requirements):
 1. Advance Products & systems, Inc.
 2. Calpico, Inc.
 3. Metraflex Co.
 4. Pipeline Seal and Insulator, Inc.
 5. Other Approved Equal.
- B. Description:
 1. Modular elastomer sealing system, designed for field assembly, to provide weatherproof seal of annular space between sleeve and conduit.
 2. 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.
 3. Pressure Plates: Stainless steel. Include two for each sealing element.
 4. 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: Rigid Aluminum Conduit.
 2. Connection to Vibrating Equipment (Transformers, Motors, etc.): Type 316 Stainless Steel Liquid-tight Flexible Metal Conduit (LFMC) with Stainless Steel Fittings.
- B. Indoor Locations:
 1. Exposed Clean and Dry Locations: Galvanized Rigid Steel or Rigid Aluminum
 2. Exposed Damp or Wet Locations: Galvanized Rigid Steel or Rigid Aluminum
 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 Type 316 Stainless Steel.
 2. Device or Outlet Boxes: NEMA FB1 Type FD PVC-coated cast galvanized 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 Nondedicated 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
 - b. Surface Mount Device or Outlet Boxes: NEMA FB1 Type FD PVC-coated cast galvanized 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 GENERAL INSTALLATION
- A. Ground and bond raceway and boxes as specified in Section 26 05 26 – Grounding and Bonding.
 - B. Fasten raceway and box supports to structure and finishes as specified in Section 26 05 29 – Hangers and Supports.
 - C. Identify raceway and boxes as specified 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 RACEWAY INSTALLATION
- A. Raceway routing is specified 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; provide material type to match provided conduit material type. Provide space on each for 25% 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 in. clearance between raceway and surfaces with temperatures exceeding 104°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:
 - 1. 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 in. 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 in. 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 and Deflection Couplings:
 - 1. Install an expansion coupling in each run of exterior aboveground conduit that has straight-run length that exceeds 100 ft for rigid metal conduit, or 25 ft for PVC conduit, to account for thermal expansion. Provide type and quantity of fittings for each run to accommodate a 125°F temperature change.
 - 2. Provide an expansion and/or deflection coupling where conduit crosses a structural joint intended for expansion, contraction, or deflection.
 - 3. Install each coupling with position, mounting and piston setting selected as specified in 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. in slabs. Conduits larger than 1 1/2 in. 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, non-shrink grout, or sleeve seal system meeting the requirements of this section.
2. Firestopping: Install conduit in a manner to preserve fire resistance rating of walls.
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 BOXES INSTALLATION

- A. Install wall mounted boxes at elevations to accommodate mounting heights as specified in Drawings.
- B. Recessed Boxes in Masonry Walls:
 1. 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:
 1. Install outlet and junction boxes no more than 6 in. 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 in. 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:
 - 1. PVC coated raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.
- B. Related Sections:
 - 1. Section 26 05 33 – Raceway and Boxes for Electrical Systems

1.2 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Product Data:
 - 1. For surface raceways, wireways and fittings, hinged-cover enclosures, and cabinets.
- C. Custom enclosures and cabinets.
- D. Source quality-control test reports.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices and Accessories:
 - 1. Listed and labeled as specified in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. See NFPA 70.
- C. All the conduit, fittings, and supporting products shall be provided by the same manufacturer to make sure that a five-year product warrantee is achieved.

1.4 WARRANTY

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers (Subject to requirements):
 - 1. Robroy (Perma-Cote/Plasti-Bond)
 - 2. Atkore/Calbond

2.2 MATERIALS

- A. PVC coated, Rigid Conduit and fittings shall meet all the performance standards specified 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 rigid conduit shall be UL Listed.

1. The PVC coating shall have been investigated by UL as providing the primary corrosion protection for the rigid metal conduit.
 2. Ferrous fittings for general service locations shall be UL Listed with PVC as the primary corrosion protection.
 3. Hazardous location fittings, prior to plastic coating shall be UL listed.
 4. All conduits and fittings shall be new, unused material.
 5. Applicable UL standards shall include:
 - a. UL 6 Standard for Safety, Rigid Metal Conduit.
 - b. UL 514B Standard for Safety, Fittings for Conduit and Outlet Boxes.
- C. The PVC coated 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 rigid aluminum.
- E. A PVC sleeve extending one pipe diameter or two in, 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 in. – 2 in. 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 hrs. 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:
 1. Conduit and conduit 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 as specified in the Manufacturer's Installation Manual. To make sure of 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. Touchup 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. This Section Includes:
 - 1. Conduit and accessories for below grade duct banks.
 - 2. Precast concrete boxes.
 - 3. Polymer concrete composite boxes.
- B. Related Sections:
 - 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 REFERENCES

- A. ASTM International:
 - 1. C857 – Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
 - 2. C858 – Standard Specification for Underground Precast Concrete Utility Structures.
 - 3. C891 – Standard Practice for Installation of Underground Precast Concrete Utility Structures.
 - 4. C1037 – Standard Practice for Inspection of Underground Precast Concrete Utility Structures.
- B. NEMA (National Electrical Manufacturers Association):
 - 1. FB 1 – Fittings, Cast Metal Boxes and Conduit Bodies for Conduit, Electrical Metallic Tubing (EMT) and Cable.
 - 2. TC 2 – Electrical Polyvinyl Chloride (PVC) Tubing and Conduit.
 - 3. TC 3 – Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
 - 4. TC 6 and 8 – Polyvinyl Chloride (PVC) Plastic Utilities for Underground Installations.
 - 5. TC 9 – Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation.
 - 6. TC 14 – Aboveground Reinforced Thermosetting Resin Conduit and Fittings.
- C. UL, Inc:
 - 1. 651A – Type EB and A Rigid PVC Conduit and HDPE Conduit.

1.3 DEFINITIONS

- A. Manhole:
 - 1. A pre-cast concrete underground box providing access to below grade cables and conductors.
- B. Handhole:
 - 1. A polymer-concrete composite underground box providing access to below grade cables and conductors.

1.4 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.

- B. Action Submittals:
 - 1. Product Data:
 - a. Submit manufacturer information for metallic conduits, nonmetallic conduits, ducts, manhole accessories, handholes, and manholes.
 - b. Accessories for manholes, handholes, boxes.
 - 2. Shop Drawings:
 - a. 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.
 - 3. Duct-Bank Coordination Drawings:
 - a. Show duct profiles and coordination with other utilities and underground structures.
 - b. Include plans and sections, drawn to scale, and show bends and locations of fittings.
- C. Informational Submittals:
 - 1. Manufacturer's Certificate:
 - a. Certify that products meet or exceed specified requirements.
 - 2. Manufacturer Instructions:
 - a. Submit detailed instructions on installation requirements, including storage and handling procedures.
 - 3. Source Quality-Control Submittals:
 - a. Indicate results of factory tests and inspections.
 - 4. Qualifications Statement:
 - a. Submit qualifications for manufacturer.
 - 5. Product Certificates:
 - a. For concrete and steel used in precast concrete manholes, as required by ASTM C858.
 - 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.

1.5 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 as required to suit field conditions and to ensure that duct runs drain to manholes and handholes and as approved by Engineer.

1.6 QUALIFICATIONS

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

1.7 SOURCE QUALITY CONTROL

- A. Testing:
 - 1. Provide shop testing of completed assembly.
- B. Inspection:
 - 1. Inspect manholes according to ASTM C1037.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Inspection:
 - 1. 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.

1.9 WARRANTY

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

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

2.2 RIGID ALUMINUM CONDUIT

- A. Description:
 - 1. Rigid Aluminum Conduit:
 - a. See ANSI C80.5.
 - 2. Fittings:
 - a. See NEMA FB 1.
 - b. Material: Rigid Aluminum.
- B. PVC COATED RIGID ALUMINUM CONDUIT
 - 1. See 26 05 33.13 – PVC Coated Conduit for requirements.

2.3 PVC CONDUIT

- A. Description:
 - 1. Rigid Plastic Conduit:
 - a. See NEMA TC 2.
 - b. Material:

- 1) PVC, Schedule 40.
- c. Fittings and Conduit Bodies:
 - 1) See NEMA TC 3.

2.4 PRECAST CONCRETE MANHOLES AND BOXES

- A. Approved Manufacturers:
 - 1. Hanson Pipe & Precast.
 - 2. Oldcastle Infrastructure Inc.
 - 3. Utility Structures Inc.
 - 4. WCP: Wichita Concrete Pipe
 - 5. Or equal.
- B. Description:
 - 1. 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:
 - 1. ASTM C857, Class A-16, H-20 rated.
- E. Shape:
 - 1. Square or as indicated on drawings.
- F. Nominal Dimensions:
 - 1. 4' x 4' minimum, or as required to accommodate installed conductors and meet minimum dimension requirements per National Electric Code.
- G. Inside Depth:
 - 1. As required for application.
- H. Base Section:
 - 1. Sump:
 - a. Size: 4 in. deep by 12 in. in diameter.
 - b. Furnish cast sleeve and 1 in. ground rod opening.
- I. Top Section:
 - 1. Furnish 39 in. diameter, grooved opening for frame and cover.
- J. Riser Casting:
 - 1. Diameter: 12 in.
 - 2. Furnish manhole steps cast into frame.
- K. Frames and Covers:
 - 1. See ASTM A48.
 - 2. Material: Class 30B gray cast iron.
 - 3. Diameter: 30 in.
 - 4. Surfacing: Machine finished with flat bearing surfaces.
 - 5. Furnish cover cast with ELECTRIC in large letters to indicate utility.
- L. Duct Entry Provisions:
 - 1. 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:
 - 1. Porcelain clamps and saddles.
- R. Manhole Steps:
 - 1. Description: Polypropylene plastic manhole step with 1/2 in. steel reinforcement.
 - 2. Cast steps at 12 in. O.C., vertically.
- S. Sump Covers:
 - 1. Material: Class 30B gray cast iron.
 - 2. See ASTM A48.

2.5 HANDHOLES

- A. Manufacturers:
 - 1. Quazite; brand of Hubbell.
 - 2. Oldcastle Infrastructure Group.
 - 3. Newbasis.
 - 4. Or equal.
- B. Description:
 - 1. 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:
 - 1. Tier 22 design loads for driveway, parking lot, and off-roadway applications subject to occasional nondeliberate heavy vehicular traffic.
- D. Shape:
 - 1. Square or rectangular.
- E. Nominal Dimensions:
 - 1. 17 in. by 30 in. minimum, or as required to accommodate installed conductors and meet minimum dimension requirements per National Electric Code.
- F. Inside Depth:
 - 1. As required for application.
- G. Covers:

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

H. Duct Entry Provisions:

1. Coordinate knockout locations and size with duct banks per drawings.

2.6 ACCESSORIES

A. Duct-Sealing Compound:

1. Nonhardening, safe for contact with human skin, not deleterious to cable insulation and workable at temperatures as low as 35°F. Capable of withstanding temperature of 300°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:

1. 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 nonmetallic 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:
 1. Circuits greater than 600VAC.
 2. 480/277 VAC circuits.
 3. 120 – 240 VAC 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 ft 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 in. below grade without prior written approval from Engineer.
2. Conduit and Duct Slope:
 - a. Minimum 4 in. per 100 ft.
 - 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 in. for all bends.
 - c. For conduits containing fiber-optic cables, provide long-sweep elbows with a minimum radius of 36 in. for all bends.
5. Install fittings to accommodate expansion and deflection. Stagger conduit and duct joints vertically at minimum 6 in. 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 ft 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. Install ducts with a minimum of 3 in. of concrete cover at bottoms, tops, and sides of duct banks.
 - e. For duct bank runs under paved areas, install two No. 4 steel reinforcing bars in top of duct bank concrete.
 - f. 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% fill of duct. If obstructions are indicated, remove obstructions and retest.
 - 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 in. 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 rigid aluminum conduit at exterior or interior wet locations, and PVC-coated rigid aluminum 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 as specified in 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 in. bed of crushed stone or gravel graded from 1 in. 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 in. bed of crushed stone or gravel graded from 1 in. 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 in. 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 as specified in 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. Subject to the requirements of 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 in. by 4 in. in size illustrating materials and engraving quality.
- D. Manufacturer's Installation Instructions:
 - 1. Specify installation instructions, special procedures, and installation.

1.3 QUALIFICATIONS

- A. Manufacturer:
 - 1. Company specializing in manufacturing Products specified in this section with minimum three years documented experience.
- B. Installer:
 - 1. 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.

1.6 WARRANTY

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 NAMEPLATES

- A. Available Manufacturers:
 - 1. Craftmark Pipe Markers
 - 2. Kolbi Pipe Marker Co.
 - 3. Pipemarket.com; Brimar Industries, Inc.
 - 4. Seton Identification Products: Brady corporation Co.
 - 5. Or Approved Equal.
- B. Product Description:
 - 1. Laminated three-layer plastic with engraved white letters on black contrasting background color.
- C. Letter Size:
 - 1. As specified in Drawings.
- D. Engraved, laminated acrylic or melamine plastic, minimum 1/16 in. thick for signs up to 20 in² and 1/8 in. 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.
- E. Nameplate Content:
 - 1. Equipment tag as denoted in Drawings.
 - 2. Equipment power supply information (voltage, full load current, phase, wire count).
 - 3. Equipment short circuit withstand rating.
 - 4. Equipment ampacity rating (when applicable).
 - 5. Source of power supply to equipment with source tag, location, and description. If multiple sources of power are present, each shall be listed.

2.2 LABELS

- A. Available Manufacturers:
 - 1. Brady Identification Inc.
 - 2. Seton Identification Products: Brady corporation Co.
 - 3. Or Approved Equal.
- B. Comply with NFPA 70 and 29 CFR 1910.145 and NFPA 70E.
- C. Self-Adhesive Warning Labels:
 - 1. Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door or other access to equipment unless otherwise specified.
- D. Metal-Backed, Butyrate Warning Signs:
 - 1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396 in. galvanized-steel backing; and with colors, legend and size required for application. 1/4 in. grommets in corners for mounting. Nominal size, 10 in. by 14 in.

- E. Sample warning label and sign shall include, but are not limited to the following legends:
 - 1. Multiple Power source Warning:
 - a. "DANGER – ELECTRICAL SHOCK HAZARD – EQUIPMENT HAS MULTIPLE POWER SOURCES."
 - 2. Workspace Clearance Warning:
 - a. "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. Available Manufacturers:
 - 1. Brady ID
 - 2. Grafoplast Wire Markers
 - 3. Ideal Industries, Inc.
 - 4. Or Approved Equal.
- B. Description:
 - 1. Cloth tape, split sleeve, or tubing type wire markers.
- C. Legend:
 - 1. Power and Lighting Circuits: Branch circuit or feeder number as specified in Drawings.
 - 2. Control Circuits: Control wire number as specified in Drawings.

2.4 UNDERGROUND WARNING TAPE

- A. Available Manufacturers:
 - 1. Brady ID
 - 2. Kolbi Pipe Marker Co.
 - 3. Seton Identification Products: Brady corporation Co.
 - 4. Or Approved Equal.
- B. Description:
 - 1. 3 in. wide plastic tape, detectable type, colored red with suitable warning legend describing buried electrical lines.

2.5 LOCKOUT DEVICES

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

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:
 - 1. Identify branch circuit by panel name and circuit number.
- B. Power-Circuit Conductor Identification:
 - 1. 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:
 - 1. 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 as specified in source and circuit number.
- D. Auxiliary Electrical Systems Conductor Identification:
 - 1. Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
 - 2. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 - 3. Use system of marker type designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 - 4. 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:
 - 1. 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.
 - 2. Equipment with Multiple Power or Control Sources:
 - a. Apply to door or cover of equipment including, but not limited to the following:
 - b. Power transfer switches
 - c. Controls with external control power connections.
 - 3. Equipment Requiring Workspace Clearance as specified in NFPA 70:
 - a. Unless otherwise specified, apply to door or cover of equipment, but not on flush panelboards and similar equipment in finished spaces.
- F. Instruction Signs:
 - 1. Operating Instructions:
 - a. 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:
 - a. Install instruction signs with white legend on a red background with minimum 3/8 in. high letters for emergency instructions at equipment used for power transfer.
- G. Equipment Identification Labels:
 - 1. 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.
 - 2. 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-button stations
- j. Power transfer equipment
- k. Contactors
- l. Control panels, including those containing programmable logic controllers (PLCs), remote terminal units (RTUs), and radio telemetry equipment
- m. Remote-controlled switches and control devices
- n. Power-generating units
- o. Voice and data cable terminal equipment
- p. 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:
 - 1. 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:
 - 1. 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:
 - 1. Use the colors listed below for ungrounded service, feeder, and branch-circuit conductors.
 - 2. Color shall be factory applied or, for sizes larger than No. 6 AWG if authorities having jurisdiction permit, field applied.
 - 3. 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
 - 4. 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
 - 5. Colors for 240/120 V, 1-phase Circuits:
 - a. L1: Black
 - b. L2: Black
 - c. N: White

- d. Ground: Green
- 6. Cables for systems with a “high-leg” shall be provided with orange color-coding tape on the high leg conductor.
- 7. Field-Applied, Color-Coding Conductor Tape:
 - a. Apply in half-lapped turns for a minimum distance of 6 in. 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 in. below finished grade, directly above buried conduit, raceway, or cable.

END OF SECTION

SECTION 26 05 73 – POWER SYSTEM STUDIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. A complete computer-based power system study including the following: short circuit analysis, equipment evaluation, protective device overcurrent coordination, and arc flash hazard analysis.
 - 2. Study shall cover all equipment, new or relocated existing equipment, installed downstream of the switchboard feeder breaker supplying the new odor control system.

1.2 DEFINITIONS

- A. One-Line Diagram:
 - 1. A diagram that specifies, by means of single lines and graphic symbols, the course of an electric circuit and the component devices or parts used therein.
- B. Protective Device:
 - 1. A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
- C. Service:
 - 1. The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.3 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Product Data:
 - 1. For computer software program to be used for studies.
- C. Submit the following after the approval of system protective devices submittals. Submittals may be in digital form.
 - 1. Power system analysis input data, including completed computer program input data sheets.
 - 2. Complete power system study report as required by this document; signed, dated, and sealed by a qualified professional engineer.
 - a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Engineer for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.
 - b. Revised single-line diagram, reflecting field investigation results and results of power system analysis.
- D. Qualification Data:
 - 1. For power system analysis specialist.

1.4 QUALITY ASSURANCE

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.
- B. Power System Analysis Specialist Qualifications:
 - 1. Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE

- A. Products (Subject to requirements, perform study using):
 - 1. SKM; PowerTools for Windows
 - 2. ESA International; EasyPower.
- B. As specified in:
 - 1. IEEE 399
 - 2. IEEE 551
 - 3. IEEE 242
 - 4. IEEE 1584
 - 5. NFPA 70E
- C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output.

2.2 DATA COLLECTION

- A. Obtain all data necessary to conduct the power system analysis.
 - 1. Verify completeness of data supplied on the one-line diagram on Drawings. Call discrepancies to the attention of Engineer.
 - 2. For new equipment, use characteristics submitted under the provisions of submittals for this Project.
 - 3. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers.
- B. Gather and tabulate the following input data to support power system study. As specified in recommendations in IEEE 1584 and NFPA 70E as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study and shall be by the engineer or its representative.
 - 1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
 - 2. Obtain electrical power utility impedance at the service, including three phase and single phase short circuit MVA and X/R ratio.
 - 3. Power sources and ties.
 - 4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.

5. For reactors, provide manufacturer and model designation, voltage rating and impedance.
6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
7. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
8. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
9. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
10. Motor horsepower and NEMA MG 1 code letter designation.
11. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
12. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.

2.3 SYSTEM MODELING

- A. Provide a list of all assumptions made. The Engineer shall review and request any changes to assumptions before final approval of the model.
- B. Equipment names used in the modeling software shall be identical to the names used on the equipment nameplates installed in the field.
- C. For systems with more than one available power source (such as a generator or second utility source), separate scenarios shall be modeled for each possible operating condition. Each of the operating conditions shall be documented and modeled in the software to determine the worst-case arc flash hazard and short circuit values for the system components.
- D. All components in the model shall be based on nameplate data from the actual field device including manufacturer, type, style, ratings, actual settings, etc. Generic substitutions or assumptions shall not be allowed unless data cannot be field verified. All assumptions or substitutions shall be documented in the report.
- E. The model shall include all electrical components of the system from the utility service (including primary relaying) down to all equipment more than 50 V. This includes all control panels, disconnects, or other panels where voltage greater than 50 V is present. Refer to requirements of arc flash analysis for evaluating hazards for equipment less than 240V.

2.4 SHORT CIRCUIT ANALYSIS

- A. Perform study following the general study procedures contained in IEEE 399.
- B. Calculate short-circuit currents as specified in IEEE 551. Begin short-circuit current analysis at the service, extending down to the system overcurrent protective devices.
- C. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- D. Actual transformer impedances shall be used if known. Design impedances shall only be used where actual impedance is unobtainable from field markings or from the manufacturer.

- E. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
 - 1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- F. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault:
 - 1. Electric utility's supply termination point.
 - 2. Incoming switchgear.
 - 3. Low-voltage switchgear.
 - 4. Motor-control centers.
 - 5. Control panels.
 - 6. Standby generators and automatic transfer switches.
 - 7. Branch circuit panelboards.
 - 8. Disconnect switches.
 - 9. Other significant locations throughout the system.

2.5 EQUIPMENT EVALUATION

- A. Provide a short circuit evaluation of all electrical equipment and protective devices. Evaluation shall compare short circuit withstand and interrupting ratings of equipment with calculated short circuit values from the study.
- B. The software performing the equipment evaluation shall automatically adjust results for system X/R ratios that are higher than equipment test X/R ratios.
- C. Equipment in the evaluation shall be marked with:
 - 1. PASS – maximum short circuit current is less than 90% of equipment rating.
 - 2. MARGINAL – maximum short circuit current is 90% – 100% of equipment rating.
 - 3. FAIL – maximum short circuit current is greater than 100% of equipment rating.

2.6 PROTECTIVE DEVICE COORDINATION STUDY

- A. Provide settings for all overcurrent protective devices to achieve the following:
 - 1. Provide selective coordination for the electrical system.
 - 2. Protect equipment and cables from damage during overcurrent conditions.
 - 3. Minimize arc flash hazards.
- B. Graphically illustrate the settings of all overcurrent protective devices utilizing time current curves (TCCs):
 - 1. Display TCCs on log-log scale graphs printed in color on 8.5 in. by 11 in. sized paper. Each TCC shall have a unique title and associated one-line diagram with legend identifying the portion of the system depicted in the TCC.
 - 2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
 - 3. Each device specified on a TCC shall include a datablock identifying the name of the device, manufacturer make and model, and overcurrent settings.
 - 4. Develop TCCs for both phase and ground protective devices.
 - 5. Plot the following listed characteristic curves, as applicable:
 - a. Power utility's overcurrent protective device.
 - b. Medium voltage equipment overcurrent relays.
 - c. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
 - d. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands.

- e. Transformer full load current, magnetizing inrush current, and ANSI through-fault protection curves.
 - f. Cables and conductors damage curves.
 - g. Ground fault protective devices.
 - h. Motor starting characteristics and motor damage points.
 - i. Generator short-circuit decrement curve and generator damage point.
 - j. The largest feeder circuit breaker in each motor control center, switchboard, and panel board.
 - 6. Provide number of TCCs as required to adequately display the selective coordination of the system.
 - 7. Provide adequate time margins between device characteristics such that selective operation is achieved.
- C. For an existing system, provide the protective device settings as existing as well as recommendations for new settings if existing does not provide adequate selectivity. If settings changes are recommended, clearly identify the recommended changes in a table format.
- D. A table shall be developed to summarize the settings for all protective devices that contain adjustable settings. The table shall include the following:
- 1. Device identification.
 - 2. For circuit breakers: manufacturer, type, style, sensor rating, long-time pickup, short-time pickup, instantaneous pickup, ground fault pickup, and associated time delay settings.
 - 3. For protective relays: manufacturer, type, style, function pickup, current multiplier, time dial, and time delays. For multifunction units, list all devices being used. Include the CT and/or PT ratios for each function.
 - 4. Include both existing settings and recommended changes for all protective devices with recommended settings changes.
- E. Transformer Primary Overcurrent Protective Devices:
- 1. Device shall not operate in response to the following:
 - a. Inrush current when first energized.
 - b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
 - c. Permissible transformer overloads as specified in IEEE C57.96 if required by unusual loading or emergency conditions.
 - 2. Device settings shall protect transformers as specified in IEEE C57.12.00, for fault currents.
- F. Motor Protection:
- 1. Select protection for low-voltage motors as specified in IEEE 242 and NFPA 70.
 - 2. Select protection for motors served at voltages more than 600 V as specified in IEEE 620.
- G. Conductor Protection:
- 1. Protect cables against damage from fault currents. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards specifying conductor size and short-circuit current.
- H. Generator Protection:
- 1. Select protection as specified in manufacturer's written recommendations and to IEEE 242.

2.7 ARC FLASH HAZARD ANALYSIS

- A. As specified in NFPA 70E and IEEE 1584 for hazard analysis study.
- B. Results from the short circuit current study and overcurrent coordination study shall be used as inputs to the arc flash hazard analysis.
- C. The flash protection boundary and incident energy shall be calculated at all significant locations in the electrical distribution system where work could be performed on energized parts. This includes but is not limited to switchboards, switchgear, motor control centers, panelboards, busways, and disconnect switches.
- D. For three-phase or single-phase equipment rated 240 VAC or less fed from transformers less than 125 kVA, refer to NFPA 70E and IEEE 1584 for determining hazard category levels. Include in the report a description of methods used to determine hazard levels for equipment in this category.
- E. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary.
- F. The incident energy calculations for multiple scenarios must be compared and the greatest incident energy must be reported for each equipment location. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full load conditions. Note that maximum utility contribution is not defined as infinite bus, but rather the maximum value reported by the utility.
- G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall account for the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:
 - 1. Fault contribution from induction motors should not be considered beyond three to five cycles.
- H. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).
- I. Arc-flash computation shall include both line and load side of a circuit breaker as follows:
 - 1. When the circuit breaker is in a separate enclosure.
 - 2. When the line terminals of the circuit breaker are separate from the work location.
- J. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds.

PART 3 - EXECUTION

3.1 POWER SYSTEM STUDY REPORT CONTENTS

- A. Executive Summary:
 - 1. Brief description of the important findings and recommendations of the study. The executive summary should not include general study information or methodology.

- B. Introduction:
1. Describe the purpose and scope of the study and the methodology used for each analysis.
 2. Provide a description of the connection of the system and the different operating scenarios analyzed.
 3. List all engineering assumptions made for the study.
- C. Input Data:
1. Provide input data for all components of the system model in tabular format, including but not limited to the following:
 - a. Cable data including size, length, number per phase, conduit type, and conductor material.
 - b. Transformer data including winding connections, kVA rating, primary and secondary voltage ratings, %Z, and X/R ratios.
 - c. Reactor data including voltage rating and inductance.
 - d. Generator contribution data including kVA rating, power factor, voltage, and subtransient reactance.
 - e. Utility contribution data including rated voltage and three phase and single-line-ground contributions with X/R ratios.
- D. One-Line Diagram:
1. Provide one-line diagram(s) generated from the computer software package that specifies all electrical distribution for the system. Include as a minimum the following information on the diagram(s):
 - a. Protective device designations and ampere ratings.
 - b. Cable sizes and lengths.
 - c. Transformer kilovolt ampere (kVA), voltage, and impedance ratings.
 - d. Motor and generator designations and kVA ratings.
 - e. Utility contribution data
 - f. Switchgear, switchboard, motor-control center, and panelboard designations, voltage ratings, bus ampacities, and short circuit current ratings.
- E. Short Circuit Current Analysis:
1. Output data shall include but not be limited to the following reports:
 - a. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, specifying the following for each overcurrent device location:
 - 1) Voltage.
 - 2) Calculated fault-current magnitude and angle.
 - 3) Fault-point X/R ratio.
 - 4) Equivalent impedance.
 - b. Momentary Duty Report: Three-phase and unbalanced fault calculations, specifying the following for each overcurrent device location:
 - 1) Voltage.
 - 2) Calculated symmetrical fault-current magnitude and angle.
 - 3) Fault-point X/R ratio.
 - 4) Calculated asymmetrical fault currents:
 - a) Based on fault-point X/R ratio.
 - b) Based on calculated symmetrical value multiplied by 1.6.
 - c) Based on calculated symmetrical value multiplied by 2.7.
 - c. Interrupting Duty Report: Three-phase and unbalanced fault calculations, specifying the following for each overcurrent device location:
 - 1) Voltage.
 - 2) Calculated symmetrical fault-current magnitude and angle.
 - 3) Fault-point X/R ratio.
 - 4) No AC Decrement (NACD) ratio.
 - 5) Equivalent impedance.

- 6) Multiplying factors for 2, 3, 5, and 8-cycle circuit breakers rated on a symmetrical basis.
- d. Multiplying factors for 2, 3, 5, and 8-cycle circuit breakers rated on a total basis.

F. Equipment Evaluation:

1. The results of the short circuit equipment evaluation shall be reported in tabular format and provide the following information:
 - a. Equipment name, voltage rating, and short circuit rating
 - b. Calculated maximum available short circuit current at each device and bus
 - c. Percent over/under duty and PASS/FAIL/MARGINAL designation as defined in Part 2 of this specification.
 - d. Components that fail the equipment evaluation shall be highlighted for easy visual identification.

G. Protective Device Coordination Study:

1. Provide a summary of the findings of the study including any major selectivity problems or recommendations.
2. Provide all TCCs needed to illustrate the system including a table of contents and descriptions for all TCCs included.
3. Include a settings table to summarize the settings for all protective devices as required in Part 2 of this specification.

H. Arc Flash Hazard Analysis:

1. Provide a brief summary of the findings of the study including a list of any locations identified as Dangerous hazard category and recommendations for hazard category reductions.
2. Provide a table specifying the worst case scenario of all busses evaluated. Table shall include but is not limited to the following:
 - a. Arcing fault magnitude.
 - b. Protective device clearing time.
 - c. Duration of arc.
 - d. Arc flash boundary.
 - e. Working distance.
 - f. Incident energy.
 - g. Hazard risk category.
3. Provide a separate table for each operating scenario. Provide the same information as required above for each table.

I. Recommendations:

1. Provide a section that summarizes and lists all recommendations for changes to the system as a result of the study. This includes protective device settings changes, equipment short circuit deficiency corrections, or other items as applicable.

3.2 ARC FLASH WARNING LABELS

- A. Provide a thermal transfer type label of high-adhesion polyester for each work location included in the analysis. Labels shall have a minimum size of 3.5 in. by 5 in.
- B. The labels shall include the following information taken directly from the arc flash hazard analysis:
 1. Equipment name (must match name on equipment nameplate).
 2. Nominal voltage.
 3. Flash protection boundary.
 4. Hazard risk category.
 5. Incident energy.
 6. Available short circuit current.

7. Working distance.
8. Glove class.
9. Engineering report number, revision number, and issue date.

- C. Labels shall be machine printed, with no field-applied markings.
- D. Labels to be applied on outdoor equipment shall have a weatherproof coating for protection from deterioration or fading due to rain and UV exposure.

3.3 LABELING

- A. Apply one arc flash label for each of the following locations:
 1. Panelboards.
 2. Disconnects.
 3. Motor control centers.
 4. Switchboards.
 5. Switchgear.
 6. Control panels.
 7. Any equipment likely to require servicing while energized.
- B. Installation of arc flash warning labels shall be done under the direct supervision and control of the power system study specialist.

3.4 ADJUSTING

- A. Contractor shall adjust both new and existing protective device trip settings as specified.
- B. Make minor modifications to equipment as specified.

3.5 DEMONSTRATION

- A. Train Owner's operating and maintenance personnel in the use of study results.

3.6 TRAINING

- A. Train Owner's operating and maintenance personnel in the potential arc flash hazards associated with working on energized equipment and the significance of arc flash warning labels.

END OF SECTION

SECTION 26 05 93 – ELECTRIC MOTORS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section Includes :
 - 1. 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 as specified in the individual driven equipment sections.

1.2 DEFINITIONS

- A. ODP: Open Drip Proof.
- B. TEFC: Totally Enclosed Fan Cooled.

1.3 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Product Data:
 - 1. For each type of product specified.
 - 2. Complete motor data shall be submitted by Supplier, including:
 - a. Machine name and specification number of driven machine.
 - b. Motor manufacturer.
 - c. Motor type or model and dimensional drawing, including weight.
 - d. Horsepower nominal.
 - e. Guaranteed minimum full load efficiency.
 - 1) Also, nominal efficiencies at 1/2 and 3/4 load.
 - f. Full load speed.
 - g. Full load current at rated horsepower for application voltage.
 - h. Service factor, minimum 1.15.
 - i. Voltage, phase, and frequency rating.
 - j. Winding insulation class.
 - k. Temperature rise class.
 - l. Frame size.
 - m. Enclosure.
 - n. NEMA design.
 - o. Thermal protection or over temperature protection.
 - p. Wiring diagram for devices such as temperature switches, space heaters and motor leak detection as applicable.
 - q. Bearing data, including recommendation of lubricants.
 - r. Inverter duty motor. Include minimum speed at which motors may be operated.
 - s. Power factor at 1/2, 3/4, and full load.
 - t. Complete nameplate data, rating, and characteristics.
 - u. Mounting arrangement, size, and location of conduit entries, including lugs.
 - v. 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 as specified in NEMA MG 1 winding temperature and trip current tests.
- C. See 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 specified in Drawings.
- C. Coordinate motor leads and lugs with wire sizes specified in Drawings.

1.6 WARRANTY

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 MOTOR REQUIREMENTS

- A. All motors shall be squirrel cage, AC 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 specified 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. Three phase motors shall be provided with Class F insulation, rated to operate at a maximum ambient temperature of 40°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 V spikes, with dV/dt as specified 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: 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 nonconditioned spaces shall have 120 VAC space heaters. Space heater size and quantity shall be suitable to maintain minimum recommended temperatures for the installed location.
- J. Where driven by a variable frequency drive and larger than 10 HP, 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.
- K. Unless otherwise specified, motor shall have no-load sound power levels not to exceed the values specified in NEMA MG 1-12.53.3.
- L. Premium Efficiency Motors:
 - 1. Motors with a nameplate rating of 1 hp 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 as specified in ANSI/NEMA MG1-12.59 – Efficiency Levels of Energy Efficient Polyphase Squirrel-Cage Induction Motors. All three values are required to be specified in the submittal.

2.2 MOTOR BEARINGS

- A. All motors shall have bearings designed for 17,500 hrs. (belted) or 100,000 hrs. (coupled) L-10 life.
- B. Horizontal motors shall be shielded open-type bearing installed with labyrinth sealed end bells with pipe plugs. Bearings shall be regreasable and have provisions for purging old grease.

2.3 MOTOR THERMAL PROTECTION

- A. Motors shall be provided with winding thermostats where specified on the equipment data sheets or contract drawings, as specified in NEMA MG-1. Thermostats shall be snap action, bimetallic, temperature actuated type switches and shall be provided with a normally closed contact. Thermostats shall be 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 specifying integral thermal protection is provided.

2.4 ACCESSORIES

- A. Motors 1 hp 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. Motors weighing 250 lbs. 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. Motors shall be fitted with permanent stainless-steel nameplates indelibly stamped or engraved with NEMA Standard motor data.

- E. Provide 120 VAC space heaters and winding thermostats as identified in the equipment data sheets or when specified in 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 airconditioned, ventilated, or protected environment like or better than the destination environment.

3.2 INSTALLATION

- A. Contractor shall perform motor installation as specified in 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 as specified in 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 as specified in both the Manufacturer's recommendations and the requirements specified herein.
- B. Perform insulation resistance tests as specified in 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 detectable, 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 nonconforming 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 nonconforming 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.

$\phi A-\phi B$ _____ $\phi B-\phi C$ _____ $\phi C-\phi A$ _____

$\phi A-G$ _____ $\phi B-G$ _____ $\phi C-G$ _____

6. Record full load voltage and current:

V_{ab} _____ V_{an} _____ I_a _____

V_{bc} _____ V_{bn} _____ I_b _____

V_{ca} _____ V_{cn} _____ I_c _____

7. Motor Nameplate FLA: _____

Running Amps: _____

P.F. _____

8. Comments:

Signature Required: _____

Company: _____

Date: _____

SECTION 26 27 26 – WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section Includes:
 - 1. 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. NEMA (National Electrical Manufacturers Association):
 - 1. WD 1 – General Requirements for Wiring Devices.
 - 2. WD 6 – Wiring Devices-Dimensional Requirements.

1.3 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Product Data:
 - 1. Submit manufacturer's catalog information showing dimensions, colors, and configurations.
- C. Samples:
 - 1. Submit two samples of each wiring device and wall plate illustrating materials, construction, color, and finish.

1.4 QUALIFICATIONS

- A. Manufacturer:
 - 1. Company specializing in manufacturing products specified in this section with minimum three years documented experience.
- B. Source Limitations:
 - 1. 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:
 - 1. 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.

1.6 WARRANTY

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Wiring devices shall be specification grade, with special devices as specified in Drawings. Should the Drawings specify a device other than those listed in this section 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 120 V 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 Approved Equal.
- B. Product Description:
 - 1. All switches and associated materials shall bear a UL 20 and as specified in NEMA WD 1.
 - 2. Provide all necessary wiring and accessories as required for complete installation.
- C. All single-pole, double-pole, three-way, and four-way switches as specified.
- 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 VAC–277 VAC
 - 2. Current: 20 amps
- F. Weatherproof, Self-Grounding, Heavy-Duty Switches:
 - 1. Flush or surface mounted as specified.
 - 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 specified in Drawings.
- G. Dimmers:
 - 1. Solid State Dimmer for LED dimmable driver: Captive linear-slide dimmer for a traditional cover plate opening.
 - 2. Output 0 V–10 V 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. Walkthrough 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 specified.
4. Output 0 V–10 V for control of dimmable LED drivers.
5. Provide power supply as specified.
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 Approved Equal.

B. Product Description:

1. 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 specified.
 - f. When specified provide GFCI type as specified.

D. Ground Fault Circuit Interrupter (GFCI) Receptacles:

1. Flush or Surface mounted as specified.
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 specified otherwise.
4. UL Standard 943 Class A, Group 1.
5. Leakage current sensitivity: 5mA plus or minus 1mA.

E. Opens circuit within 25 milliseconds of reaching 5 mA.

1. Duplex, arc resistant and prewired.
 2. Cover plate materials and colors shall match standard receptacles as specified this section.
 3. All exterior or interior wet locations, or as specified in Drawings.
- F. Weatherproof Receptacles:
1. Flush or Surface mounted as specified.
 2. Rated 20A at 125 VAC, Fed. Spec. W-C-596. NEMA reference 5-20R.
 3. GFCI receptacle as specified in this Section when specified.
 4. Provide a gray receptacle with a cast aluminum weatherproof cover.
- G. Provide while-in-use cover for outdoor locations.
1. Provide hinged self-closing, gasketed type covers for indoor locations.
 2. All exterior or interior wet locations, or as specified in Drawings.
- H. Floor Receptacles:
1. Receptacles shall be compatible with the recessed box assembly. Provide 20-amp, 125 V, 2-pole, 3-wire, grounding, gray duplex receptacles, NEMA configuration 5-20R.
 2. Recessed boxes shall include duplex receptacles and network keystone jacks as specified.
- I. Poke-Through Floor Devices:
1. 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-amp, 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 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-A 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. 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 specified in Drawings.
- B. Install wall switch 48 in. above finished floor.
- C. Install convenience receptacle 24 in. above finished floor.
- D. Install convenience receptacle 6 in. above counter and back splash of counter.
- E. Install dimmer 48 in. 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 V–125 V.
 - 2. Percent Voltage Drop under 15-A Load: A value of 6% 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, specifying 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 as specified in 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 REFERENCES

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

1.3 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Product Data:
 - 1. For each type of product specified. Include construction details, material, dimensions, descriptions of individual components and finishes for spare-fuse cabinets. Include the following for each fuse type specified:
 - a. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
 - 1) For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
 - 2) Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
 - b. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
- C. Operation and Maintenance Data:
 - 1. For fuses to include in emergency, operation, and maintenance manuals.
 - 2. Ambient temperature adjustment information.
 - 3. 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% 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:
 - 1. Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.
- C. Electrical Components, Devices and Accessories:
 - 1. 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. Approved Manufacturers:
 - 1. Cooper Bussmann; Eaton
 - 2. Edison Fuse, Inc.
 - 3. Mersen
 - 4. Littelfuse, Inc.

2.2 DESIGN REQUIREMENTS

- A. Select fuses to provide appropriate levels of short circuit and overcurrent protection for the following components:
 - 1. 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:
 - 1. NEMA FU 1, Class as specified or as specified in Drawings.
 - 2. Feeders: Class RK1, RK5, or L, fast acting
 - 3. Motor Branch Circuits: Class RK1 or RK5, time delay
 - 4. Control Circuits: Class CC fast acting.
- B. Voltage:
 - 1. Rating suitable for circuit phase-to-phase voltage.

PART 3 - EXECUTION

3.1 EXAMINATION

- 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 specifying 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. This Section Includes:
 - 1. Fusible switches
 - 2. Nonfusible switches
- B. Related Sections:
 - 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 REFERENCES

- A. NEMA (National Electrical Manufacturers Association):
 - 1. FU 1 – Low Voltage Cartridge Fuses.
 - 2. KS 1 – Enclosed and Miscellaneous Distribution Equipment Switches (600 V Maximum).
- B. NETA (International Electrical Testing Association):
 - 1. ATS – Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

1.3 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Product Data:
 - 1. Submit switch ratings and enclosure dimensions.
- C. Product Data:
 - 1. For each type of enclosed switch, circuit breaker, accessory, and component specified. Include dimensioned elevations, sections, weights and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
 - 2. Enclosure types and details for all types specified, including NEMA 250, Type 1.
 - 3. Current and voltage ratings.
 - 4. Short-circuit current ratings (interrupting and withstand, as appropriate).
 - 5. Include evidence of Nationally Recognized Testing Laboratory listing for series rating of installed devices.
 - 6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
- D. Shop Drawings:
 - 1. For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
 - 2. Wiring Diagrams: for power, signal, and control wiring.
- E. Qualification Data:
 - 1. For qualified testing agency.
- F. Field quality-control reports.
 - 1. Test procedures used.
 - 2. Test results as specified in requirements.

3. Results of failed tests and corrective action taken to achieve test results as specified in requirements.

G. Operation and Maintenance Data:

1. For enclosed switches to include in emergency, operation, and maintenance manuals.
2. Manufacturer's written instructions for testing and adjusting enclosed switches.

H. Closeout Submittals:

1. Project Record Documents:
 - a. Record actual locations of enclosed switches and ratings of installed fuses.

1.4 QUALIFICATIONS

A. Manufacturer:

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

1.5 QUALITY ASSURANCE

A. Source Limitations:

1. 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:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. See NFPA 70.

1.6 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.

1.7 WARRANTY

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCH ASSEMBLIES

A. Available Manufacturers:

1. Eaton
2. Schneider Electric; Square D
3. ABB
4. Siemens
5. Or Approved Equal.

B. Description:

1. NEMA KS 1, Type HD, enclosed load interrupter knife switch. Handle lockable in OFF position. UL98 and NEMA KS 1, 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. Switch Ratings:
 - 1. Ampacity: As specified in Drawings.
 - 2. Short Circuit Withstand/Interrupting Rating: 200kA.
- E. Service Entrance:
 - 1. 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. Schneider Electric; Square D
 - 3. ABB
 - 4. Siemens
 - 5. Or Approved Equal.
 - 6. NEMA KS 1, Type HD enclosed load interrupter knife switch. Handle lockable in OFF position. UL 98 and NEMA KS 1, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- B. 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.
- C. Switch Ratings:
 - 1. Ampacity Rating: As specified in Drawings.
 - 2. Short Circuit Withstand Rating: 10kA minimum. Switches shall be series rated with upstream protective devices to withstand available fault current at switch location where the available fault current exceeds 10kA.
- D. 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 (Nondedicated 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 as specified in 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 specified.
- B. Install enclosed switches plumb. Provide supports as specified in Section 26 05 29 – Hangers and Supports for Electrical Systems.
- C. Height:
 - 1. 5 ft to operating handle. Receive Engineer or Owner approval for other mounting heights. In no instance shall the operating handle be greater than 6 ft, 7 in. above the floor or working platform.
- D. Install fuses for fusible disconnect switches. See Section 26 28 13 – Fuses for product requirements.
- E. Install engraved plastic nameplates as specified in 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 specified NEMA fuse class and size installed.

3.3 FIELD QUALITY CONTROL

- A. Perform inspections and tests specified 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 onsite, 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

SECTION 26 29 23 – VARIABLE–FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of 3-phase, squirrel-cage induction motors.
 - 2. VFDs provided as part of the Bio-trickling Filter control panel.

- B. Related Sections:

1.2 QUALIFICATIONS

- A. Manufacturer:
 - 1. The manufacturer shall have a minimum of 15 years of experience in the manufacturer of variable frequency motor controllers.
- B. Support:
 - 1. The manufacturer shall maintain factory trained and authorized service facilities within 100 miles of the project and shall have a demonstrated record of service for at least the previous ten years.
 - 2. Support personnel are to be direct employees of the manufacturer.
 - 3. The manufacturer shall provide all required startup and training services.

1.3 DEFINITIONS

- A. CE:
 - 1. Conformance Europeene (European Compliance).
- B. CPT:
 - 1. Control power transformer
- C. EMI:
 - 1. Electromagnetic interference
- D. IGBT:
 - 1. Insulated-gate bipolar transistor
- E. LED:
 - 1. Light-emitting diode
- F. MCP:
 - 1. Motor-circuit protector
- G. NC:
 - 1. Normally closed
- H. NO:
 - 1. Normally open
- I. OCPD:
 - 1. Overcurrent protective device

- J. PCC:
 - 1. Point of common coupling
- K. PID:
 - 1. Control action, proportional plus integral plus derivative
- L. PWM:
 - 1. Pulse-width modulated
- M. RFI:
 - 1. Radio-frequency interference
- N. TDD:
 - 1. Total demand (harmonic current) distortion
- O. THD(V):
 - 1. Total harmonic voltage demand
- P. VFC:
 - 1. Variable frequency motor controller
- Q. VFD:
 - 1. Variable frequency drive
- R. MPS:
 - 1. Motor Protection System

1.4 SUBMITTALS

- A. Product Data:
 - 1. For each type and rating of VFC specified. Include features, performance, electrical ratings, operating characteristics, shipping and operating weights, and furnished specialties and accessories.
- B. Shop Drawings:
 - 1. For each VFC specified. Include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.
 - 2. Show tabulations of installed devices, equipment features, and ratings. Include:
 - a. Each installed unit's type and details.
 - b. Factory-installed devices.
 - c. Enclosure types and details.
 - d. Nameplate legends.
 - e. Short-circuit current (withstand) rating of enclosed unit.
 - f. Features, characteristics, ratings, and factory settings of each VFC and installed devices.
 - g. Specified modifications.
 - 3. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring.
- C. Coordination Drawings:
 - 1. Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFCs. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Specify field measurements.

- D. Seismic Qualification Certificates:
 - 1. For VFCs, accessories, and components, from manufacturer.
 - 2. Basis for Certification: Specify whether withstand certification is based on actual test of assembled components or on calculation.
 - 3. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 4. Detailed description of equipment anchorage devices on which the certification is based, and their installation requirements.
- E. Product Certificates:
 - 1. For each VFC, from manufacturer.
- F. Operation and Maintenance Data:
 - 1. For VFCs to include emergency, operation, and maintenance manuals.
 - 2. Include the following:
 - a. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and MCP trip settings.
 - b. Manufacturer's written instructions for setting field-adjustable overload relays.
 - c. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
 - d. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
- G. Load-Current and List of Settings of Adjustable Overload Relays:
 - 1. Compile after motors have been installed and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.5 PERFORMANCE REQUIREMENTS

- A. Seismic Performance:
 - 1. VFCs shall withstand the effects of earthquake motions determined as specified in ASCE/SEI 7.
 - 2. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.6 QUALITY ASSURANCE

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

1.7 PROJECT CONDITIONS

- A. Environmental Limitations:
 - 1. Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions unless otherwise specified:
 - a. Operating Ambient Temperature Range in Conditioned Spaces: 32–104°F.
 - b. Operating Ambient Temperature Range in Nonconditioned Spaces: 32–122°F.
 - c. Storage Ambient Temperature Range: (-40)–158°F.
 - d. Relative Humidity Range: 5–95% non-condensing.
 - e. Altitude: Up to 3,300 ft.

1.8 WARRANTY

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

1.9 COORDINATION

- A. Coordinate features of motors, load characteristics, installed units, and accessory devices to be compatible with the following:
 - 1. Torque, speed, and horsepower requirements of the load.
 - 2. Ratings and characteristics of supply circuit and required control sequence.
 - 3. Ambient and environmental conditions of installation location.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

PART 2 - PRODUCTS

2.1 VARIABLE FREQUENCY DRIVES

- A. Products in this section rated less than 75HP shall be manufactured by:
 - 1. Danfoss VLT AutomationDrive FC 301/ FC 302
 - 2. Eaton PowerXL DG1.
- B. General Requirements for VFCs:
 - 1. See NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.
- C. VFC Description:
 - 1. Variable-frequency power converter (rectifier, dc bus, and IGBT, PWM inverter) factory packaged in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more 3-phase induction motors by adjusting output voltage and frequency.
 - 2. Units suitable for operation of NEMA MG 1, Design A and Design B motors as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
 - 3. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
 - 4. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.
- D. Output Rating:
 - 1. Three-phase; 10 Hz–60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.
- E. Unit Operating Requirements:
 - 1. The VFC shall accept nominal plant power at 60 Hz.
 - 2. Input AC Voltage Tolerance: Plus 10% and minus 15% of VFC input voltage rating.
 - 3. Input AC Voltage Unbalance: Not exceeding 5%.
 - 4. Input Frequency Tolerance: Plus or minus 3% of VFC frequency rating.
 - 5. Minimum Efficiency: 97% at 60 Hz, full load.
 - 6. Minimum Displacement Primary-Side Power Factor: 95% under any load or speed condition.
 - 7. Minimum Short-Circuit Current (Withstand) Rating: 10 kA.
 - 8. Vibration Withstand: See IEC 60068-2-6.

9. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.5 times the base load current for 3 seconds.
 10. Starting Torque: Minimum 100% of rated torque from 3 Hz–60 Hz.
 11. Speed Regulation: Plus or minus 5%.
 12. Stop Modes: Programmable; includes ramp, coast, fast, and dc injection braking.
- F. Isolated Control Interface:
1. Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
 2. Signal: Electrical, 4 mA DC–20 mA DC.
- G. Internal Adjustability Capabilities:
1. Minimum Speed: 5–25% of maximum rpm.
 2. Maximum Speed: 80–100% of maximum rpm.
 3. Acceleration: 0.1%–999.9 seconds.
 4. Deceleration: 0.1%–999.9 seconds.
 5. Current Limit: 30 to minimum of 150% of maximum rating.
- H. Self-Protection and Reliability Features:
1. Input transient protection by means of surge suppressors to provide 3-phase protection against damage from supply voltage surges 10% 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.
- I. Automatic Reset/Restart:
1. 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.
- J. Power-Interruption Protection:
1. To prevent motor from reenergizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.
- K. Bidirectional Autospeed Search:
1. 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.
- L. Torque Boost:
1. 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.
- M. Motor Temperature Compensation at Slow Speeds:

1. Adjustable current fallback based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
- N. Integral Input Disconnecting Means and OCPD:
1. NEMA AB 1, thermal-magnetic circuit breaker with pad-lockable, door-mounted handle mechanism.
 2. Disconnect Rating: Not less than 115% of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
 3. Auxiliary Contacts: NO/NC, arranged to activate before switch blades open.
 4. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
 5. NC and NO alarm contact that operates only when circuit breaker has tripped.

2.2 CONTROLS AND INDICATION

- A. Panel-Mounted Operator Station:
1. Manufacturer's standard front-accessible, LCD display and keypad.
- B. Status Lights:
1. Refer to contract drawings for required status lights for each VFD.
 2. At a minimum provide the following:
 - a. VFD Running
 - b. VFD Fault
- C. Control Switches:
1. Refer to contract drawings for required control switches for each VFD.
 2. At a minimum provide the following:
 - a. Three position selector switch
 - b. Reset pushbutton
- D. Control Signal Interfaces:
1. Electric Input Signal Interface:
 - a. A minimum of two programmable analog inputs: 4 mA DC–20 mA DC.
 - b. A minimum of six multifunction programmable digital inputs.
 2. Output Signal Interface: A minimum of one programmable analog output signal(s) (4 mA DC–20 mA DC), which can be configured for any of:
 - a. Output frequency (Hz)
 - b. Output current (load)
 - c. DC-link voltage (VDC)
 - d. Motor torque (percent)
 - e. Motor speed (rpm)
 - f. Set point frequency (Hz)
 3. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120 VAC, 1 A) for remote indication of:
 - a. VFD Running
 - b. VFD Fault
 4. Communication: Provide Ethernet/IP communication support.
 5. Other control signal interfaces as specified in Contract Drawings.

2.3 LINE CONDITIONING AND FILTERING

- A. Input Line Conditioning:
1. For VFDs smaller than 75HP provide 6 pulse rectifier with a minimum 5% input reactor or DC link choke impedance.

2.4 ENCLOSURES

- A. VFC Enclosures:
 - 1. NEMA 250 to comply with environmental conditions at installed location.
 - 2. Interior Dedicated Locations (Electrical Rooms): Type 1
 - 3. Interior Dry Locations (Nondedicated Spaces subject to Dust, Dirt only): Type 12
 - 4. Interior Wet Locations (Wash-Down or Corrosive): Type 4X
 - 5. Exterior Locations: Type 3R
- B. Air Conditioning:
 - 1. Where VFDs are installed outdoors or indoors in nonconditioned spaces, provide air conditioning meeting:
 - a. The VFD enclosure shall be supplied with integral air conditioning sized as required to maintain a maximum temperature of 35°C inside the enclosure at full load conditions and at worst case ambient temperatures. The enclosure cooling system shall not compromise the enclosure's NEMA rating.
 - b. Power supply for air conditioning equipment shall be derived from the incoming power supply to the VFD enclosure. Multiple power sources are not acceptable.

2.5 ACCESSORIES

- A. General Requirements for Control-Circuit and Pilot Devices:
 - 1. NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise specified.
 - 2. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty, oil tight type.
 - a. Push Buttons: Recessed types; maintained or momentary as required.
 - b. Pilot Lights: LED types; push to test.
 - c. Selector Switches: Rotary type.
 - d. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
- B. Control Relays:
 - 1. Auxiliary and adjustable solid-state time-delay relays.
- C. Cooling Fan and Exhaust System:
 - 1. Supply and/or exhaust fans, with composite stainless-steel intake and exhaust grills and filters; 120 VAC; obtained from integral CPT. Fan system shall not compromise the NEMA rating of the enclosure.
- D. Spare control-wiring terminal blocks; wired.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, as specified in requirements for installation tolerances, and other conditions affecting performance.
- B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Floor-Mounting Controllers:
 - 1. Install VFCs on 4 in. nominal thickness concrete base. See requirements for concrete base specified in Division 03 – Concrete.
 - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise specified, install dowel rods on 18 in. centers around the full perimeter of concrete base.
 - 3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 5. Install anchor bolts to elevations required for proper attachment to supported equipment.
- C. Temporary Lifting Provisions:
 - 1. Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- D. Install fuses in each fusible-switch.
- E. Install fuses in control circuits if not factory installed.
- F. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
- G. See NECA 1.

3.3 IDENTIFICATION

- A. Identify VFCs, components, and control wiring.
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each VFC with engraved nameplate.
 - 3. Label each enclosure-mounted control and pilot device.
- B. Operating Instructions:
 - 1. Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.4 CONTROL WIRING INSTALLATION

- A. Install wiring between VFCs and remote devices and facility's central-control system.
- B. Bundle, train, and support wiring in enclosures.
- C. Connect selector switches and other automatic control devices where applicable.
 - 1. Connect selector switches to bypass only those manual- and automatic control devices that have no safety functions when switches are in manual-control position.
 - 2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks as specified in manufacturer's written instructions.

3.6 ADJUSTING

- A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.
- B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
- C. Set field-adjustable circuit-breaker trip ranges as recommended by the manufacturer.

3.7 PROTECTION

- A. Temporary Heating:
 - 1. Apply temporary heat to maintain temperature as specified in manufacturer's written instructions until controllers are ready to be energized and placed into service.
- B. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

END OF SECTION

**DIVISION 31
EARTHWORK**

SECTION 31 05 19.13 – GEOTEXTILE FILTER FABRIC

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section Includes:
 - 1. This work shall consist of the installation of a nonwoven geotextile fabric.

1.2 REFERENCES

- A. ASTM International:
 - 1. D3786 – Standard Test Method for Bursting Strength of Textile Fabrics – Diaphragm Bursting Strength Tester Method
 - 2. D4355 – Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus
 - 3. D4491 – Standard Test Methods for Water Permeability of Geotextiles by Permittivity
 - 4. D4632 – Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
 - 5. D4833 – Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products
 - 6. D4751 – Standard Test Method for Determining Apparent Opening Size of a Geotextile
 - 7. D4886 – Standard Test Method for Abrasion Resistance of Geotextiles (Sandpaper/Sliding block Method)
 - 8. D4533 – Standard Test Method for Trapezoid Tearing Strength of Geotextiles
 - 9. D5261 – Standard Test Method for Measuring Mass per Unit Area of Geotextiles
 - 10. D6241 – Standard Test Method for Static Puncture Strength of Geotextiles and Related Products Using a 50mm Probe

1.3 SUBMITTALS

- A. See Section 01 33 00 – Submittal Procedures.
- B. Certificates:
 - 1. Certify that products meet or exceed specified requirements.

1.4 QUALITY ASSURANCE

- A. Installation shall be performed as specified in manufacturer's recommendations and by Engineer.

1.5 WARRANTY

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 MATERIAL

- A. The nonwoven geotextile fabric shall be an 8 oz fabric, US Fabrics US 205NW or equal. The fabric shall be of nonwoven needle punched construction and consist of long-chain polymeric filaments or fibers composed of polypropylene, polyethylene, or polyamide. The filaments and fibers shall be oriented whereby they retain their relative positions with each other and allow the passage of water as specified.

- B. The fabric shall be mildew, insect and rodent resistant and shall be inert to chemicals commonly found in soil. The nonwoven fabric shall conform to the physical property requirements below:

Physical Property	Test Method	Test Results
Weight	ASTM D5261	8 oz/sy
Tensile Strength, wet (lbs.)	ASTM D4632	205 lbs.
Elongation, wet, (%)	ASTM D4632	50%
Permittivity	ASTM D4491	1.35 sec-1
Puncture Strength, (lbs.)	ASTM D4833	130 lbs.
CBR Puncture	ASTM D6241	535 lbs.
Mullen Burst Strength, (psi)	ASTM D3786	350 psi
Abrasion Resistance, (% Strength Retained)	ASTM D4886	90
s	ASTM D4751	80 US Sieve
Ultraviolet Resistance, (% Strength Retention)	ASTM D4355 (After 500 Xenon Weatherometer hrs.)	70%
Trapezoidal Tear	ASTM D4533	85 lbs.
Water Flow Rate	ASTM D4491	90 gal/min/sf

- C. The nonwoven geotextile fabric shall be furnished in a protective wrapping which shall protect the fabric from ultraviolet radiation and from abrasion due to shipping and handling.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Fabric Exposure Following Placement:
- Exposure of the geotextile filter fabric to the elements, particularly the sun, between lay down and cover shall be a maximum of 7 days.
- B. Nonwoven Geotextile Fabric:
- Place in the manner and at the locations shown in Drawings or as directed by Engineer. The surface to receive the fabric shall be prepared to a smooth condition free of obstructions, depressions, and debris. The fabric shall be placed loosely, NOT in a stretched condition.
- C. The Contractor shall anchor the geotextile fabric at outer edges of the riprap courses by embedding the fabric down, across, and up a 1 ft deep by 1 ft wide trench. The fabric shall be centered on the pipe. The anchoring trench shall be backfilled with rock material approved by Engineer. There shall be no separate payment for Geotextile Fabric; it shall be subsidiary to other items.
- D. Where necessary, the fabric shall be placed to provide a minimum 24 in. overlap. The fabric shall be placed transverse to the direction of the flow with the upstream panel overlapping the downstream panel. All installations shall be subject to approval by Engineer.
- E. Repairs:
- A geotextile patch, of the same material, shall be placed over any damaged area and shall extend 12 in. beyond the perimeter of the tear or damaged area. Patch shall be either glued or sewn to the mother fabric or as approved by Engineer.

END OF SECTION

SECTION 31 11 00 – SITE PREPARATION

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section Includes:
 - 1. The Work required for site preparation.

1.2 DEFINITIONS

- A. Interfering or Objectionable Material:
 - 1. Trash, rubbish, and junk; vegetation and other organic matter, whether alive, dead, or decaying; topsoil.
- B. Clearing:
 - 1. Removal of interfering or objectionable material lying on or protruding above ground surface.
- C. Grubbing:
 - 1. Removal of vegetation and other organic matter including stumps, buried logs, and roots greater than 2 in. caliper to a depth of 12 in. below subgrade.
- D. Scalping:
 - 1. Removal of sod without removing more than upper 3 in. of topsoil.
- E. Stripping:
 - 1. Removal of topsoil remaining after applicable scalping is completed.
- F. Project Limits:
 - 1. Areas, as shown or specified, within which Work is to be performed.

1.3 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Shop Drawings:
 - 1. Drawings clearly showing clearing, grubbing, and stripping limits.

1.4 QUALITY ASSURANCE

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

1.5 SCHEDULING AND SEQUENCING

- A. Prepare site only after adequate erosion and sediment controls are in place. Limit areas exposed to uncontrolled 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. Clear, grub, and strip areas needed for waste disposal, borrow, or site improvements within limits shown or specified.
- B. DO NOT injure or deface vegetation that is NOT designated for removal.

3.2 LIMITS

- A. DO NOT extend beyond Project limits:
 - 1. Excavation, including trenches, 5 ft beyond top of cut slopes or shored walls.
 - 2. Fill:
 - a. Clearing and Grubbing: 5 ft beyond toe of permanent fill.
 - b. Stripping and Scalping: 2 ft beyond toe of permanent fill.
 - 3. Structures: 15 ft outside of new structures.
 - 4. Roadways: Clearing, grubbing, scalping, and stripping 15 ft 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 within limits shown or specified.
- B. Fell trees so that they fall away from facilities and vegetation NOT designated for removal.
- C. Cut stumps NOT designated for grubbing to within 6 in. of ground surface.
- D. Cut off shrubs, brush, weeds, and grasses to within 2 in. of ground surface.

3.4 GRUBBING

- A. Grub areas within limits shown or specified.

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. DO NOT remove topsoil until after scalping is completed.
- B. Strip areas within limits to minimum depths shown or specified. DO NOT remove subsoil with topsoil.
- C. Stockpile strippings, meeting requirements for topsoil, separately from other excavated material.

3.7 TOPSOIL

- A. Natural, friable, sandy loam, obtained from well-drained areas, free from objects larger than 1 1/2 in. 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 in. by 2 in. 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:
 - 1. 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 22 13 – SUBGRADE PREPARATION

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section Includes:
 - 1. Work and testing required for preparing subgrade.
- B. Related Sections:
 - 1. Section 02 41 00 – Demolition
 - 2. Section 31 11 00 – Site Preparation
 - 3. Section 31 23 16 – Excavation
 - 4. Section 31 23 23.13 – Fill and Backfill

1.2 REFERENCES

- A. ASTM International:
 - 1. D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/cf)
 - 2. D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cf)

1.3 DEFINITIONS

- A. Optimum Moisture Content:
 - 1. See Section 31 23 23.13 – Fill and Backfill.
- B. Prepared Ground Surface:
 - 1. Ground surface after completion of clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and scarification and compaction of subgrade.
- C. Relative Compaction:
 - 1. See Section 31 23 23.13 – Fill and Backfill.
- D. Relative Density:
 - 1. See Section 31 23 23.13 – Fill and Backfill.
- E. Subgrade:
 - 1. Layer of existing soil after completion of clearing, grubbing, scalping of topsoil prior to placement of fill, roadway structure or base for floor slab.
- F. Standard Specifications:
 - 1. The latest edition, including supplements, of the Alabama Department of Transportation Standard Specifications.

1.4 SEQUENCING AND SCHEDULING

- A. Prior to preparation, complete applicable Work specified in:
 - 1. Section 02 41 00 – Demolition
 - 2. Section 31 11 00 – Site Preparation
 - 3. Section 31 23 16 – Excavation

1.5 QUALITY ASSURANCE

- A. Notify Engineer when subgrade is ready for compaction or whenever compaction is resumed after a period of extended inactivity.

1.6 ENVIRONMENTAL REQUIREMENTS

- A. Prepare subgrade when unfrozen and free of ice and snow.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

- A. Keep subgrade free of water, debris, and foreign matter during compaction or proof-rolling.
- B. Bring subgrade to proper grade and cross-section and uniformly compact surface.
- C. DO NOT use sections of prepared ground surface as haul roads. Protect prepared from traffic.
- D. Maintain prepared ground surface in finished condition until next course is placed.

3.2 MOISTURE CONDITIONING

- A. Dry Subgrade:
 - 1. Add water, then mix to make moisture content uniform throughout.
- B. Wet Subgrade:
 - 1. Aerate material by blading, discing, harrowing, or other methods, to hasten drying process.

3.3 TESTING

- A. Test roll subgrade as specified in Standard Specifications to detect soft or loose subgrade or unsuitable material, as determined by Engineer.

3.4 CORRECTION

- A. Soft or Loose Subgrade:
 - 1. Adjust moisture content and recompact,
Or
 - 2. Over excavate as specified in Section 31 23 16 – Excavation, and replace with suitable material from the excavation, as specified in Section 31 23 23.13 – Fill and Backfill.

END OF SECTION

SECTION 31 22 19 – GRADING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Removal and storage of topsoil.
 - 2. Rough grading the site for site structures, building pads, and drive and parking aisles.
 - 3. Finished grading for planting.
- B. Related Sections:
 - 1. Section 31 23 16 – Excavation
 - 2. Section 31 23 23.13 – Fill and Backfill
 - 3. Section 31 23 16.13 – Trenching for Site Utilities

1.2 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Project Record Documents:
 - 1. Accurately record actual locations of utilities remaining by horizontal dimensions, elevations or inverts, and slope gradients.

1.3 QUALITY ASSURANCE

- A. Perform Work as specified in the Alabama Department of Transportation Standard Specifications.
 - 1. Maintain one copy on site.

1.4 PROJECT CONDITIONS

- A. Protect above – and below – grade utilities that remain.
- B. Protect plants, lawns, rock outcroppings, and other features to remain as a portion of final landscaping.
- C. Protect benchmarks, survey control points, existing structures, fences, sidewalks, paving and curbs from grading equipment and vehicular traffic.

1.5 WARRANTY

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Topsoil:
 - 1. Shall be soil suitable for sustaining grass and vegetation and shall NOT have any particles larger than 3/4 in. in diameter and shall be free of any trash, debris, or deleterious material. See Section 16 of applicable State Standards.
- B. Other Fill Materials:
 - 1. See Section 31 23 23.13 – Fill and Backfill.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that survey benchmark and intended elevations for the Work are as specified.

3.2 PREPARATION

- A. Identify required lines, levels, contours, and datum.
- B. Stake and flag locations of known utilities.
- C. Locate, identify, and protect utilities that remain from damage.
- D. Notify utility company to remove and relocate utilities.

3.3 ROUGH GRADING

- A. Remove topsoil from areas to be further excavated, relandscaped, or regraded without mixing with foreign materials.
- B. DO NOT remove topsoil when wet.
- C. Remove subsoil from areas to be further excavated, relandscaped, or regraded.
- D. DO NOT remove wet subsoil, unless it is subsequently processed to obtain optimum moisture content.
- E. When excavating through roots, perform work by hand and cut roots with sharp axe.
- F. Stability:
 - 1. Replace damaged or displaced subsoil to same requirements as for specified fill.

3.4 SOIL REMOVAL

- A. Stockpile excavated topsoil onsite.
- B. Stockpile excavated subsoil onsite.
- C. Stockpiles:
 - 1. Use areas designated onsite; pile depth NOT to exceed 8 ft; protect from erosion.

3.5 FINISHED GRADING

- A. Before Finished Grading:
 - 1. Verify building and trench backfilling have been inspected.
 - 2. Verify subgrade has been contoured and compacted.
- B. Remove debris, roots, branches, stones, more than 1/2 in. in size. Remove soil contaminated with petroleum products.
- C. In areas where vehicles or equipment have compacted soil, scarify surface to depth of 3 in.
- D. Place topsoil in areas where seeding is specified.

- E. Place topsoil in compacted thicknesses:
 - 1. Areas to be Seeded with Grass:
 - a. 6 in.
 - 2. Areas to be Sodded:
 - a. 4 in.
 - 3. Shrub Beds:
 - a. 18 in.
 - 4. Flower Beds:
 - a. 12 in.
 - 5. Planter Boxes:
 - a. To within 3 in. of box rim
- F. Place topsoil during dry weather.
- G. Remove roots, weeds, rocks, and foreign material while spreading.
- H. Near plants spread topsoil manually to prevent damage.
- I. Fine grade topsoil to eliminate uneven areas and low spots. Maintain profiles and contour of subgrade.
- J. Lightly compact placed topsoil.

3.6 TOLERANCES

- A. Top Surface of Subgrade:
 - 1. Plus or minus 1/10 ft from required elevation.
- B. Top Surface of Finished Grade:
 - 1. Plus or minus 1/2 in.

3.7 FIELD QUALITY REQUIREMENTS

- A. See Section 31 23 23.13 – Fill and Backfill for compaction density testing.

3.8 CLEANING AND PROTECTION

- A. Remove unused stockpiled topsoil and subsoil. Grade stockpile area to prevent standing water.
- B. Leave site clean and raked, ready to receive landscaping.

END OF SECTION

SECTION 31 23 16 – EXCAVATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Work and materials associated with excavation.
- B. Related Sections:
 - 1. Section 02 41 00 – Demolition
 - 2. Section 31 11 00 – Site Preparation
 - 3. Section 31 23 19 – Dewatering
 - 4. Section 31 50 00 – Excavation Support Systems

1.2 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Shop Drawings:
 - 1. Excavation Plan, Detailing:
 - a. Methods and sequencing of excavation.
 - b. Proposed locations of stockpiled excavated material.
 - c. Proposed locations of 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 over-excavation.

1.4 WEATHER LIMITATIONS

- A. Material excavated when frozen or when air temperature is less than 32°F 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:
 - 1. Complete applicable Work specified in Section 02 41 00 – Demolition, prior to excavating.
- B. Clearing, Grubbing, and Stripping:
 - 1. Complete applicable Work as specified in Section 31 11 00 – Site Preparation, prior to excavating.
- C. Dewatering:
 - 1. See Section 31 23 19 – Dewatering, prior to initiating excavation.
- D. Excavation Support:
 - 1. Install and maintain, as specified in Section 31 50 00 – Excavation Support Systems, 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 specified and as necessary to accomplish Work. Excavate to within tolerance of plus or minus 0.1 ft 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. Excavation is unclassified. Complete all excavation regardless of the type, nature, or condition of the materials encountered.

3.3 TRENCH WIDTH

- A. Minimum Width of Trenches:
 - 1. Single Pipes, Conduits, Direct-Buried Cables, and Duct Banks:
 - a. Less than 4 in. Outside Diameter or Width: 18 in.
 - b. Greater than 4 in. and up to 18 in. Outside Diameter or Width: 12 in. greater than outside diameter or width of pipe, conduit, direct-buried cable, or duct bank.
 - c. Greater than 18 in. Diameter or Width: 24 in. greater than outside diameter or width of pipe, conduit, direct-buried cable, or duct bank.
 - 2. Multiple Pipes, Conduits, Cables, or Duct Banks in Single Trench: 18 in. greater than aggregate width of pipes, conduits, cables, duct banks, plus space between.
 - 3. Increase trench widths by thicknesses of sheeting.
- B. Maximum Trench Width:
 - 1. Unlimited, unless otherwise shown or specified, or unless excess width will cause damage to existing facilities, adjacent property, or completed Work.

3.4 PIPE BEDDING GROOVES FOR NONPERFORATED DRAIN LINES

- A. Semicircular, trapezoidal, or 90-degree-V.
- B. Excavated or plowed into trench bottom. Forming groove by compaction shall NOT be acceptable.

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. Post signs that are 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 DISPOSAL OF SPOIL

- A. Dispose of excavated materials, which are unsuitable or exceed quantity needed for fill or backfill,
- B. Dispose of debris resulting from removal of underground facilities as specified in Section 02 41 00 – Demolition, for demolition debris.
- C. Dispose of debris resulting from removal of organic matter, trash, refuse, and junk as specified in Section 31 11 00 – Site Preparation, for clearing and grubbing debris.

3.7 EXCAVATION SAFETY

- A. See applicable federal, state, and local regulations for requirements.

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% relative compaction
 - Or,
 - 2. Over-excavation 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. This Section Includes:
 - 1. Backfilling and compacting for utilities outside the building to utility main connections.
- B. Related Sections:
 - 1. Section 31 22 19 – Grading
 - 2. Section 31 23 16 – Excavation
 - 3. Section 31 23 23.13 – Fill and Backfill
 - 4. Section 31 23 23.16 – Trench Backfill
 - 5. Section 33 41 19 – Pipe Laying

1.2 REFERENCES

- A. ASTM International:
 - 1. D1556 – Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
 - 2. D2167 – Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method
 - 3. D6938 – Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
 - 4. D3017 – Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)
 - 5. D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cf)
 - 6. D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/cf)
- B. AASHTO
 - 1. T180 – Standard Method of Test for Moisture–Density Relations of Soils Using a 4.54 kg (10 lb.) Rammer and a 457 mm (18 in.) Drop

1.3 DEFINITIONS

- A. Subgrade Elevations:
 - 1. 4 in. below finished grade elevations specified in Drawings, unless otherwise specified.
- B. Finished Grade Elevations:
 - 1. 4 in. above subgrade elevations specified in Drawings, unless otherwise specified.

1.4 SUBMITTALS

- A. Subject to requirements as specified in Section 01 33 00 – Submittal Procedures.
- B. Compaction Density Test Reports.

1.5 PROJECT CONDITIONS

- A. Provide enough fill to meet project schedule and requirements. When necessary, store materials on site in advance of need.

- B. Verify that survey benchmarks and intended elevations for the work are as specified.

1.6 WARRANTY

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 UTILITIES

- A. Contractor shall contact statewide utility location service two working days before starting excavation.
- B. The location and/or elevation of existing utilities as shown on these plans is based on records of the various utility companies and, where possible, measurements taken in the field. The information is not to be relied upon as being exact or complete. The Contractor must call each utility owner at least two working days before any excavation to request exact field location of utilities.
- C. Protect utilities encountered during excavation.
- D. DO NOT interrupt service in utilities encountered during excavation without approval of the utility owner.
- E. If utilities are damaged or utility service is interrupted by work under this section, the utility owner has the first right to repair. If public health or safety is at risk, Contractor shall take appropriate prudent action to repair damage and service interruption. Costs of utility protection and repair shall be at no additional cost to the Owner.
- F. If existing utilities are found to interfere with the permanent facility being constructed, notify the Engineer for instructions. Do not proceed with permanent relocation of utilities without written instructions from the Engineer.

2.2 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.
- D. See Section 31 22 19 – Grading, for additional requirements.

3.2 TRENCHING

- A. Requirements:
 - 1. Provide and install trench bracing and shoring that conforms to the requirements of 29 CFR Part 1926 Subpart P of the OSHA Standards. Bracing shall be so arranged as not to

- place any strain on portions of completed work until the construction has proceeded far enough to provide ample strength.
 - 2. Over-excavation, whether by Contractor's negligence or at direction of the Engineer, shall be repaired to required lines and grades.
 - 3. Trenches shall be dug to the alignment and depth required and shall not advance more than 100 ft ahead of the completed pipe, unless otherwise permitted by the Engineer.
 - B. Notify Owner's Representative of unexpected subsurface conditions and discontinue affected Work in areas until notified to resume work.
 - C. Slope banks of excavations deeper than 4 ft to angle of repose or less until shored.
 - D. DO NOT interfere with 45-degree bearing splay of foundations.
 - E. Cut trenches wide enough to allow inspection of installed utilities.
 - F. Hand trim excavations. Remove loose matter.
 - G. Remove excavated material that is unsuitable for reuse from site.
 - H. 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 specified using unfrozen materials.
 - B. Employ a placement method that does NOT disturb or damage other work.
 - C. Systematically fill to allow maximum time 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 in. 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 97% of maximum dry density.
 - G. Compaction Density, Unless Otherwise Specified.
 - 1. Under paving, slabs-on-grade, and similar construction: 97% of maximum dry density.
 - 2. All other locations: 95% of maximum dry density.
 - H. Reshape and recompact fills subjected to vehicular traffic.

3.5 BEDDING AND FILL AT SPECIFIC LOCATIONS

- A. Utility Piping, Conduits, and Duct Bank:
 - 1. Bedding: Use general fill.
 - 2. Cover with general fill.
 - 3. Fill up to subgrade elevation.
 - 4. Compact in maximum 8 in. lifts to 95% of maximum dry density.
- B. At Pipe Culverts:
 - 1. Bedding: use general fill.
 - 2. Place filter fabric specified in Section 31 05 19.13 – Geotextile Filter Fabric, over compacted bedding.
 - 3. Cover with general fill.
 - 4. Fill up to subgrade elevation.
 - 5. Compact in maximum 8 in. lifts to 95% of maximum dry density.

3.6 TOLERANCES

- A. Top Surface of General Backfilling:
 - 1. Plus or minus 1 in. from required elevations.

3.7 FIELD QUALITY REQUIREMENTS

- A. Perform compaction density testing on compacted fill as specified in ASTM D1556, ASTM D2167, ASTM D6938, or ASTM D3017.
- B. Evaluate results in relation to compaction curve determined by testing uncompacted material as specified in ASTM D698 ("Standard Proctor"), ASTM D1557 ("Modified Proctor"), or AASHTO T180.
- C. If tests specify work does NOT meet specified requirements, remove work, replace, and retest.
- D. Frequency of Tests; each lift.

3.8 CLEANUP

- 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 16.16 – TRENCHING FOR WATER AND SEWER LINES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section Includes:
 - 1. Excavation required for the construction of water and sewer pipes and appurtenances.
- B. Related Sections:
 - 1. Section 31 23 23.16 – Trench Backfill
 - 2. Section 33 41 19 – Pipe Laying

1.2 WARRANTY

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 UTILITIES

- A. Contractor shall contact statewide utility location service two working days before starting excavation.
- B. The location and/or elevation of existing utilities as shown on these plans is based on records of the various utility companies and, where possible, measurements taken in the field. The information is not to be relied upon as being exact or complete. The Contractor must call each utility owner at least two working days before any excavation to request exact field location of utilities.
- C. Protect utilities encountered during excavation.
- D. DO NOT interrupt service in utilities encountered during excavation without approval of the utility owner.
- E. If utilities are damaged or utility service is interrupted by work under this section, the utility owner has the first right to repair. If public health or safety is at risk, Contractor shall take appropriate prudent action to repair damage and service interruption. Costs of utility protection and repair shall be at no additional cost to the Owner.
- F. If existing utilities are found to interfere with the permanent facility being constructed, notify the Engineer for instructions. Do not proceed with permanent relocation of utilities without written instructions from the Engineer.

2.2 FILL MATERIALS

- A. Shall be as specified in Section 31 23 23.16 – Trench Backfill.

PART 3 - EXECUTION

3.1 GENERAL

- A. Requirements:
 - 1. Provide and install trench bracing and shoring as specified in 29 CFR Part 1926 Subpart P of the OSHA Standards. Bracing shall be so arranged as not to place any strain on

portions of completed work until the construction has proceeded far enough to provide ample strength.

2. Over-excavation, whether by Contractor's negligence or at direction of the Engineer, shall be repaired to required lines and grades.
3. Trenches shall be dug to the alignment and depth required and shall not advance more than 100 ft ahead of the completed pipe, unless otherwise permitted by the Engineer.

- B. Notify property residents two working days prior to beginning excavation on property.
- C. Excavated materials not suitable for backfill or embankment shall not be incorporated into the project but shall be disposed of by Contractor.
- D. Excavate with caution so that structures and underground conduits can be protected.
- E. Excavate every type of material encountered to the lines and elevations necessary to complete the project.
- F. Reroute surface water before excavating and protect excavated trench from entrance of surface water.
- G. In general, the sheeting and bracing shall be removed as the trench or excavation is backfilled, and in such a manner as to avoid the caving in of the bank or disturbance of adjacent areas or structures. The voids left by the withdrawal of sheeting shall be backfilled the same as trench excavations.
- H. Provide "before and after" color photographs of lawns and gardens to Engineer.
- I. Comply with Section 33 41 19 – Pipe Laying.

3.2 TRENCH DEPTH

- A. Excavate to the elevation necessary to provide the depth of bedding material under the barrel of the pipe, noted on the plans or in these specifications, whichever is greater.
- B. All over-excavation up to 2 ft shall be backfilled with bedding material in 6 in. layers and tamped to a bearing capacity equal to the adjacent undisturbed earth. Over excavation greater than 2 ft will require excavation operation to stop until an engineered backfill is determined. Over excavation shall not proceed until approved by Engineer. Contractor shall bear all expense involved if he fails to obtain prior approval from the Engineer.

3.3 TRENCH WIDTH

- A. Excavate to the width shown in detail drawings. Specified width dimensions must be maintained from trench bottom to an elevation 12 in. above barrel of pipe. Over-width excavation will require excavation operation to stop until additional earth loads can be compared to strength of pipe. Costs of unauthorized deviation from the specified width will be borne by the Contractor.

3.4 TRENCH LENGTH

- A. Excavate to a maximum distance of 100 ft from the pipe jointing operation. Longer distances will be considered when conditions warrant.

3.5 EXCAVATION IN ROCK

- A. When rock is encountered, excavate to an elevation 6 in. below the pipe and to the trench width as shown in the details at no additional cost to Owner.

3.6 EXCAVATION IN UNSUITABLE SOIL

- A. Where, in the judgment of the Engineer, the planned bottom of trench is found to be unstable, excavation shall stop until an engineered subgrade stabilization method is determined.

3.7 EXCAVATION IN WET CONDITIONS

- A. Where the planned bottom of trench contains water or the trench bottom is soft from excess water, excavation depth shall increase a minimum of 6 in. or as directed by the Engineer.

3.8 EXCAVATION IN UNFORESEEN STRUCTURE

- A. Preserve unforeseen structures encountered in excavation.
- B. Advise the Engineer when unforeseen structure interferes with planned work. Engineer will determine if plan changes or if structure will be abandoned.

3.9 UNAUTHORIZED EXCAVATION

- A. Unauthorized excavation is removal of materials beyond specified elevations or dimensions without the Engineer or Owner's specific prior approval.

3.10 UNSUITABLE AND EXCESS EXCAVATED MATERIAL:

- A. Excavated material not suitable for backfill and excess excavated material shall be disposed of by Contractor in a manner approved by the Engineer and applicable governmental regulations.

3.11 EXCAVATION DEWATERING

- A. Wellpointing or deep wells, where required to keep the excavation dry and the subgrade stable, shall be installed when the excavation extends to within 2 ft of the water table, except as herein provided, and shall be in continuous operation until backfill is completed to this level.
- B. When construction equipment is to be operated in an area that has been excavated, and wellpointing or deep wells are required to keep the excavation dry and the subgrade stable, the wellpointing or deep wells shall be installed when the excavation extends to within 5 ft of the water table.
- C. There shall be sufficient pumping equipment, in good working order, readily available at all times to remove any water that accumulates in excavations to the extent that a stable subgrade is obtained.
- D. Where the excavation crosses natural drainage channels, the work shall be conducted in such a manner that unnecessary damage or delays in the prosecution of the work will be prevented.
- E. Trench dewatering shall discharge to an approved location as specified in the Stormwater Pollution Prevention Plan.
- F. Wellpoint dewatering for the sewer or water line construction will not be mandatory where a properly stabilized subgrade can be obtained by use of granular bedding. If granular bedding is

utilized by the Contractor for stabilization of the trench bottom in lieu of wellpointing, such bedding material will not be measured for separate payment but will be considered subsidiary to the pipe installation.

- G. Where dewatering might be necessary to properly install the sewer or water line, such as at drainage channel crossings and tunnel or boring locations, the Contractor shall submit his proposal for this dewatering to the Owner for approval.
- H. Dewatering operations shall continue until pipe has been backfilled and a sufficient cover depth has been reached to prevent flotation of pipe.

END OF SECTION

SECTION 31 23 19 – DEWATERING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Work required to dewater excavations.

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 ft 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 groundwater 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:
 - 1. Work and materials required for fill and backfill for all excavations other than trench type excavations.
- B. Related Sections:
 - 1. Section 02 41 00 – Demolition
 - 2. Section 03 30 00 – Cast-In-Place Concrete
 - 3. Section 31 11 00 – Site Preparation
 - 4. Section 31 22 13 – Subgrade Preparation
 - 5. Section 31 23 16 – Excavation
 - 6. Section 31 23 23.16 – Trench Backfill
 - 7. Section 32 11 00 – Base Course

1.2 REFERENCES

- A. ASTM International:
 - 1. C117 – Standard Test Method for Materials Finer Than 75 μm (No. 200) Sieve in Mineral Aggregates by Washing.
 - 2. C136 – Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
 - 3. D75 – Standard Practice for Sampling Aggregates.
 - 4. D698 – Standard Test Methods for Laboratory Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cf).
 - 5. D1556 – Standard Test Method for Density of Soil in Place by the Sand Cone Method.
 - 6. D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/cf).
 - 7. D6938 – Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
 - 8. D4253 – Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
 - 9. 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 as specified in 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 as specified in ASTM D698 specified to maximum dry density for relative compaction.
 - 2. Determine field moisture content on basis of fraction passing 3/4 in. sieve.
- C. Relative Density:
 - 1. Calculated as specified in ASTM D4254 based on maximum index density determined as specified in ASTM D4253 and minimum index density determined as specified in ASTM D4254.

- D. Prepared Ground Surface:
 - 1. Ground surface after completion of required demolition, clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and preparation.
- E. Completed Course:
 - 1. A course or layer that is ready for next layer or next phase of Work.
- F. Lift:
 - 1. Loose (uncompacted) layer of material.
- G. Geosynthetics:
 - 1. 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:
 - 1. Area within planes sloped downward and outward at 60 degrees from horizontal measured from:
 - a. 1 ft outside outermost edge at base of foundations or slabs.
 - b. 1 ft outside outermost edge at surface of roadways or shoulder.
 - c. 0.5 ft outside exterior at spring line of pipes or culverts.
- J. Borrow Material:
 - 1. Material from required excavations or from designated borrow areas on or near site.
- K. Selected Backfill Material/Select Fill:
 - 1. Materials available onsite that Engineer determines to be suitable for specific use.
- L. Imported Material:
 - 1. Materials obtained from sources suitable for specified use.
- M. Structural Fill:
 - 1. Fill materials as required under structures, pavements, and other facilities.
- N. Embankment Material:
 - 1. Fill materials required to raise existing grade in areas other than under structures.
- O. Standard Specification:
 - 1. The latest edition, including supplements of the Alabama Department of Transportation Standard Specifications.

1.4 SUBMITTALS

- A. Subject to requirements as specified in Section 01 33 00 – Submittal Procedures.
- B. 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 sections.

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
 - 4. Section 31 22 13 – Subgrade Preparation
- 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 as specified in Section 31 22 13 – Subgrade Preparation.

PART 2 - PRODUCTS

2.1 SOURCE QUALITY REQUIREMENTS

- A. Gradation Tests:
 - 1. It shall be the Contractor's responsibility to conduct testing as necessary to locate acceptable sources of imported material.

2.2 EARTH FILL

- A. Excavated material from required excavations, free from rocks larger than 3 in., from roots and other organic matter, ashes, cinders, trash, debris, and other deleterious materials.

2.3 SELECT FILL

- A. Onsite or imported Earth Fill, free of organic matter or rock larger than 2 in. Plasticity Index (PI) to be between 8 and 15, liquid limit less than 35, and a maximum of 70% passing the No. 200 sieve with organics < 2%.

2.4 GRANULAR FILL

- A. Type A aggregate meeting all the requirements of Section 15 of the Standard Specifications.

2.5 WATER FOR MOISTURE CONDITIONING

- A. Free of hazardous or toxic contaminants, or contaminants deleterious to proper compaction.

2.6 BASE COURSE ROCK

- A. As specified in Section 32 11 00 – Base Course.

2.7 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 in. 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 ft 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 ft, unless dimensions or grades are specified otherwise.
 - 2. Grade to establish and maintain slopes and drainage as specified. Reverse slopes are NOT permitted.
- G. Settlement:
 - 1. 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 plus or minus 2% of the optimum required for compaction as determined by ASTM D698.

3.2 BACKFILL UNDER AND AROUND STRUCTURES

- A. Under Facilities:
 - 1. Within influence area beneath structures, slabs, pavements, curbs, piping, conduits, duct banks, and other facilities, backfill with granular fill, unless otherwise specified. Place granular fill in lifts of 6 in. maximum thickness and compact each lift to minimum of 95% relative compaction as determined as specified in ASTM D698, Method C.
- B. Subsurface Drainage:
 - 1. Backfill with granular drain material where specified. Place granular drain material in lifts of 6 in. maximum thickness and compact each lift to minimum of 90% relative density.
- C. Other Areas:
 - 1. Backfill with select fill to lines and grades specified, with proper allowance for topsoil thickness where specified. Place in lifts of 6 in. maximum thickness and compact each lift to minimum 95% relative compaction as determined as specified in ASTM D698, Method C.

3.3 FILL

- A. Outside Influence Areas Beneath Structures, Tanks, Pavements, Curbs, Slabs, Piping, and Other Facilities:
 - 1. Unless otherwise specified, place select fill.
 - 2. Allow for 6 in. thickness of topsoil where required.
 - 3. Maximum 9 in. thick lifts.
 - 4. Place and compact fill across full width of embankment.
 - 5. Compact to minimum 95% relative compaction as determined as specified in ASTM D698, Method C.
 - 6. 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 specify material does NOT meet section 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:
 - 1. As specified in ASTM.
 - 2. During placement of materials, test:
 - a. One test per every other lift per 200 LF of roadway or trench.
 - b. A minimum of two tests on granular fill beneath structures.
 - c. A minimum of two tests per 300 yds³ 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. Place and Compact as specified in Section 32 11 00 – Base Course.

3.6 REPLACING OVEREXCAVATED MATERIAL

- A. Replace excavation carried below grade lines specified or established by Engineer:
 - 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 Over-excavation: Either trench stabilization material or granular pipe base material, as specified in Section 31 23 23.16 – Trench Backfill.
 - b. Authorized Over-excavation: 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 over-excavation 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 SUMMARY

- A. Section Includes:
 - 1. Installation materials and methods for open trench installation of utility lines.
 - 2. Trench Excavation Safety Systems.
- B. Related Sections:
 - 1. Section 03 30 00 – Cast-in-Place Concrete
 - 2. Section 31 23 23.13 – Fill and Backfill
 - 3. Section 31 23 19 – Dewatering
 - 4. Section 31 50 00 – Excavation Support Systems
 - 5. Section 32 12 16 – Asphalt Concrete Pavement

1.2 REFERENCES

- A. ANSI:
 - 1. 253.1, Safety Color Code.
- B. APWA:
 - 1. Uniform Color Code for Temporary Marking of Underground Utility Locations.
- C. ASTM International:
 - 1. D448 – Standard Classification for Sizes of Aggregate for Road and Bridge Construction.
 - 2. C33 – Standard Specification for Concrete Aggregates
 - 3. C94 – Specification for Ready-Mixed Concrete.
 - 4. C117 – Standard Test Method for Materials Finer than 75 micrometer (No. 200) Sieve in Mineral Aggregates by Washing.
 - 5. C136 – Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
 - 6. C150 – Standard Specification for Portland Cement.
 - 7. C618 – Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
 - 8. D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil using Standard Effort (12,400 ft-lbf/cf).
 - 9. D1140 – Standard Test Methods for Amount of Material in Soils Finer than the No. 200 (75 micrometer) Sieve in Soils by Washing.
 - 10. D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil using Modified Effort (56,000 ft-lbf).
 - 11. D3776 – Standard Test Methods for Mass per Unit Area (Weight) of Fabric.
 - 12. D3786 – Standard Test Method for Bursting Strength of Textile Fabrics: Diaphragm Bursting Strength Tester Method.
 - 13. D4253 – Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
 - 14. D4254 – Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
 - 15. D4318 – Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
 - 16. D4533 – Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
 - 17. D4832 – Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.
 - 18. D4991 – Standard Test Method for Leakage Testing of Empty Rigid Containers by Vacuum Method.

19. D5034 – Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test).

1.3 DEFINITIONS

- A. Base Rock:
1. Granular material upon which manhole bases and other structures are placed.
- B. Bedding Material:
1. Granular material upon which pipes, conduits, cables, or duct banks are placed.
- C. Imported Material:
1. Material obtained by the Contractor from source(s) offsite.
- D. Lift:
1. Loose (uncompacted) layer of material.
- E. Pipe Zone:
1. 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:
1. Graded trench bottom after stabilization and installation of bedding material.
- G. Relative Compaction:
1. 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:
1. As specified by ASTM D4253 and ASTM D4254.
- I. Selected Backfill Material:
1. Material available that the Engineer determines to be suitable for a specific use.
- J. Well-Graded:
1. 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 shall be placed on the coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters.

1.4 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Shop Drawings:
1. Manufacturer's descriptive literature for marking tapes.
- C. Samples:
1. Trench stabilization material
 2. Bedding and pipe zone material
 3. Granular drain
 4. Granular backfill

5. Select backfill
6. Sand(s)
7. Geotextile

D. Quality requirements Submittals:

1. Catalog and manufacturer's data sheets for compaction equipment.

E. Certified Gradation Analysis:

1. 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.

F. Controlled Low Strength Material:

1. Certified mix design and test results. Include material types and weight per cubic yard for each component of mix.

1.5 WARRANTY

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

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 in.
4. Identifying Lettering: Minimum 1 in. high, permanent black lettering imprinted continuously over entire length.
5. Manufacturers and Products:
 - a. Reef Industries; Terra Tape
 - b. Allen Precision Equipment; 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 in.
4. Identifying Lettering: Minimum 1 in. 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 Precision Equipment; Detectatape

C. Color:

1. As specified in APWA Uniform Color Code for Temporary Marking of Underground Facilities.

Color ¹	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
Notes:	
1. As specified in ANSI Z53.1, Safety Color Code.	

2.2 TRENCH STABILIZATION MATERIAL

- A. Clean, hard, durable 3 in. 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% by weight passing the 1/4 in. sieve.

2.3 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% passing No. 200 sieve, as determined as specified in ASTM D1140, or gravel or crushed rock within maximum particle size and other requirements as follows unless otherwise specified.
 - 1. Duct Banks: 3/4 in. maximum particle size.
 - 2. PVC Irrigation System Piping, and Ductile Iron Pipe with Polyethylene Wrap: 3/8 in. maximum particle size.
 - 3. Pipe Under 18 in. Diameter: 3/4 in. maximum particle size, except 1/4 in. for stainless steel pipe, copper pipe, tubing, and plastic pipe under 3 in. diameter.
 - 4. Pipe Greater than 18 in. Diameter: 1 1/2 in. maximum particle size for ductile iron pipe, concrete pipe, welded steel pipe, and pretensioned or prestressed concrete cylinder pipe. 3/4 in 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% 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% passes No. 200 sieve, the fraction that passes No. 40 sieve shall be nonplastic as determined as specified in ASTM D4318.

2.4 SELECT FILL

- A. As specified in Section 31 23 23.13 – Fill and Backfill.

2.5 CONTROLLED LOW STRENGTH FILL

- A. Select and proportion ingredients to obtain compressive strength between 50 psi–150 psi at 28 days as specified in 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.

2.6 CONCRETE BACKFILL

- A. Provide as specified in Section 03 30 00 – Cast-In-Place Concrete.

2.7 TOPSOIL

- A. Topsoil removed and stockpiled from onsite excavation.

2.8 SOURCE QUALITY REQUIREMENTS

- A. Perform gradation analysis as specified in ASTM C136 for:
 - 1. Select 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:
 - 1. As specified in Section 31 23 19 – Dewatering.
 - 2. 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.
 - 3. Remove water in a manner that minimizes soil erosion from trench sides and bottom.
 - 4. 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:
 - 1. 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 specified.
- B. Soft Subgrade:
 - 1. If it is encountered that it may require removal to prevent pipe settlement, notify Engineer. Engineer shall determine the depth of over-excavation, 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 in. lifts to required grade, providing allowance for bedding thickness.
- C. Compact each lift 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 in.
- C. Hand grade and compact each lift to provide a firm, unyielding surface.
- D. Minimum Thickness:
 - 1. Pipe, 15 in. and Smaller:
 - a. 4 in.
 - 2. Pipe, 18 in.–36 in:
 - a. 6 in.
 - 3. Pipe, 42 in. and Larger:
 - a. 12 in.
 - 4. Conduit:
 - a. 3 in.
 - 5. Direct-Buried Cable:
 - a. 3 in.
 - 6. Duct Banks:
 - a. 3 in.
- E. Check grade and correct irregularities in bedding material. Loosen top 1 in.–2 in. 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:
 - 1. 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:
 - 1. Pipe: 12 in. above top of pipe, unless specified otherwise.
 - 2. Conduit: 3 in. above top of conduit, unless specified otherwise.
 - 3. Direct-Buried Cable: 3 in. above top of cable, unless specified otherwise.
 - 4. Duct Bank: 3 in. above top of duct bank, unless specified 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 in. and Smaller Diameter: First lift less than or equal to pipe-diameter.
 - 2. Pipes Over 10 in. Diameter: Maximum 6 in. 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 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 MARKING TAPE INSTALLATION

- A. Continuously install marking tape along centerline of all buried piping, at depth of 2 ft. Coordinate with Piping Installation Drawings.
 - 1. Metallic Marking Tape: Install with nonmetallic piping.
 - 2. Plastic Marking Tape: Install with metallic piping.

3.7 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 ft 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 ft 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 specified.
- B. Select Excavated Backfill:
 - 1. Place in lifts NOT exceeding 9 in. thickness.
 - 2. Mechanically compact each lift to a minimum of 95% relative compaction prior to placing succeeding lifts.
- C. Excavated Backfill:
 - 1. Backfill trench above the pipe zone with granular backfill in lifts NOT exceeding 8 in. Compact each lift to a minimum of 95% relative compaction prior to placing succeeding lifts.
- D. Concrete Backfill:
 - 1. Place above bedding.
 - 2. Minimum Concrete Thickness: 6 in. 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 in. 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.

3.8 REPLACEMENT OF TOPSOIL

- A. Replace topsoil in top 6 in. of backfilled trench.
- B. Maintain the finished grade of topsoil even with adjacent area and grade as necessary to restore drainage.

3.9 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:
 - 1. 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:
 - 1. Add topsoil where applicable and as necessary to maintain the surface of the backfilled trench level with the adjacent ground surface.
- D. Asphaltic Pavement:
 - 1. Replace settled areas or fill with asphalt as specified in Section 32 12 16 – Asphalt Concrete Pavement.
- E. Other Areas:
 - 1. Add excavated material where applicable and keep the surface of the backfilled trench level with the adjacent ground surface.

3.10 SETTLEMENT OF BACKFILL

- A. Settlement of trench backfill, or of fill or facilities constructed over trench backfill, shall 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:
 - 1. Work required to install and remove excavation support systems.
- B. Related Sections:
 - 1. Section 31 23 23.13 – Fill and Backfill

1.2 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Shop Drawings:
 - 1. Excavation support plan.
 - 2. Movement monitoring plan.
- C. Quality requirements Submittals:
 - 1. Movement measurement data and reduced results specifying 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. Design, provide, and maintain shoring, sheeting, and bracing as necessary and where shown to support the sides of excavations and to prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed Work.
- B. Minimum areas for shoring, sheeting, and bracing are shown on the Drawings. It shall be the Contractor's responsibility to determine if areas require excavation slope retention to protect existing structures and facilities from damage resulting from the Contractor's excavation or excavation methods.
- C. The Contractor shall also be responsible for providing shoring, sheeting, and bracing of excavations as needed for worker safety and as may be required by federal, state, and local regulations.

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 ft).
 3. Plots of data trends.
 4. Interval between surveys (not to exceed five 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

SECTION 31 63 16 – AUGER CAST PILES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes auger cast piles.
- B. Related Specification Sections include but are not necessarily limited to:
 - 1. Section 03 20 00 – Concrete reinforcement
 - 2. Section 03 30 00 – Cast-in-Place Concrete.
- C. UNIT PRICES
 - 1. Contract Sum: Base Contract Sum on number and dimensions of piles from tip to pile top.
 - 2. Work of this Section is affected as follows:
 - a. Pile Length: Additional payment for pile lengths in excess of that indicated, and credit for pile lengths less than that indicated, is calculated at unit prices stated in the Contract, based on net addition or deduction to total pile length as determined by engineer and measured to nearest 12 inches.
 - b. Number of Piles: Additional payment for number of piles in excess of that indicated, and credit for number of piles less than that indicated, is calculated at unit prices stated in the Contract.
 - c. Unit prices include labor, materials, tools, equipment, and incidentals for excavation, grout fill, reinforcement, testing and inspection, and other items for complete pile installation.
 - d. Test piles that become part of permanent foundation system are considered as an integral part of the Work.
 - e. No payment is made for rejected piles, including piles out of specified tolerance or defective piles.
- D. Test Piles: Same unit price as indicated for production piles.

1.2 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM C1077, ASTM D3740, and ASTM E329 for testing indicated
- B. Mix Designs: For each type of grout. Include description of type and proportions of ingredients.
- C. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - 2. AWS D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."

1.3 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures
- B. Product Data: For each type of product.
- C. Design Mixtures: For each design mixture. Submit alternative design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
 - 1. Indicate amounts of mixing water to be withheld for later addition at Project site.

- D. Shop Drawings: For auger cast piles, sealed by a professional engineer in the State for which the Work is to be performed.
 - 1. Identify each pile and indicate pile dimensions, cross sections, locations, and sizes.
 - 2. Indicate types and configurations of reinforcement and detail fabrication.
 - 3. Detail connections to pile caps.
 - 4. Include methods of centralizing reinforcement, type and size of centralizing devices, and locations on reinforcing bars.
 - 5. Static Pile Tests: Include arrangement of static test pile reaction frame, test and anchor piles, equipment, and instrumentation. Submit structural analysis data signed and sealed by a qualified professional engineer in the state of the Work being performed, responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Welding certificates.
- C. Material Certificates: For the following:
 - 1. Cementitious materials.
 - 2. Concrete admixtures.
 - 3. Steel reinforcing.
- D. Equipment Data: Description of drilling and pumping equipment including the following:
 - 1. Type and make of drilling rig, rated capacity, and boom lengths.
 - 2. Torque of drilling machine and horsepower of hydraulic power unit.
 - 3. Pressure and discharge capacity of grout pump.
 - 4. Automated monitoring equipment to be used.
- E. Static Pile Test Reports: Submit within three days of completing each test.
- F. Certified Piles Survey: Submit within 7 days of completion.
- G. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Record Drawings.
- B. Certified Pile Survey: Submit within seven days of pile installation completion.

1.6 PRECONSTRUCTION TESTING

- A. Test Piles: Construct of diameter, depth, and at locations indicated on Drawings or, if not indicated, of same diameter and depth as largest production piles and at locations approved by Engineer, to confirm allowable load of piles and demonstrate Installer's construction methods, equipment, standards of workmanship, and tolerances.
 - 1. If Engineer determines that test pile does not comply with requirements, excavate for and cast another until it is accepted.
 - 2. Tests: Arrange and perform the following pile tests:
 - a. Axial Compressive Static Load Test: ASTM D1143/D1143M, Procedure A, Quick Test
 - b. Lateral Load Test: ASTM D3966, Procedure A; Standard Loading
 - 3. Equip each test pile with two telltale rods, according to ASTM D1143/D1143M, for measuring deformation during load test.

4. Provide pile reaction frame, anchor piles, equipment, and instrumentation with enough reaction capacity to perform tests. Notify Engineer at least 48 hours in advance of performing tests. On completion of testing, remove testing structure, anchor piles, equipment, and instrumentation.
 - a. Allow a minimum of 7 days to elapse after installing test piles before starting pile testing.
 - b. Test Piles: See Drawings for production piles designated to be used as test piles.
5. Approval Criteria:
 - a. Axial Compression Test – At 150% Design Load as defined on drawings:
 - 1) Net settlement of not more than 0.01in/ton of test load.
 - 2) Total settlement not more than 1 inch provided the load settlement curve shows no sign of failure.
 - 3) No plunging failure or sharp break in the load settlement curve.
 - b. Lateral Load Test – At 200% Design Load as defined on drawings:
 - 1) Total lateral movement of not more than 1 inch for a fixed head test.
6. Test Pile Records: Prepare records for each test pile compiled and attested to by a qualified professional engineer. Include same data as required for permanent piles.

1.7 FIELD CONDITIONS

- A. Protect structures, underground utilities, and other construction from damage caused by pile excavation.
- B. Survey Work: Engage a qualified land surveyor or professional engineer to perform surveys, layouts, and measurements for auger cast piles. Before excavating, lay out each pile to lines and levels required. Record actual measurements of each pile's location, shaft diameter, bottom and top elevations, deviations from specified tolerances, and other specified data.
 1. Record and maintain information pertinent to each pile and indicate on record Drawings. Cooperate with Owner's testing and inspecting agency to provide data for required reports.

PART 2 - PRODUCTS

2.1 STEEL REINFORCEMENT

- A. Provide reinforcing steel conforming to requirements of Section 03 20 00 – Concrete Reinforcing.
 1. Reinforcing sizes, number, configurations, spacing, and lengths to be designed by contractor.
- B. Centralizers: Devices to center steel reinforcement in excavation; spaced not less than 20 feet vertically.

2.2 CONCRETE

- A. Comply with Section 03 30 00 – Cast-in-Place Concrete, except as modified below:
 1. Aggregate: ASTM C33 with 100 percent passing a No. 8 sieve, free of materials with deleterious reactivity to alkali in cement. Provide aggregate from single source.
 2. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures. Do not use calcium chloride or admixtures containing calcium chloride.
 - a. Water-Reducing Admixture: ASTM C494/C494M, Type A.
 - b. Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type D.
 - c. High-Range, Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type G.
 - d. Plasticizing and Retarding Admixture: ASTM C1017/C1017M, Type II.

3. Fluidifier: ASTM C937, with expansion of less than 4 percent.

2.3 RELATED MATERIALS

- A. Pile-Top Forms: Metal, glass-fiber-reinforced plastic, paper, or fiber tubes. Provide units with enough wall thickness to resist plastic concrete loads without detrimental deformation. Diameter same as pile diameter.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Maintain positive (clockwise) rotation of auger during withdrawal. Promptly remove excavated spoils to prevent accumulation.
- B. Grout Placement: Place grout in continuous operation.
 1. Lift auger 6 to 12 inches at start of grout pumping to facilitate tip plug removal, then return to previously established tip elevation.
 2. Develop an initial grout head of 60 inches before start of auger withdrawal and maintain during extraction.
 3. Monitor pumped grout volumes using automated monitoring equipment.
 4. Volume of placed grout is at least 115% of theoretical volume. If less than required volume is placed for any given 60-inch segment, lower auger a minimum of 60 inches, or to bottom of pile if less than 60 inches available, and restart withdrawal.
 5. If grout pumping is interrupted during placement, lower auger a minimum of 60 inches, or to bottom of pile if less than 60 inches available, and restart withdrawal.

3.2 FIELD QUALITY CONTROL

- A. Special Inspections: a qualified special inspector to perform the following special inspections:
 1. Pile excavation, placement, and testing.
 2. Steel reinforcement welding.
- B. Testing Agency: a qualified testing agency to perform tests and inspections.
- C. Grout Tests: Testing of samples of fresh grout obtained according to ASTM C172/C172M shall be performed according to the following requirements:
 1. Flow Rate: ASTM C939 and ASTM C109/C109M using a flow cone with 0.75-inch opening.
 2. Compressive Strength: ASTM C109/C109M with cube specimens restrained from expansion according to ASTM C942.
 - a. Testing Frequency: Obtain six-inch cubes for each 50-cu. yd. or fraction thereof of grout placed, but not less than one set for each day's pour. Obtain an additional set of cubes from each truck during test pile placement.
 - b. Test two cubes at 7 days, two cubes at 28 days, and hold two cubes in reserve.
 - c. Strength of each grout mixture is satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi
 - d. Report test results in writing to Engineer, grout manufacturer, and Contractor within 48 hours of testing. List Project identification name and number, date of placement, name of testing and inspecting agency, location of grout batch in Work, design compressive strength at 28 days, grout mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests in reports of compressive-strength tests.

- e. Additional Tests: Testing and inspecting agency to make additional tests of grout if test results indicate that compressive strengths or other requirements have not been met, as directed by Engineer.
 - f. Perform additional testing and inspecting, at Contractor's expense, to determine compliance of replaced or additional work with specified requirements.
 - g. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.
 - D. Pile Inspection Reports: Prepare inspection reports for each auger cast pile as follows:
 - 1. Pile location.
 - 2. Pile diameter.
 - 3. Actual top and bottom elevations.
 - 4. Final top centerline location and deviations from requirements.
 - 5. Variation from plumb.
 - 6. Date and time of starting and completing.
 - 7. Position and condition of reinforcing steel and splices or mechanical couplings.
 - 8. Automatic monitoring equipment record including grout volume actually pumped.
 - 9. Grout testing results.
 - 10. Remarks, unusual conditions encountered, and deviations from requirements.
 - E. Certified Piles Survey: Prepared by a qualified land surveyor or professional engineer showing final location of piles in relation to the property survey and existing benchmarks.
 - 1. Notify Engineer when deviations from locations exceed allowable tolerances.
 - F. Auger cast piles will be considered defective if they do not pass tests and inspections.
 - G. Prepare test and inspection reports.
- 3.3 DISPOSAL OF SURPLUS AND WASTE MATERIALS
- A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

END OF SECTION

SECTION 31 66 13 – AGGREGATE PIER GROUND IMPROVEMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Designing, furnishing, and installing aggregate pier ground improvement system in the locations shown on the Contract Drawings and as specified herein.
- B. Related Sections:
 - 1. Division 01 – General Requirements
 - 2. Section 31 23 16 – Excavation
 - 3. Section 31 23 23.13 – Fill and Backfill

1.2 DEFINITIONS

- A. Aggregate Piers: columns of compacted aggregate used to reinforce the ground to increase bearing capacity and reduce settlement of a structure.
- B. General Contractor: main contractor responsible for the project.
- C. Designer: party responsible for the design of aggregate pier ground improvement elements.
- D. Installer: party subcontracted to install aggregate pier ground improvement elements.

1.3 REFERENCES

- A. ASTM International:
 - 1. C33 – Standard Specification for Concrete Aggregates
 - 2. D1143 – Standard Test Methods for Deep Foundation Elements Under Static Axial Compressive Load
 - 3. D3689 – Standard Test Method for Individual Piles Under Static Axial Tension Load
 - 4. D6913 – Standard Test Method for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

1.4 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
 - 1. Detailed design calculations and construction drawings prepared by the Designer of the aggregate pier ground improvement system. Package shall include additional geotechnical investigation data used to determine basis for aggregate pier ground improvement system design. All calculations and drawings shall be sealed by a Professional Engineer currently registered in the State of Work.
 - 2. Detailed explanation of the design parameters for settlement calculations.
 - 3. Detailed description of installation equipment for aggregate pier construction.
 - 4. Construction sequence plan including drilling and compaction procedures.
 - 5. Installation records, complete test data, analysis of the test data and recommended design parameter values based on the modulus test results.
 - 6. Daily aggregate pier progress reports with accurate record of pier installations including pier location, length, average lift thickness, and final elevations of the base and top of piers. The record shall also indicate the type and size of the densification equipment used. The installer shall immediately report any unusual conditions encountered during installation to the General Contractor, Aggregate Pier Designer, and Testing Agency.
 - 7. Experience qualifications of aggregate pier enhancement installer.

8. Modulus test data, analysis of the data and the concluding recommended design parameters prepared by a Professional Engineer currently registered in the State of Work.

1.5 GENERAL CONTRACTOR RESPONSIBILITIES

- A. Furnish all labor, material, equipment, and incidental items necessary to install the aggregate pier ground improvement system and complete the work as shown on the Drawings and as specified herein.
- B. Perform any additional geotechnical investigation work necessary to provide parameters needed to complete design and construction of aggregate pier ground improvement system prior to submission of design package.
- C. Provide all necessary access including access ramps, haul roads, etc., prior to the commencement of the construction of the aggregate pier ground improvement system.
- D. Furnish the names of all subcontractors which he proposes to use for design and construction of this work including necessary evidence and/or experience records. The subcontractor performing the design and construction of the aggregate pier ground improvement system shall have a minimum of five (5) years of experience in design and construction of these systems on similar projects.

1.6 QUALIFICATIONS

- A. The aggregate pier ground improvement Installer and Designer shall have a minimum of five years of continuous experience for performance in similar applications.
- B. The Installer performing the work shall be fully qualified, experienced and equipped to complete this work. The Installer shall submit the following information to the Engineer of Record for review and approval before any work is performed. The following information is required at least three weeks prior to the start of work:
 1. The number of years of experience in performing this type of specialized work.
 2. Resumes of the management, supervisory, and key personnel.
 3. A list of clients that the subcontractor has performed this type of work including names, phone numbers, date installed, and description of the projects.
- C. Prequalification:
 1. All aggregate pier companies shall be prequalified to be considered an acceptable aggregate pier Designer.
 2. A complete prequalification package shall be submitted to the Engineer of Record for consideration 14 days prior to the date set for receipt of bids.
 3. Include:
 - a. Complete construction drawings showing the size and layout of all aggregate pier elements.
 - b. Complete experience record for the aggregate piers as specified in Paragraph 1.6.B. and designed and built in the aggregate pier company's own name. The record shall include the number of aggregate piers, name, address, and telephone number of the Owner, the year of construction, and the name and telephone number of the Engineer for the project.
 - c. Construction schedule which details the duration for aggregate pier construction.
 4. Acceptable Aggregate Pier Companies:
 - a. Keller: Hanover, Maryland.
 - b. Geopier: Davidson, North Carolina.

PART 2 - MATERIALS

2.1 AGGREGATE (STONE):

- A. Aggregate used in aggregate piers shall be approved by the aggregate pier ground improvement system Designer. Aggregates used shall be suitable for use in piers constructed below the water table or saturated conditions if applicable.
- B. Backfill aggregate shall consist of hard, angular to sub-angular durable rock fragments, with the majority of particles in the range of 1/8th inch to 1-1/2 inches such as No. 57 stone meeting requirements of ASTM C33.
- C. Potable water or other approved sources of water shall be used to increase aggregate moisture content where required. General Contractor shall furnish water to the pier installer.

PART 3 - EXECUTION

3.1 DESIGN REQUIREMENTS

- A. Aggregate pier elements shall be designed to ensure the subgrade over the area being enhanced by the aggregate pier installation can provide a minimum bearing capacity as shown on the construction drawings.
- B. Aggregate pier enhancement shall be designed in accordance with generally accepted engineering practice and the methods described herein.
- C. Design Considerations:
 - 1. Bearing capacity of all members being supported by the aggregate pier enhanced area.
 - a. Bearing capacities shall exceed bearing pressures listed on drawings.
 - 2. Total and differential settlement:
 - a. Maximum projected settlement of 1 inch.
 - b. Maximum differential settlement of 1/2 inch.
- D. The design of the aggregate pier ground improvement shall include development of an adequate stiffness modulus to accomplish this design parameter. The stiffness modulus shall be verified by the result of the Aggregate Pier Modulus test, as described herein.
 - 1. Stiffness modulus values will be supplied to the Engineer of Record for a design review of the facilities supported on aggregate pier ground improvements.
- E. The aggregate pier ground improvement system shall be designed to preclude plastic bulging deformations at the top-of-pier design stress and to preclude significant tip stresses as determined from the shape of the telltale test curve from telltales installed in modulus test piers. The results of the modulus test shall be used to verify design assumptions.

3.2 SITE PREPARATION

- A. General Contractor shall locate and protect underground and above ground utilities and other structures from damage during installation of aggregate pier elements.
- B. General Contractor shall provide site access to installer of aggregate piers after earthwork in the area has been completed.
- C. Site subgrade shall be established within 6 inches of final design subgrade, as approved by the Engineer of Record.

- D. A dry, level, and stable working surface shall be established and maintained to provide wet weather protection of the subgrade and to provide access for efficient operation of the aggregate pier installation. Positive drainage will be maintained to protect the site from wet weather and surface ponding of water.
- E. General Contractor shall coordinate all excavations made subsequent to pier installations so at least five feet of horizontal distance remains between edge of any installed stone pier and the excavation.
- F. If spoils are generated by aggregate pier installation, the General Contractor shall remove spoils from the work area in a timely manner to prevent interruption of aggregate pier installation.

3.3 EXCAVATION

- A. All aggregate pier elements shall be pre-augured using mechanical drilling or excavation equipment.
- B. Obstructions
 - 1. Obstructions encountered during excavation or drilling that will prevent installation of the aggregate piers to design depth or cause the aggregate pier to stray from its specified location during installation shall be promptly removed. To the extent the obstructions are shown in the geotechnical report, removal of obstructions shall be performed at no additional cost to the owner.
 - 2. Obstructions include, but are not limited to, boulders, timbers, concrete, bricks, utility lines, etc., that prevent installing the aggregate piers to the required depth or cause the aggregate pier to drift from the required locations.
 - 3. Dense natural rock or weathered rock shall not be deemed obstructions, and piers may be terminated short of design lengths on such materials. The aggregate pier Designer shall be notified within 24 hours to verify that the short piers are acceptable.
- C. No excavations shall be made after installation of aggregate pier elements within a horizontal distance of five feet from the edge of any pier, without the written approval of the aggregate pier Designer.

3.4 DENSIFICATION

- A. Aggregate pier elements shall be constructed in accordance with the approved design and shop drawings.
- B. The bottom of the excavation shall be densified prior to the placement of the aggregate. If wet, soft, or sensitive soils are present, open-graded stone, such as No. 57 stone in accordance with ASTM C33 or other stone approved by aggregate pier Designer, shall be placed at the bottom of the excavation and compacted to stabilize the element bottom and may serve as the initial lift when approved by the aggregate pier Designer.
- C. Densification shall be provided using vibrated aggregate pier systems:
 - 1. Stable ground conditions:
 - a. Pre-drilling to the design depth shall be performed with an auger diameter determined by the aggregate pier Designer.
 - b. A high-energy impact or vibratory densification apparatus shall be employed to densify lifts of aggregate.
 - c. The vibrator shall be raised and lowered repeatedly, such that on each re-penetration, the tip of the vibrator advances to within limits determined by the aggregate pier Designer.

- d. Lift heights of aggregate shall be per the aggregate pier Designer's signed and sealed design.
- 2. Unstable ground conditions:
 - a. A bottom feed vibratory densification apparatus, in which the aggregate is fed through the tip of the vibrator, shall be employed to densify lifts of aggregate.
 - b. The vibrator shall be raised and lowered repeatedly, such that on each re-penetration, the tip of the vibrator advances to within limits determined by the aggregate pier Designer.
 - c. Lift heights of aggregate shall be per the aggregate pier Designer's signed and sealed design.
- 3. The aggregate shall be removed and replaced with fresh aggregate if soil cave-ins exceeding 10% of the lift volume occur during the aggregate placement. Steel casings may be used to stabilize the cavity.

3.5 PLACEMENT TOLERANCES

- A. The center location of each aggregate pier shall be within six inches of the planned locations indicated. The final measurement on the top of piers shall be the lowest point on the aggregate in the last compacted lift. Piers installed outside of the tolerances specified and deemed not acceptable shall be rebuilt at no additional cost to the Owner.

3.6 REJECTED AGGREGATE PIER ELEMENTS

- A. Aggregate pier elements improperly located or installed beyond the maximum allowable tolerances shall be abandoned and replaced with new piers, unless other remedial measures are approved by the Designer. All material and labor required to replace rejected piers shall be provided at no additional cost to the Owner.

3.7 QUALITY CONTROL

- A. The Installer shall have a full-time quality control (QC) representative to verify and report all QC installation procedures. The Installer shall immediately report any unusual conditions encountered during installation to the Designer, the General Contractor, and the Testing Agency. The QC procedures shall include the preparation of Aggregate Pier Progress Reports completed during each day of installation containing the following information: aggregate pier location, aggregate pier length and drilled diameter, planned and actual aggregate pier elevations at the top and bottom of the element, average lift thickness for each pier, soil types encountered at the bottom of the pier and along the length of the element, depth to groundwater (if encountered), documentation of any unusual conditions encountered, and type and size of densification equipment used.
- B. A modulus test shall be performed to verify the parameter values selected for design. The modulus tests shall be of the type and installed in a manner as specified herein.
 - 1. A telltale shall be installed at the bottom of the test pier to allow determination of bottom-of-pier deflections. Acceptable performance is indicated when the bottom of the pier deflection is no more than 20% of the top of pier deflection at the design stress level.
 - 2. ASTM D-1143 general test procedures shall be used as a guide to establish load increments, load increment duration, and load decrements.
 - 3. With the exception of the load increment representing approximately 115% of the design maximum top of pier stress, all load increments shall be held for a minimum of 15 minutes, a maximum of 1 hour, and until the rate of deflection reduces to 0.01 inch per hour, or less.
 - 4. The load increment representing approximately 115% of the design maximum stress on the aggregate pier shall be held for a minimum of 15 minutes, a maximum of 4 hours, and until the rate of deflection reduces to 0.01 inches per hour or less.

5. A seating load equal to 5% of the total load shall be applied to the loaded steel plate prior to application of load increments and prior to measurement of deflections to compensate for surficial disturbance.
 6. Aggregate pier modulus testing shall be performed in accordance with the requirements outlined in the design submittal.
 7. The location of the aggregate pier modulus test shall be coordinated with the Geotechnical Engineer.
- C. After completion of the bottom pier bulb, or at any time during the process of constructing the pier, the energy source may be turned off, and bottom stabilization verification test may be performed. These tests shall be performed when a new soil formation is encountered, or at the beginning of the construction to provide quantitative information on pier stabilization.
1. Bottom stabilization tests are performed by placing a reference bar over the cavity, marking the tamper shaft, applying energy to the tamper for an additional 15 seconds, and observing the downward deflection of the tamper shaft by observing the deflection of the mark on the tamper shaft.
 2. Acceptable performance is indicated if the vertical movement of the shaft is less than 150% of the vertical movement measured for the modulus test pier.
 3. If the measured vertical movement exceeds 150% of the value achieved during the modulus test, added energy is applied to re-densify the bulb. The procedure for measure is then repeated. If there is still movement greater than 150% of that achieved by the modulus test, a lift of loose stone may be placed on top of the compacted stone, and the verification test may be performed on this next lift after it is densified. If there is excessive movement on this lift, another lift may be placed and tested. Movement must be limited to below 150% of the values achieved for the modulus test before completion of 2/3 of the pier depth.
- D. An independent testing agency, employed by Owner, shall observe the installation of the aggregate piers and provide additional testing services as deemed necessary. The observation of the independent testing agency will be in addition to the observation provided by QC representative defined herein furnished by Installer of aggregate piers. Aggregate pier Installer shall alert independent testing agency prior to proceeding with any installation or testing of aggregate piers.

3.8 FOOTINGS

- A. Excavation and surface compaction shall be the responsibility of the General Contractor.
- B. Footing bearing surfaces shall be free of all water and compacted prior to placement of any reinforcement. Place footing concrete immediately after footing excavation is made and approved, preferably the same day as the excavation. Footing concrete must be placed on the same day if the footing is bearing on moisture-sensitive soils. If same day placement of footing concrete is not possible, open excavations shall be protected from surface water accumulation. A lean concrete mud-mat may be used. Other methods must be pre-approved by the Engineer of Record.
- C. Water shall not be allowed to pond in the footing excavation at any time.

END OF SECTION

DIVISION 32
EXTERIOR IMPROVEMENTS

SECTION 32 11 00 – BASE COURSE

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Work and materials required to install base course.
- B. Related Sections:
 - 1. Section 31 22 13 – Subgrade Preparation

1.2 REFERENCES

- A. AASHTO (American Association of State Highway and Transportation Officials):
 - 1. T 89 – Standard Method for Determining the Liquid Limit of Soils.
 - 2. T 90 – Determining the Plastic Limit and Plasticity Index of Soils.
 - 3. T 96/ASTM C131 – Standard Test Method for Resistance to Degradation of Small Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
 - 4. T 99 – Standard Methods of Test for the Moisture-Density Relations of Soils Using a 5.5 lb. (2.5 kg) Rammer and a 12 in. (305 mm) Drop.
 - 5. T 180 – Standard Methods of Test for the Moisture-Density Relations of Soils Using a 10 lb. (4.54 kg) Rammer and an 18 in. (457 mm) Drop.
 - 6. T 191 – Standard Method of Test for Density of Soil In-Place by the Sand-Cone Method.

1.3 DEFINITIONS

- A. Completed Course:
 - 1. Compacted, unyielding, free from irregularities, with smooth, tight, even surface, true to grade, line, and cross-section.
- B. Completed Lift:
 - 1. Compacted with uniform surface reasonably true to cross-section.
- C. Standard Specification:
 - 1. The latest edition, including supplements of the Alabama Department of Transportation Standard Specifications.

1.4 SUBMITTALS

- A. Quality requirements Submittals:
 - 1. Certified Test Results on Source Materials: Submit copies from commercial testing laboratory twenty (20) days prior to delivery of materials to project.
 - 2. Certified Results of In-Place Density Tests from independent testing agency.

1.5 WARRANTIES

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 BASE COURSE ROCK

- A. Alabama Department of Transportation Type B aggregate meeting all the requirements of Section 825 of the Standard Specifications.

2.2 SOURCE QUALITY REQUIREMENTS

- A. Contractor:
 - 1. Tests necessary to locate acceptable source of materials as specified in requirements.
- B. Final approval of aggregate material shall be based on materials' test results on installed materials.
- C. Should separation of coarse from fine materials occur during processing or stockpiling, immediately change methods of handling materials to correct uniformity in grading.

PART 3 - EXECUTION

3.1 PREPARATION

- A. As specified in Section 31 22 13 – Subgrade Preparation.
- B. Obtain Engineer's acceptance of subgrade before placement of base course rock.
- C. DO NOT place base materials in snow or on soft, muddy, or frozen subgrade.

3.2 EQUIPMENT

- A. As specified in Section the latest edition, including supplements of the Alabama Department of Transportation Standard Specifications
- B. Compaction Equipment:
 - 1. Adequate in design and number to provide compaction and obtain the specified density for each layer.

3.3 HAULING AND SPREADING

- A. Hauling Materials:
 - 1. DO NOT haul over surfacing in process of construction.
 - 2. Loads: Of uniform capacity.
 - 3. Measure capacity of truck to determine vehicle load and quantity.
 - 4. Maintain consistent gradation of material delivered; loads of widely varying gradations shall be cause for rejection.
- B. Spreading Materials:
 - 1. Distribute material to provide required density, depth, grade and dimensions with allowance for subsequent lifts.
 - 2. Produce even distribution of material upon roadway without segregation.
 - 3. Should segregation of coarse from fine materials occur during placing, immediately change methods of handling materials to correct uniformity in grading.

3.4 CONSTRUCTION OF COURSES

- A. General:
 - 1. Complete each lift in advance of laying succeeding lift to provide required results and adequate inspection.
- B. Base Course:
 - 1. Maximum Completed Lift Thickness: 6 in.
 - 2. Completed Course Total Thickness: As specified.

3. Spread lift on preceding course to required cross-section.
4. Lightly blade and roll surface until thoroughly compacted.
5. Add keystone to achieve compaction and as required when aggregate does NOT compact readily due to lack of fines or natural cementing properties:
 - a. Use base 1/4 minus crushed aggregate material as keystone.
 - b. Spread evenly on top of crushed base course, using spreader boxes or chip spreaders.
 - c. Roll surface until keystone is worked into interstices of crushed base course without excessive displacement.
 - d. Continue operation until course has become thoroughly keyed, compacted, and shall NOT creep or move under roller.
6. Blade or broom surface to maintain true line, grade, and cross-section.

3.5 ROLLING AND COMPACTION

- A. Blade or otherwise work existing surface as necessary to achieve a smooth and thoroughly compacted surface.
- B. Commence compaction of each layer of base after spreading operations and continue until density of 100% of maximum density has been achieved as determined by AASHTO T 99.
- C. Commence rolling at outer edges of surfacing and continue toward center; DO NOT roll center of road first.
- D. Apply water as needed to obtain densities.
- E. Place and compact each lift to required density before succeeding lift is placed.
- F. Bind up preceding course before placing leveling course. Remove floating or loose stone from surface.
- G. Blade or otherwise work surfacing as necessary to always maintain grade and cross-section, and to keep surface smooth and thoroughly compacted.
- H. Surface Defects:
 1. Remedy surface defects by loosening and rerolling entire area, including surrounding surface, until thoroughly compacted.
 2. Finished Surface: True to grade and crown before proceeding with surfacing.

3.6 SURFACE TOLERANCES

- A. Finished Surface of Base Course:
 1. Within plus or minus 0.04 ft of grade specified at any individual point.
- B. Overall Average:
 1. Within plus or minus 0.01 ft from crown and grade specified.

3.7 FIELD QUALITY REQUIREMENTS

- A. In-Place Density Tests:
 1. Construct base course so areas shall be ready for testing.
 2. Allow reasonable length of time for testing laboratory to perform tests and obtain results during normal working hours.
 3. Prove areas meet specified requirements before identifying density test locations.

4. Perform a minimum of 2 tests on completed course per 200 yds³ of material placed as specified in T 191, or T 238 at locations acceptable to Engineer.

B. Cleaning

1. Remove excess material, clean stockpile areas of aggregate.

END OF SECTION

SECTION 32 12 16 – ASPHALT CONCRETE PAVEMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Providing and placing Asphalt Concrete Hot Mix (ACHM).
- B. Related Sections:
 - 1. Section 31 22 13 – Subgrade Preparation

1.2 REFERENCES

- A. ASTM:
 - 1. D2950 – Standard Test Method for Density of Bituminous Concrete in Place by Nuclear Methods.
 - 2. D2041 – Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures.
 - 3. E699 – Standard Practice for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating Building Components.

1.3 DEFINITIONS

- A. Combined Aggregate:
 - 1. All mineral constituents of an asphalt concrete mix, including mineral filler and separately sized aggregates.
- B. Standard Specification:
 - 1. The latest edition, including supplements of the Alabama Department of Transportation Standard Specifications.

1.4 SUBMITTALS

- A. Shop Drawings:
 - 1. Job-mix formula for pavements.
- B. Quality requirements Submittals:
 - 1. Manufacturer's Certificate of Compliance:
 - a. Aggregate: Gradation.
 - b. Asphalt for Binder: Type and grade.
 - c. Tack Coat: Type and grade of asphalt.
 - d. Mixes: Job-mix formula approved by the Materials Engineer for the State of Alabama.
 - 2. Manufacturer's Certificate of Proper Installation.
 - 3. Statement of qualification for independent testing laboratory.
 - 4. Test Results:
 - a. For Each Trial Batch of the Mix Design:
 - 1) Aggregate gradation
 - 2) Asphalt content
 - 3) Stability number
 - 4) Percent air voids
 - 5) Percent voids in mineral aggregate
 - 6) Density
 - 7) Retained strength

- b. Asphalt cement for binder
- c. Field density

1.5 QUALIFICATIONS

- A. Independent Testing Laboratory:
 - 1. As specified in ASTM E699.

1.6 ENVIRONMENTAL REQUIREMENTS

- A. Temperature:
 - 1. DO NOT apply asphalt materials or place asphalt mixes when ground temperature is lower than 50°F, air temperature is lower than 40°F, or application surface is wet.
 - 2. Measure ground and air temperature in shaded areas away from heat sources or wet surfaces.

1.7 WARRANTY

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 AGGREGATE

- A. As specified in Section 424 of the Standard Specifications for hot or warm plant mix bituminous pavement; however, reclaimed material shall NOT be acceptable. The Maximum Aggregate Size, as defined in Subarticle 424.02(d), shall be 3/4 inch.

2.2 MINERAL FILLER

- A. As specified in Section 424 of the Standard Specifications.

2.3 TACK COAT

- A. Emulsified asphalt as specified in Section 405 of the Standard Specifications.

2.4 ASPHALT CONCRETE MIXTURE

- A. Surface Course:
 - 1. Surface Course Type B, as specified in Section 424 of the Standard Specifications..
- B. Base Course:
 - 1. Base Course Type B, as specified in Section 424 of the Standard Specifications..

2.5 ASPHALT CEMENT

- A. Surface Course:
 - 1. PG 67-22 as specified in Section 424 of the Standard Specifications..
- B. Base Course:
 - 1. PG 67-22 as specified in Section 424 of the Standard Specifications..

2.6 SOURCE QUALITY REQUIREMENTS

- A. Tests:

1. Furnish services of independent testing laboratory to conduct tests.
2. Job-Mix Formula for Pavements:
 - a. Define gradation for each of the aggregate constituent used in mixture and establish exact proportion of each constituent to produce a gradation of aggregate within specified limits.
 - b. Bulk specific gravity for each aggregate constituent.
 - c. Measured maximum specific gravity of mix at optimum asphalt content determined as specified in ASTM D2041.
 - d. Properties as specified in Section 424, for at least four different asphalt contents other than optimum, two below optimum, and two above optimum.
 - e. Percent of asphalt lost due to absorption by aggregate.
 - f. After each job-mix formula is established, the combined aggregate grading of respective mixture furnished to the Project shall meet tolerances specified in Section 424.

PART 3 - EXECUTION

3.1 GENERAL

- A. Application Equipment:
 1. As specified in Standard Specifications.
- B. Roadways:
 1. Construct to lines, grades, and cross-sections shown.
- C. Traffic Control:
 1. Minimize inconvenience to traffic, but keep vehicles off freshly treated or paved surfaces to avoid pickup and tracking of asphalt. Always maintain at least one-way traffic.
 2. Contractor shall be solely responsible for traffic control and for meeting all federal, state, and local requirements for such.

3.2 CONTROL OF LINE AND GRADE

- A. Provide and maintain intermediate control of the underlying base to meet finished surface grades and minimum thickness.

3.3 SURFACE PREPARATION FOR ASPHALT OVER EXISTING GRAVEL ROAD

- A. Blade or otherwise work existing surface as necessary to achieve a smooth and thoroughly compacted surface.
- B. Surface Depressions:
 1. Fill with base course, and thoroughly compact.

3.4 TACK COAT

- A. DO NOT apply more tack coat than necessary for the day's paving operation.
- B. Application:
 1. Apply tack coat uniformly to clean dry surfaces. Avoid overlapping of applications. Touch up missed or lightly coated surfaces and remove excess tack coat.
- C. Application Rate:
 1. Minimum 0.05 gal to maximum 0.15 gal of asphalt (residual if diluted emulsified asphalt) per square yard of surface area. Apply at rate, within range specified, sufficient to assure

good bonding, but NOT too heavy that surplus asphalt flushes into asphalt concrete being placed.

3.5 ASPHALT CONCRETE PAVEMENT PLACEMENT

- A. Lay asphalt concrete over prepared base in a single lift to a total compacted thickness as shown on Plans.
- B. Collect and dispose of segregated aggregate from raking process. DO NOT scatter material over finished surface.

3.6 CONNECTIONS WITH EXISTING FACILITIES

- A. Where asphalt concrete pavement connects to an existing roadway surface, bridge, railway crossing, or other facility, modify existing roadway profile to produce a smooth riding connection to existing facility.
- B. Modifying Existing Surfaces: Sawcut existing paved surfaces to provide meet lines and surfaces. Allow for sufficient depth of removal to reinstall a minimum thickness of 1 in. of asphalt concrete.
 - 1. Meet Lines: Lines straight and edges vertical.
 - 2. Edges of Meet Line Cuts: Paint with tack coat prior to placing pavement.
 - 3. Sealing Meet Line: After placement of pavement, by painting with liquid asphalt or emulsified asphalt, cover immediately with clean, dry sand.
- C. Paint edges of contact surfaces (curbs, manhole frames), before laying pavement, with tack coat or paving asphalt cement to provide watertight joints. DO NOT stain adjacent surfaces NOT intended to be coated.

3.7 JOINTS

- A. Offset edge of each layer a minimum of 6 in. so joints shall NOT be directly over those in underlying layer.
- B. Offset longitudinal joints in roadway pavements, so longitudinal joints in wearing layer coincide with pavement centerlines and lane divider lines.
- C. Form transverse joints by cutting back on previous day's run to expose full vertical depth of layer.

3.8 PATCHING

- A. Patch Thickness:
 - 1. 3 in. or thickness of adjacent asphalt concrete, whichever is greater.
- B. Preparation:
 - 1. Remove damaged, broken, or unsound asphalt concrete adjacent to patches. Trim to straight lines exposing smooth, sound, vertical edges.
 - 2. Prepare patch as specified in Section 31 22 13 – Subgrade Preparation.
- C. Construction:
 - 1. Place asphalt concrete mix across full width of patch in layers of equal thickness.
 - 2. Spread and grade asphalt concrete with hand tools or mechanical spreader, depending on size of area to be patched.

3. Finished surface of patch shall be flush with adjacent surface and match grade, slope, and crown of adjacent surface.

D. Compaction:

1. Roll patches with power rollers capable of providing compression of 200 to 300 PLI. Use hand tampers where rolling is impractical.
2. Begin rolling top course at edge of patches, lapping adjacent asphalt surface at least 1/2 the roller width. Progress toward center of patch overlapping each preceding track by at least 1/2 the width of roller. Make sufficient passes over entire area to remove roller marks and to produce desired finished surface.

E. Surface Smoothness of Replaced Pavement:

1. New pavement shall NOT deviate more than 1/4 in. or less than 0 in. when a straightedge is laid across patched area between edges of new pavement and surface of old surfacing.

3.9 COMPACTION

- A. Roll until roller marks are eliminated and a density of 92% of measured maximum density determined in accordance with ASTM D2041 and ASTM D2950 is obtained.

3.10 JOINT COMPACTION

- A. Place top or wearing layer as continuously as possible.
- B. Pass roller over unprotected end of freshly laid mixture only when laying of layer is discontinued long enough to permit mixture to become chilled.
- C. Cut back previously compacted mixture when Work is resumed to produce a slightly beveled edge for full thickness of layer.
- D. Cut away waste material and lay new mix against fresh cut.

3.11 TOLERANCES

- A. Conduct measurements for conformity with crown and grade immediately after initial compression. Correct variations immediately by removal or addition of materials and by continuous rolling.
- B. Tolerance Measurements:
1. Completed Surface of Top or Wearing Layer: Uniform texture, smooth, and uniform to crown and grade.
 2. Completed surface shall NOT vary more than 1/8 in. from lower edge of 10 ft straightedge placed on surface parallel to centerline.
 3. Transverse slope of completed surface shall NOT vary more than 1/4 in. in 10 ft from the rate of transverse slope shown.
 4. Finished grade shall NOT vary more than 0.02 ft.
- C. Correct deviations more than specified tolerances by addition of asphalt concrete mixture to low places or removal of material from high places.
- D. Wearing surface may be removed and replaced to achieve a satisfactory finished surface, if surface of completed pavement deviates by more than twice the specified tolerances.

3.12 FIELD QUALITY REQUIREMENTS

A. General:

1. Provide services of independent testing laboratory to conduct tests.

END OF SECTION

SECTION 32 31 13 – CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section Includes:
 - 1. Labor, materials, equipment, and incidentals required to furnish and install the chain link fence and gates.
 - 2. The security fencing around the site and access gates to control entry and exit of the facility.
- B. Related Sections:
 - 1. Section 02 41 00 – Demolition
 - 2. Section 03 30 00 – Cast-In-Place Concrete

1.2 REFERENCES

- A. ASTM International:
 - 1. A121 – Standard Specification for Metallic-Coated Carbon Steel Barbed Wire.
 - 2. A392 – Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric.
 - 3. A491 – Standard Specification for Aluminum-Coated Steel Chain-Link Fence Fabric.
 - 4. A1018 – Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Carbon, Commercial, Drawing, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
 - 5. A824 – Standard Specification for Metallic-Coated Steel Marcellised Tension Wire for Use with Chain Link Fence.
 - 6. B6 – Standard Specification for Zinc.
 - 7. C94 – Standard Specification for Ready-Mixed Concrete.
 - 8. C143 – Standard Test Method for Slump of Hydraulic-Cement Concrete.
 - 9. C387 – Standard Specifications for Packaged, Dry, Combined Materials for Concrete and High Strength Mortar.
 - 10. F552 – Standard Terminology Relating to Chain Link Fencing.
 - 11. F567 – Standard Practice for Installation of Chain-Link Fence.
 - 12. F626 – Standard Specification for Fence Fittings.
 - 13. F668 – Standard Specification for Polyvinyl Chloride (PVC) and Other Organic Polymer-Coated Steel Chain-Link Fence Fabric.
 - 14. F900 – Standard Specification for Industrial and Commercial Swing Gates.
 - 15. F1043 – Standard Specification for Strength and Protective Coatings on Steel Industrial Chain Link Fence Framework.
 - 16. F1083 – Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures.
 - 17. F1183 – Standard Specifications for Aluminum Alloy Chain Link Fence Fabric.
 - 18. F1184 – Standard Specifications for Industrial and Commercial Horizontal Slide Gates.
 - 19. IEEE, Inc:
 - a. National Electrical Safety Code.
 - 20. NEMA:
 - a. 250, Enclosures for Electrical Equipment (1,000 volts max.).

1.3 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.

- B. Action Submittal:
 - 1. Shop Drawings:
 - a. Detailed information and specifications for materials, finishes, and dimensions.
 - b. Card access system serial communication interface card code message format.
 - 2. Samples:
 - a. Approximately 6 in², or 6 in. long of posts, rails, braces, fabric, wire, ties, and fittings.
- C. Informational Submittals:
 - 1. Quality requirements Submittals:
 - a. Manufacturer's recommended installation instructions.
 - b. Evidence of Supplier and installer qualifications.

1.4 SCHEDULING AND SEQUENCING

- A. Complete necessary site preparation and grading before installing chain link fence and gates.

1.5 WARRANTY

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Match style, finish, and color of each fence component with that of other fence components.

2.2 CHAIN LINK FENCE FABRIC

- A. Galvanized fabric as specified in ASTM, Class 1; galvanized after weaving.
- B. Height:
 - 1. 72 in., unless otherwise shown.
- C. Wire Gauge:
 - 1. No. 9, barewire.
- D. Pattern:
 - 1. 2 in. diamond-mesh.
- E. Diamond Count:
 - 1. Manufacturer's standard and consistent for fabric furnished of same height.
- F. Loops of Knuckled Selvages:
 - 1. Closed or nearly closed with space NOT exceeding diameter of wire.
- G. Wires of Twisted Selvages:
 - 1. Twisted in a closed helix three full turns.
 - 2. Cut at an angle to provide sharp barbs that extend minimum 1/4 in. beyond twist.

2.3 POSTS

- A. General:
 - 1. Strength and Stiffness Requirements:
 - a. ASTM F1043, Light Industrial Fence, except as modified in this section.

2. Steel Pipe: ASTM F1083.
3. Roll-Formed Steel Shapes: from ASTM A1018, Grade 45, Steel.
4. Lengths: Manufacturer's standard with allowance for minimum embedment below finished grade of 22 in. plus 3 in. for each 1 ft of fence height greater than 4 ft.
5. Protective Coatings:
 - a. Zinc Coating: ASTM F1043, Type A external and internal coating.

B. Line Posts:

1. Steel Pipe:
 - a. Outside Diameter: 2.375 in.
 - b. Weight: 3.65 lbs/ft

C. End, Corner, Angle, and Pull Posts:

1. Steel Pipe:
 - a. Outside Diameter: 2.875 in.
 - b. Weight: 5.79 lbs/ft

D. Posts for Swing Gates:

1. ASTM F900.
 - a. Outside Dimensions: 4 in. diameter.
 - b. Weight: 6.56 lbs/ft

2.4 TOP RAILS AND BRACE RAILS

1. Galvanized steel pipe.
2. Protective Coatings: As specified for posts.
3. Strength and Stiffness Requirements: ASTM F1043, Top Rail, Heavy or Light Industrial Fence.
4. Steel Pipe:
 - a. ASTM F1083.
 - b. Outside Diameter: 1.66 in.
 - c. Weight: 2.27 lbs/ft

2.5 FENCE FITTINGS

A. General:

1. As specified in ASTM F626, except as modified by this article.

B. Post and Line Caps:

1. Designed to accommodate passage of top rail through cap, where top rail required.

C. Tension and Brace Bands:

1. No exceptions to ASTM.

D. Tension Bars:

1. One-piece, no exceptions to ASTM F626.
2. Equal in length to full height of fabric.

E. Truss Rod Assembly:

1. 3/8 in. diameter

F. Barb Arms:

1. 45-degree arm for supporting three strands of barbed wire.

2.6 TENSION WIRE

- A. Zinc-coated steel marcelled tension wire as specified in ASTM A824, Type II, Class 2.

2.7 BARBED WIRE

- A. Zinc-Coated Barbed Wire:
 - 1. ASTM A121, Chain Link Fence Grade:
 - 2. Line Wire: Two strands of No. 12 GA–112 GA.
 - 3. Barbs:
 - a. Number of Points: Four
 - b. Length: 318 in. minimum
 - c. Shape: Round
 - d. Diameter: No. 14 GA
 - e. Spacing: 5 in.

2.8 GATES

- A. General:
 - 1. Gate Operation: Opened and closed easily by one person.
 - 2. Welded Steel Joints: Paint with zinc-based paint.
 - 3. Chain Link Fabric: Attached securely to gate frame at intervals NOT exceeding 15 in.
- B. Swing Gates:
 - 1. ASTM F900.
 - 2. Hinges:
 - a. Furnished with large bearing surfaces for clamping in position.
 - b. Designed to swing either 180 degrees outward, 180 degrees inward, or 90 degrees in or out, as shown, and NOT twist or turn under action of gate.
 - 3. Latches: Plunger bar arranged to engage stop, except single gates of openings less than 10 ft wide may each have forked latch.
 - 4. Gate Stops: Mushroom type or flush plate with anchors, suitable for setting in concrete.
 - 5. Locking Device and Padlock Eyes: Integral part of latch, requiring one padlock for locking both gate leaves of double gates.
 - 6. Hold-Open Keepers: Designed to automatically engage gate leaf and hold it in open position until manually released.

2.9 CONCRETE

- A. Provide as specified in Section 03 30 00 – Cast-In-Place Concrete.

2.10 REPAIR AND SALVAGE OF EXISTING FENCE

- A. Non-Salvageable or Nonreusable Parts:
 - 1. Fence posts
 - 2. Gate posts
 - 3. End, corner angle, and pull posts
 - 4. Tension and brace bands
 - 5. Tension wire
- B. Salvageable or Reusable Items:
 - 1. Fence fabric
 - 2. Post caps
 - 3. Top rails and brace rails
 - 4. Truss rod assemblies

- 5. Barb arms
- 6. Barbwire
- C. All items specified as salvageable shall NOT be bent, twisted, dented, or damaged in any way. Any such items shall NOT be considered for reuse.
- D. All items NOT considered for salvage or reuse shall be disposed of offsite at the Contractor's expense. See Section 02 41 00 – Demolition.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install chain link fences and gates as specified in ASTM F567, except as modified in this section, and as specified in fence manufacturer's recommendations, as approved by Engineer. Erect fencing in straight lines between angle points.
- B. Provide all necessary hardware for a complete fence and gate installation.

3.2 PREPARATION

- A. Establish locations of fence lines, gates, and terminal posts.

3.3 POST SETTING

- A. Driven posts are NOT acceptable.
- B. Post Hole Depth:
 - 1. Minimum 3 ft below finished grade.
 - 2. 2 in. deeper than post embedment depth below finish grade.
- C. Backfill post holes with concrete to 2 in. above finished grade.
- D. Before concrete sets, crown, and finish top of concrete to readily shed water.

3.4 BRACING

- A. Brace gate and corner posts diagonally to adjacent line posts to ensure stability.

3.5 TOP RAILS

- A. Install top rail sleeves with springs at 105 ft maximum spacing to permit expansion in rail.

3.6 CHAIN LINK FABRIC

- A. DO NOT install fabric until concrete has cured minimum 7 days.
- B. Install fabric with twisted and barbed selvage at top.

3.7 BARBED WIRE

- A. Install three strands of barbed wire on brackets, tighten, and secure at each bracket.

3.8 GATES

- A. Hang gates and adjust hardware so gates operate satisfactorily from open or closed position.
- B. Set gate stops in concrete to engage center drop rod or plunger bar.

3.9 FIELD QUALITY REQUIREMENTS

- A. Gate Tests:
 - 1. Prior to acceptance of installed gates and gate operator systems, demonstrate proper operation of gates under each possible open and close condition specified.

3.10 REUSE OF EXISTING FENCE MATERIAL

- A. Existing fence material shall be installed on new posts using new tension bars, brace bands, and tension wire.
- B. Existing fence fabric shall NOT be spliced to new fence fabric at mid-length between posts where the existing fence fabric ends. A pull post shall be installed with new brace bands, tension bands, and tension wire. Provide a knuckled selvage at the cut portion of the fence as shown on the Drawings.

END OF SECTION

DIVISION 33
UTILITIES

SECTION 33 05 16 – UNDERGROUND ELECTRICAL DUCTS AND MANHOLES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section Includes:
 - 1. The Work required for metal conduits.
- B. Related Sections:
 - 1. Section 03 10 00 – Concrete Forming
 - 2. Section 03 30 00 – Cast-in-Place Concrete
 - 3. Section 31 23 16 – Excavation
 - 4. Section 31 23 23.13 – Fill and Backfill

1.2 REFERENCES

- A. ANSI:
 - 1. C80.1 – American National Standard for Electrical Rigid Steel Conduit (ERSC) 2005.
- B. ANSI/NEMA:
 - 1. FB 1 – Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable; National Electrical Manufacturers Association; 2014.
- C. NFPA:
 - 1. 70 – National Electrical Code; National Fire Protection Association, 2005.

1.3 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Product Data:
 - 1. Provide for metallic conduit and nonmetallic conduit.
- C. Shop Drawings:
 - 1. Specify dimensions, reinforcement, size and locations of openings, and accessory locations for precast manholes.
- D. Manufacturer's Instructions:
 - 1. Specify application conditions and limitations of use stipulated by product testing agency specified under Quality Assurance. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.4 QUALITY ASSURANCE

- A. As specified in NFPA 70.
- B. Manufacturer Qualifications:
 - 1. Company specializing in manufacturing the products specified in this section with service facilities available.
- C. Products:
 - 1. Listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified.

1.5 WARRANTIES

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 CONDUIT AND DUCT

- A. Rigid Steel Conduit:
 - 1. ANSI C80.1
 - 2. Fittings: NEMA FB 1, steel

2.2 ACCESSORIES

- A. Underground Warning Tape:
 - 1. 4 in. wide plastic tape, detectable type colored with suitable warning legend describing buried electrical lines.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as specified.
- B. Verify routing and termination locations of duct bank prior to excavation for rough-in.

3.2 DUCT BANK INSTALLATION

- A. Install duct to locate top of duct bank at depths as specified in Drawings.
- B. Install duct with minimum slope of 4 in. per 100 ft (0.33%). Slope duct away from building entrances.
- C. Cut duct square using saw or pipe cutter; deburr cut ends.
- D. Insert duct to shoulder of fittings; fasten securely.
- E. Install no more than equivalent of three 90 degree bends between pull points.
- F. Provide suitable fittings to accommodate expansion and deflection where required.
- G. Stagger duct joints vertically in concrete encasement 6 in. minimum.
- H. Use suitable separators and chairs installed NOT greater than 4 ft on centers.
- I. Band ducts together before backfilling.
- J. Securely anchor duct to prevent movement during concrete placement.
- K. Place concrete under provisions of Section 03 30 00 – Cast-In-Place Concrete. Use mineral pigment to color concrete red.
- L. Provide minimum 3 in. concrete cover at bottom, top, and sides of duct bank.
- M. Provide two No. 4 steel reinforcing bars in top of bank under paved areas.

- N. Provide suitable pull string in each empty duct except sleeves and nipples.
- O. Swab duct:
 - 1. Use suitable caps to protect installed duct against entrance of dirt and moisture.
- P. Interface installation of underground warning tape with backfilling. Install tape 6 in. below finished surface.

END OF SECTION

SECTION 33 13 00 – DISINFECTION OF WATER SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section Includes:
 - 1. Work, material, and procedures for disinfection of installed potable water lines.

1.2 REFERENCES

- A. AWWA (American Water Works Association):
 - 1. B300 – Hypochlorites
 - 2. B301 – Liquid Chlorine
 - 3. B303 – Sodium Chlorite
 - 4. C651 – Disinfecting Water Mains
 - 5. C652 – Disinfection of Water-Storage Facilities
 - 6. C653 – Disinfection of Water Treatment Plants
 - 7. C654 – Disinfection of Wells

1.3 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Quality Requirements Submittals:
 - 1. Procedures and plans for disinfection and testing.
 - 2. Type of disinfecting solution and method of preparation.

1.4 SEQUENCING AND SCHEDULING

- A. Completion and acceptance of internal painting of system(s).
- B. Hydrostatic and pneumatic testing, pressure testing, functional and performance testing, and acceptance of pipelines, pumping systems, structures, and equipment.
- C. Commence Disinfection.

1.5 WARRANTIES

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 WATER FOR DISINFECTION AND TESTING

- A. Clean, uncontaminated, and potable.
- B. Owner shall supply potable quality water; Contractor shall convey in disinfected pipelines or containers.

2.2 CONTRACTOR'S EQUIPMENT

- A. Furnish chemicals and equipment, such as pumps and hoses, to accomplish disinfection.

2.3 MIXING DISINFECTANT

- A. Preparation:
 - 1. The purpose of the stock solution is to facilitate mixing and dilution to make sure of a uniform disinfecting solution.
 - 2. The Contractor shall NOT be required to mix a stock solution if a liquid chlorine gas feed system is used that can accurately feed a desired amount of chlorine to mix a final (dilute) disinfecting solution.
 - 3. Prepare solution by mixing:
 - a. Liquified chlorine gas as specified in AWWA B301 and water mixture.
 - b. Dry chlorine gas as specified in AWWA B301.
 - c. Calcium hypochlorite as specified in AWWA B300
or
Sodium hypochlorite as specified in AWWA B303 powder or liquid and water mixture.
- B. Feed dry chlorine gas through devices to regulate the rate of flow and make sure of uniform diffusion of gas into water within the pipe or vessel being treated. Chlorinating devices for feeding chlorine gas solution or the gas itself shall prevent water backflowing into chlorine cylinder.
- C. Use proportions of hypochlorite or chlorine to water:
 - 1. Chlorine Gas or Liquid (100% Cl): 1 lb. per 1.75 gal. water.
 - a. Apply liquid chlorine gas-water solution by means of a solution feed chlorinating device.
 - 2. Calcium Hypochlorite (65 to 70% Cl): 1 lb. per 7.5 gal. water.
 - a. If calcium hypochlorite is used, first mix dry powder with water to make a thick paste, then thin to a 1% solution (10,000 ppm chlorine).
 - 3. Sodium Hypochlorite (5.25% Cl): 1 gal per 4.25 gal water.
 - a. If sodium hypochlorite procedure is used, dilute the liquid with water to obtain a 1% solution.

PART 3 - EXECUTION

3.1 GENERAL

- A. Disinfect pumps and pipelines, installed, or modified under this Project, intended to hold, transport, or otherwise contact potable water:
 - 1. Disinfect new pipelines that connect to existing pipelines up to the point of connection.
 - 2. Disinfect surfaces of materials that will contact finished water, both during and after construction using spray method described below.
 - 3. Disinfect prior to contact with finished water. Prevent and avoid recontamination.
- B. Prior to application of disinfectants, clean equipment and pipelines of loose and suspended material. Flush pipelines until clear of suspended solids and color. Use water suitable for flushing and disinfecting.
- C. As specified, unless modified in these sections:
 - 1. AWWA C651 for pipes and pipelines
 - 2. AWWAC652 for tanks and reservoirs
 - 3. AWWA C654 for wells
- D. Allow freshwater and stock disinfectant solution to flow into the pipe or vessel at a measured rate so that the chlorine-water solution is at the specified strength. DO NOT place concentrated commercial disinfectant in the pipeline or vessel before it is filled with water.

3.2 PIPING AND PIPELINES

- A. Flushing:
 - 1. Before disinfecting, flush all foreign matter from pipeline. Provide hoses, temporary pipes, ditches, and other conduits as needed to dispose of flushing water without damage to adjacent properties. Flushing velocities shall be at least 2.5 fps. For large diameter pipe, where it is impractical or impossible to flush the pipe at specified velocity, clean the pipeline in-place from the inside by brushing and sweeping, then flush the line.
 - 2. Flush pipelines through flushing branches and remove branches after flushing is completed. Operate valves during flushing process at least twice during each flush.
 - 3. Flush service connections and hydrants. Flush distribution lines prior to flushing hydrants and service connections.
- B. Disinfecting Solution:
 - 1. Chlorine water solution with a free chlorine concentration of NOT less than 50 ppm.
- C. Disinfecting Procedure:
 - 1. As specified in AWWA C651, unless modified in this section.
- D. Point of Application:
 - 1. Inject chlorine mixture into pipeline to be treated at beginning of line through corporation stop or suitable tap in top of pipeline.
 - 2. Control water from existing system to flow slowly into pipeline during application of chlorine.
 - 3. Control rate of chlorine solution flow in proportion to rate of water entering pipe so that combined mixture shall contain NOT less than 50 ppm of free available chlorine.
 - 4. Prevention chlorine solution into line supplying water.
- E. Retention Period:
 - 1. Retain treated water in pipeline for at least 24 hours to destroy all non-spore-forming bacteria. At end of 24-hour period, disinfecting solution shall contain at least 10 ppm of free chlorine or the pipeline shall be recleaned, disinfecting solution shall be reapplied, and specified procedure repeated.
 - 2. Operate valves, hydrants, and appurtenances during disinfection to ensure that disinfecting solution is dispersed into all parts of pipeline, including dead-ends and areas that otherwise may NOT be treated.
 - 3. After disinfection, flush water from the permanent source until water through the pipeline is equal chemically and bacteriologically to permanent source of supply.

3.3 PUMPS

- A. Disinfecting Solutions:
 - 1. Minimum free chlorine concentration of 200 ppm.
- B. Disinfecting Procedure:
 - 1. As specified in AWWA unless modified in this section.
- C. Application:
 - 1. Inject the disinfecting solution into the pump and associated piping and circulate for a minimum two hour period of time. At the end of the two hour period, the solution shall have a strength of at least 100 ppm free chlorine.
 - 2. Operate valves and/or pump appurtenances during disinfection to ensure that the disinfecting solution is dispersed into all parts of the pumps and lines.

3. If the disinfecting solution contained in the pumps has a residual free chlorine concentration less than 100 ppm after the two hour retention period, reclean the pump, reapply disinfecting solution, and retest until a satisfactory test result is obtained.
4. After chlorination, flush the water from the pumps until the water through the units is chemically and bacteriologically equal to the permanent source of supply.

3.4 DISPOSAL OF DISINFECTING WASTEWATER

- A. DO NOT allow flow into a waterway without neutralizing disinfectant residual.
 1. See AWWA C652 for acceptable neutralization methods.

3.5 TESTING

- A. Test Equipment:
 1. Clean containers and equipment used in sampling and ensure they are free of contamination.
 2. Obtain sampling bottles with instructions for handling from laboratory.
- B. Chlorine Concentration Sampling and Analysis:
 1. Sampling Frequency for Disinfecting Solution: Two samples per disinfecting procedure.
 2. Residual Free Chlorine Samples: Two samples per disinfecting procedure.
 3. Dechlorinated Disinfecting Wastewater Residual Samples: Two samples per disinfecting procedure.
 4. Sampling Locations: Each 1,000 ft of pipeline or each building.
 5. Analysis to be performed by the Owner's laboratory.
- C. After pipelines have been cleaned, disinfected, and refilled with potable water, Owner shall take water Samples and have them analyzed for conformance to bacterial limitations for public drinking water supplies. Samples shall be analyzed for coliform concentrations as specified in the latest edition of Standard Methods for the Examination of Water and Wastewater.
 1. A minimum of two Samples on each of two consecutive days from each separable structure every 1,000 ft of pipeline shall be obtained and analyzed by standard procedures outlined by state and local regulatory agencies.
- D. If the minimum Samples required above are NOT bacterially negative, the disinfecting procedures and bacteriological testing shall be repeated on the respective facilities until bacterial limits are met.

END OF SECTION

SECTION 33 31 23 – TESTING SANITARY SEWER SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. The Work necessary to test gravity sewer pipe, force main pipe, manholes and appurtenances.
- B. Related Sections:
 - 1. Section 33 39 13 – Concrete Manholes
 - 2. Section 40 05 00 – Piping Systems Testing
 - 3. Section 40 23 39 – Process Piping – General

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

- A. The Contractor is responsible for supplying all equipment required to conduct testing and all testing shall be conducted by the Contractor.
- B. All testing shall be conducted in the presence of the Engineer.

3.2 GRAVITY SEWER TESTING

- A. The Contractor shall have the option of verifying water tightness by either air testing or water testing. The Engineer shall have the option to require testing by both methods to verify marginal results.
- B. Gravity Sewers – Air Testing:
 - 1. After gravity sanitary sewer and service pipe have been laid, all newly laid sewer main pipe shall be subject to an air pressure test to determine watertightness from air loss.
 - 2. Test Equipment:
 - a. Equipment specified in this section to perform the air test shall be provided by the Contractor. The test gauge shall have incremental divisions of 0.10 psi and have an accuracy of at least plus or minus 0.04 psi. In no case shall a test gauge be used which has incremental divisions of greater than 0.25 psi. The gauge shall be of sufficient size to determine accuracy.
 - 3. Procedure:
 - a. As each section of sewer is completed between manholes, each section shall be air tested. When practical, house connections in each section shall be completed. Air test shall be low pressure air test based on the principle of air pressure loss per period. Contractor shall prepare a log of testing and submit this to the Engineer as each section is completed and tested. All tests shall be accomplished in the presence of the Engineer.
 - b. The test section of the sewer line is plugged at each end. One of the plugs used at the manhole shall be tapped and equipped for air inlet connection for filling the line from the air compressor.
 - c. All service laterals, stubs and fittings into the sewer test section shall be properly capped or plugged, and carefully braced against the internal pressure to prevent air leakage by slippage and blowouts.

- d. Connect air hose to tapped plug selected for the air inlet. Then connect the other end of the air hose to the portable air control equipment, which consists of valves and pressure gauge used, to:
 - 1) Control air entry rate to the sewer test section.
 - 2) Monitor the air pressure in the pipeline.
- e. More specifically, the air control equipment includes a shutoff valve, pressure regulating valve, pressure reduction valve and a monitoring pressure gauge having a pressure range from 0 psi–5 psi. The gauge shall have minimum divisions of 0.10 psi and an accuracy of 0.04 psi.
- f. Connect another air hose between the air compressor (or other source of compressed air) and the air control equipment. This completes the test equipment setup. Test operations may commence.
- g. Supply air to the test section slowly, filling the pipeline until a constant pressure of 4.0 psig is maintained. The air pressure shall be regulated to prevent the pressure inside the pipe from exceeding 5.0 psig.
- h. When constant pressure of 4.0 psig is reached, throttle the air supply to maintain the internal pressure between 3.5 psig–4.0 psig for at least 5 minutes. This time permits the temperature of the entering air to equalize with the temperature of the pipe wall. If leakage is detected at any cap or plug, release the pressure in the line and tighten all leaky caps and plugs.
- i. Then start the test operation again by supplying air. When it is necessary to bleed off the air to tighten or repair a faulty plug, a new 5-minute interval shall be allowed after the pipeline has been refilled.
- j. After the stabilization period, adjust the air pressure to 3.5 psig and shut off or disconnect the air supply. Observe the gauge until the air pressure reaches 3.5 psig. At 3.5 psig commence timing with a stopwatch which is allowed to run until the line pressure drops to 2.5 psig at which time the stopwatch is stopped. The time required, as shown on the stopwatch for a pressure loss of 1.0 psig, is used to compute the air loss.
- k. If the time in minutes and seconds for the air pressure to drop from 3.5 psig to 2.5 psig is greater than that specified in the table for the designated pipe size, the section undergoing test shall have passed and shall be presumed to be free of defects. The test may be discontinued at that time.
- l. If the time in minutes and seconds for the 1.0 psig drop is less than that specified in the table for the designated pipe size, the section of pipe shall NOT have passed the test; therefore, adequate repairs shall be made and the line retested.
- m. Pipe sizes with their respective recommended minimum times, in minutes and seconds, for acceptance by the air test method:

Minimum Time for a 1.0 psig Pressure Drop (Min:Secs)										
Distance Between Manholes (Feet)	Nominal Diameter (Inches)									
	8	10	12	15	18	21	24	30	36	42
100	7:33	9:26	11:20	14:10	17:00	19:50	22:47	35:37	51:17	69:48
150	7:33	9:26	11:20	14:10	17:00	26:11	34:11	53:25	76:55	104:42
200	7:33	9:26	11:23	17:48	25:38	34:54	45:34	71:13	102:34	139:37
250	7:33	9:53	14:14	22:15	32:03	43:38	56:58	89:02	128:12	174:30
300	7:35	11:52	17:05	26:42	38:27	52:21	68:22	106:50	153:50	209:24
350	8:51	13:51	19:56	31:09	44:52	61:08	79:46	124:38	179:29	244:19
400	10:07	15:49	22:47	35:36	51:17	69:48	91:10	142:26	205:07	279:13
450	11:23	17:48	25:38	40:04	57:41	78:32	102:33	160:15	230:46	314:07
500	12:39	19:47	28:29	44:31	64:06	87:15	113:57	178:03	256:24	349:01

Times for distances NOT listed in the table can be obtained by calculating the straight-line ratio between distances given.

- n. For testing of long sections or sections of larger diameter pipes, or both, a timed-pressure drop of 0.5 psig may be used in lieu of a 1.0 psig timed-pressure drop as approved by the Owner or Engineer. If a 0.5 psig pressure drop is used, the appropriate required test time shall be exactly 1/2 the values specified in the table.
 - o. An air pressure correction is required when the prevailing ground water is above the sewer line being tested. Under this condition, the air test pressure shall be increased 0.433 psi for each foot the ground water level is above the invert of the pipe.
 - p. Height of ground water above sewer pipe shall be determined by a method approved by the Engineer.
 - q. Any leaks in the system shall be repaired immediately upon discovery. Costs for repairing faulty work, including excavating and re-backfilling and for making tests, shall be paid for by the Contractor.
4. Safety Precautions:
- a. The low-pressure air test may be dangerous to personnel if, through lack of understanding or carelessness, a line is over pressurized or plugs are installed improperly. It is extremely important that the various plugs be installed to prevent the sudden expulsion of a poorly inflated plug. As an example of the hazard, a force of 250 lbs. is exerted on an 8 in. plug by an internal pressure of 5 psi. Observe the following safety precautions.
 - 1) No one shall be allowed in the manholes during the test or when a plugged pipe is under pressure.
 - 2) Gauges, air piping manifolds, and valves shall be located at the top of the ground.
 - 3) Install and brace all plugs securely.
 - 4) DO NOT over pressurize the lines.

C. Gravity Sewers – Water Testing:

- 1. Water testing shall be by either the infiltration method or by the exfiltration method if approved by the Engineer. Testing for water tightness shall be made by the Contractor in the presence of the Engineer. The Contractor shall provide all equipment, plugs, bulkheads, fittings, water, etc. needed for the testing. The water used for testing shall be paid for by the Contractor.
- 2. The Engineer shall have the right to direct that either the infiltration or the exfiltration water testing be performed based on groundwater conditions at the time.
- 3. The tests and measurements of the infiltration method shall be as approved by the Engineer. In all cases, the pipeline shall NOT leak under exterior ground water pressure more than 100 gal/in. of nominal pipe diameter per mile of pipe per 24 hours. Leaks causing any sewer to fail such test shall be repaired until infiltration meets the allowable limit.
- 4. If, in the opinion of the Engineer, the ground water table at the time of testing is too low to produce dependable infiltration measurement results, the Contractor shall perform the exfiltration method test. The allowable limit shall be as given above including any manholes in the section(s) being tested. Water required for exfiltration test shall be obtained at the Contractor's expense.
- 5. Where the exfiltration test method is used:
 - a. The downstream end of the pipe section being tested shall be plugged and the plug shall be braced and blocked securely. No one shall be allowed to enter a manhole where a plugged pipe is under pressure. Any other pipe entrances to the upstream manhole shall likewise be securely plugged.
 - b. Only water from a source approved by the Engineer shall be used to perform the test. Wastewater shall NOT be used to perform exfiltration testing.
 - c. Water shall be added through the upstream manhole of the line section being tested to a depth of 2.0 ft above the inside top of the outgoing pipe (or 2.0 ft above the ground water level – see d. below). The water shall be maintained at this level for 24 hours prior to beginning the exfiltration test measurement.

- d. There shall be a minimum of 2.0 ft positive head above the inside top of the pipe at the high end of the section being tested. This means, if the ground water in the trench is at (or above) the top of the pipe, then the manhole shall be filled to a point at least 2.0 ft above the ground water level.
- e. The test shall be conducted for two hours. The leakage shall be determined by the calculated change in total volume of water used in the test.

3.3 PIPE DEFLECTION TESTING

- A. General:
 - 1. All PVC, FRP, and Ductile Iron gravity sewer lines shall be mandrel tested as specified in these sections prior to acceptance.
- B. Allowable Deflection:
 - 1. The maximum allowable pipe deflection shall NOT exceed 5% of the inside diameter.
- C. Mandrel:
 - 1. The mandrel shall be hand-pulled by the Contractor through all PVC, FRP, and Ductile Iron gravity sewer lines no earlier than 30 days after the trench has been completely backfilled. Any sections of the sewer NOT passing the mandrel shall be uncovered and the Contractor shall rebed, reround, or replace the sewer to the satisfaction of the Engineer. Any repaired section shall be retested after a sufficient time has elapsed to ensure that trench settlement has stopped. This retest time shall be totally dependent upon method of repair. If the trench has been opened, the retest shall have the same requirements as the original installation. If the pipe has been rerounded, retest shall NOT occur sooner than seven days after rerounding.
 - 2. The mandrel (Go/No-Go) device shall be cylindrical in shape and constructed with either 9 or 16 evenly spaced arms or prongs. Mandrels with fewer arms shall be rejected as NOT sufficiently accurate. The contact length of the mandrel's arms shall equal or exceed the nominal diameter of the sewer to be inspected. Critical mandrel dimensions shall carry a tolerance of plus or minus 0.01 in. The mandrel and all necessary equipment for the mandrel test shall be provided by the Contractor.
 - 3. The Owner reserves the right to mandrel test any PVC, FRP, or Ductile Iron sewer pipe before acceptance, and also prior to expiration of the first year of operation. If a previously accepted line fails a mandrel test performed during the first year of operation, the defects shall be corrected at the Contractor's expense.

3.4 TELEVISION INSPECTION

- A. The Contractor shall televise all newly installed sewer mains as follows:
- B. The Contractor shall clean all lines thoroughly prior to the start of televising.
- C. The Contractor shall televise each segment of pipe.
- D. The camera shall be moved through the line in either direction at a uniform slow rate NOT to exceed 60 ft/min, by means of cable winches, or similar mechanisms. Under no circumstances shall the camera be tethered to a hydraulically propelled or high-velocity jet cleaning device while the cleaning device is on.
- E. The Contractor shall review the video for possible defects in material or workmanship.
- F. The Contractor shall correct any defects discovered during the television inspection at the Contractor's expense.

- G. The Contractor shall deliver to the Engineer final video in DVD format and logs after all defects have been repaired.

3.5 INSPECTION OF SERVICE LINES

- A. All building sewer lines shall be installed and tested as specified in all state, regional, and local plumbing codes.
- B. All building sewer installations shall be inspected and approved by an authorized local governing agency inspector.
- C. Backfill may only be placed on the completed portions of a building sewer following inspection. No approval certificate shall be issued until all portions of a building sewer from the main connection to the building foundation have been inspected and approved by an authorized inspector. At the time of inspection, the pipe should be in place in the trench and "safed-up", but the top half of the pipe barrel exposed. No approval shall be given for building sewers all or a portion of which are covered at the time of inspection.
- D. All building sewers are subject to testing to ensure water tightness. All tests shall be performed in the presence of the Engineer. Tests may be either by:
 - 1. Water Loss Test Procedure; or,
 - 2. Low Pressure Air Loss Procedure.
- E. If, in the opinion of the Engineer, the line in question is properly installed and free from open joints and breaks, building sewers constructed entirely of cast iron soil pipe may be connected to the sewer without testing.
- F. Water Loss Test Procedure
 - 1. Plug the section of line to be tested at the lower end and fill section with water so that at least 4 ft of head is obtained.
 - 2. The maximum acceptable water loss while so filled is NOT more than 100 gal per 24 hrs. per inch of pipe diameter per mile of pipe. This is approximately 3/16 gal for a 100 ft long section of 4 in. pipe tested 30 minutes.
- G. Low Pressure Air Loss Procedure
 - 1. Plug securely both ends of the line to be tested.
 - 2. Charge the line with air to a pressure of 4.5 psig.
 - 3. Allow at least five minutes for the temperature in the pipe to stabilize.
 - 4. Measure the time required for a 1.0 psi drop in pressure.
 - 5. The minimum time for a 1 psi loss is $28.5 \times d$ sec where d = the nominal diameter in inches of the pipe being tested.

3.6 MANHOLE TESTING

- A. Testing, Observations and Guarantee Period:
 - 1. The testing required shall be performed by the Contractor at all manholes and documented to the satisfaction of the Engineer.
 - 2. Testing shall NOT be performed on a specific manhole until all work has been completed for that specific manhole.
 - 3. Any manholes that are observed to be leaking by the Engineer shall be subject to additional repairs and retested by the Contractor at no additional cost to the Owner.
- B. Inflow Testing:
 - 1. All rehabilitated manholes and new manholes shall be dye tested. Manholes shall be dye water tested in the presence of the Engineer. The dye test shall consist of applying a

concentrated dye solution around the manhole frame. Dyed water shall be applied for at least ten minutes.

2. Manholes observed to be actively leaking shall have failed the test and shall NOT be acceptable. Manholes failing the test shall require additional rehabilitation by the Contractor at no additional compensation. The manhole shall then be retested as described above until a successful test is made.

C. Vacuum Testing:

1. All new and rehabilitated manholes shall be vacuum tested by the Contractor in the presence of the Engineer for sources of infiltration. Testing shall be made during high groundwater conditions, wherever possible.
2. Manholes shall be tested after installation with all connections (existing and/or proposed) in place. Drop-connections and gas sealing connections shall be installed prior to testing. The lines entering the manhole shall be temporarily plugged with the plugs braced to prevent them from being drawn into the manhole. The plugs shall be installed in the lines beyond drop-connections, gas sealing connections, etc. The test head shall be placed inside the frame at the top of the manhole and inflated as specified in manufacturer's recommendations. Plate type test heads that rest on top of the frame are also acceptable. A vacuum of 10 in. of mercury shall be drawn, and the vacuum pump shall be turned off. With the valve closed, the level of vacuum shall be read after the required test time. If the drop in the level is less than 1 in. of mercury (final vacuum greater than 9 in. of mercury), the manhole shall have passed the vacuum test. After a successful test, the temporary plugs shall be removed. The required test time is determined from the table below.

Minimum Time Required for a Vacuum Drop of 1 in. H _g (10 in. H _g – 9 in. H _g) (min:sec)				
Depth of Manhole (feet)	Manhole Inside Diameter (inches)			
	48 in.	60 in.	72 in.	96 in.
8	:20	:26	:32	:45
10	:25	:33	:40	1:00
12	:30	:39	:48	1:07
14	:35	:46	:57	1:18
16	:40	:52	1:05	1:29
18	:45	:59	1:13	1:40
20	:50	1:05	1:21	1:52
22	:55	1:12	1:29	2:03
24	:60	1:19	1:37	2:14
26	1:05	1:25	1:45	2:25
28	1:10	1:32	1:53	2:36
30	1:15	1:38	1:01	2:47
Add for each Additional 2 ft	:05	:07	:08	:11

3. Manhole vacuum levels observed to drop greater than 1 in. of mercury (Final vacuum less than 9 in. of mercury) shall have failed the test and shall require additional rehabilitation. The Contractor shall make the necessary repairs at no additional compensation for only those work items completed by the Contractor. The manhole shall then be retested as described above until a successful test is made.

3.7 PRESSURE TEST FOR FORCE MAINS

- A. Perform hydrostatic leakage tests for force mains by filling the force main with water and increasing the pressure to a testing pressure of 150% of the working pressure with a minimum of 100 psi.
- B. The duration of the leakage test shall be two hours or as specified by the Engineer.
- C. The force main shall NOT be accepted until the actual leakage is equal to or less than the allowable. In addition, all obvious leaks shall be repaired.
- D. The allowable leakage rate per hour for ductile iron, PVC, FRP or concrete pipe shall be calculated by:

$$L = \frac{ND \times P^5}{7400}$$

L = Allowable Leakage (gallons per hour)

N = Number of Joints in Pipeline Tested

D = Nominal Diameter (inches)

P = Test Pressure (psi)

3.8 SYSTEM COORDINATION

- A. Maintain existing sewer flow through new connecting manholes until new sewer is approved by Engineer.
- B. Reshape manhole bottom to divert sewer flow into new sewer after new sewer is approved by Engineer.
- C. Locate sewer services before completing the first manhole downstream from the sewer service.

END OF SECTION

SECTION 33 39 13 – CONCRETE MANHOLES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. The Work necessary to completely furnish and install cast-in-place manholes and precast manholes and related items.
- B. Related Sections:
 - 1. Section 03 10 00 – Concrete Forming
 - 2. Section 03 20 00 – Concrete Reinforcement
 - 3. Section 03 30 00 – Cast-In-Place Concrete
 - 4. Section 03 62 00 – Non-Shrink Grout
 - 5. Section 33 31 23 – Testing Sanitary Sewer Systems
- C. General Requirements:
 - 1. Manholes shall be of diameter and constructed to elevations as specified in Plans.
 - 2. Precast or Cast-In-Place manholes are acceptable, however all manholes for this project shall be of like kind, unless otherwise stated in the Plans or as directed by the Engineer.
 - 3. Manhole steps are NOT required and shall NOT be accepted.
 - 4. All materials shall equal or exceed the standards specified in this section.
 - 5. During the process of unloading, all manhole materials shall be inspected by the Contractor and any damaged material set aside.
 - 6. All manholes where the top elevation is greater than 2 ft above adjacent ground shall use hinged frames and cover as specified in this section.
 - 7. After manholes and connecting pipelines are installed, the Contractor shall test for defects and leakage as specified in Section 33 31 23 – Testing Sanitary Sewer Systems.
 - 8. Inspection of materials at the manufacturer's plant, at the point of delivery, on the job site, or in place shall NOT relieve the Contractor of his responsibility and the material may be subject to rejection until final acceptance of the completed project.

1.2 REFERENCES

- A. ASTM International:
 - 1. C478 – Standard Specification for Circular Precast Reinforced Concrete Manhole Sections.
 - 2. C443 – Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
 - 3. C361 – Standard Specification for Reinforced Concrete Low-Head Pressure Pipe.
 - 4. C1619 – Standard Specification for Elastomeric Seals for Joining Concrete Structures.
 - 5. A48 – Standard Specification for Gray Iron Castings.
 - 6. C990 – Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
 - 7. D790 – Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
 - 8. D695 – Standard Test Method for Compressive Properties of Rigid Plastics.
 - 9. D638 – Standard Test Method for Tensile Properties of Plastics.
 - 10. D4541 – Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.

1.3 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.

- B. Quality requirements Submittals:
 - 1. Shop drawings for precast manholes.
 - 2. Diameter, dimensions, and thickness.
 - 3. Reinforcement.
 - 4. Manhole frame and cover make and model.
 - 5. Concrete mix designs.
 - 6. Other materials used in construction of manholes.
 - 7. Special shipping, storage and protection, and handling instructions.
 - 8. Test procedures.
 - 9. Test results, reports, and certifications.

PART 2 - PRODUCTS

2.1 CAST-IN-PLACE MANHOLES

- A. Concrete:
 - 1. Concrete shall contain 100% calcareous aggregates and be as specific in 03 30 00 - Cast-In-Place Concrete.
- B. Inverts:
 - 1. Inverts shall be formed as shown on the detail drawings to the grades specified. Manholes with inverts NOT conforming to these grades may be subject to removal and replacement at the Contractor's expense.
 - 2. Concrete for inverts shall be as specified in Section 03 30 00 – Cast-In-Place Concrete.
- C. Pipe Connections:
 - 1. Waterstop gaskets shall be required at ALL cast-in-place manhole connections. Manhole seals shall be concrete manhole adapter by Fernco, A-Lok, or equal.

2.2 MANHOLE FRAMES AND COVERS

- A. Standard Frames and Covers:
 - 1. Frames:
 - a. Frame material shall be cast iron or ductile iron as specified in ASTM A48, Class 35 or better. The frame shall exhibit a tensile strength of NOT less than 35,000 psi.
 - b. Frames for standard manholes shall be Deeter 1266 for nontraffic areas and Deeter 1235-A for traffic areas, or approved equal(s), and shall have 4 3/4 in. diameter holes drilled in the bottom flange. The holes shall be centered in the flange and shall be equally spaced 90 degrees apart.
 - c. Bearing surfaces between the ring and cover shall be machine finished or ground to assure non-rocking fit in any position, and interchangeability.
 - 2. Covers:
 - a. The cover shall form a water-resistant seal between the frame and manhole cover surface. The cover shall have concealed pick holes and a machined bearing surface on the bottom of the casting. The cover shall be as specified in ASTM A48, Class 35 or better, for Gray Iron. The cover shall have a tensile strength of 35,000 psi.
 - b. A typical standard manhole cover design shall be Deeter 1266 for nontraffic areas and Deeter 1235-A for traffic areas or approved equal(s).
 - c. Covers shall set flush with the rim of the frame and shall have no larger than a 1/8 in. gap between the frame and cover.
 - d. Bearing surfaces shall be machine finished.
 - e. Manhole lids shall have "SANITARY SEWER" cast on the lids.
 - 3. Watertight Manhole Inserts:
 - a. This standard covers the furnishing and installation of watertight gasketed manhole inserts in the sanitary sewer collection system.

- 1) Materials (Stainless Steel):
 - a) Stainless steel inserts shall be installed at locations with pipe diameters greater than 15 in. and as directed by the Engineer.
 - b) Stainless steel inserts:
 - i. TETHERLOK stainless steel Rainstopper Southwestern Packing and Seals, Inc.
 - ii. Or Approved Equivalent.
 - c) Insert shall be 304 stainless steel.
- B. Hinged Manhole Frames and Covers:
 1. Covers and frames as specified in ASTM A48, Class 35 or better, for Gray Iron or equivalent ISO standard. Contractor shall provide verification of equivalency.
 2. Covers shall be hinged and incorporate a 90-degree blocking system to prevent accidental closure.
 3. Covers shall be one man operable using standard tools.
 4. Frames shall be circular with a 22 in. clear opening.
 5. The frame depth shall NOT exceed 4 in., and the flange shall incorporate bedding slots, bolt holes and lifting eyes.
 6. Lids shall be lockable and lock/unlock hardware and tools shall be provided with each lid.
 7. Lids shall have "SANITARY SEWER" cast on the surface.
- C. Manhole Frame Seals
 1. The material for the seals between the frames and concrete shall be a bitumastic gasket material, meeting, or exceeding ASTM C990.
 2. Bitumastic gasket material:
 - a. Ram-Nek
 - b. EZ-STIK
 - c. Or Approved Equal.

2.3 COATINGS

- A. Interior Coatings:
 1. Manholes located on 15 in. and larger sewer lines shall be epoxy coated on the interior.
 2. Manhole located within 100 ft of a 15 in. and larger sewer line shall be epoxy coated on the interior.
 3. Transition manholes in which, a force main discharges into a gravity sewer line shall be epoxy coated on the interior.
 4. The products shall only be applied by personnel thoroughly familiar with handling of the coating material, and as specified in the manufacturer's specifications, recommendations and requirements.
 - a. Raven Ultra High-Build Epoxy Coating, designated as Raven 405, with an average thickness of 100 mils and a minimum thickness of 80 mils.
 - b. Warren Environmental Systems, designated as S-301, with an average thickness of 100 mils and a minimum thickness of 80 mils.
 - c. Epoxies Requirements:
 - 1) Flexural Strength ASTM D790 6,000 psi
 - 2) Compressive Strength ASTM D695 8,000 psi
 - 3) Tensile Strength ASTM D638 4,000 psi
 - 4) Tensile Elongation ASTM D638 4%
 - 5) Adhesion ASTM D4541 Concrete Substrate Failure
 5. Any damage to an epoxy system on existing manholes shall be repaired by the Contractor at the expense of the Contractor.
- B. Exterior Coatings:
 1. All precast manhole sections shall have the exterior coated with two mop coats of coal tar epoxy:

- a. Kop Coat "Bitumastic Black Solution"
 - b. Tnemec "46-450 Heavy Tnemecol"
 - c. Carboline "Bitumastic 300M"
 - d. Or Approved Equal.
2. Dry film thickness shall be a minimum of 14.0 mils per coat. Recoating shall be done as specified manufacturer's recommendations.

PART 3 - EXECUTION

3.1 GENERAL

- A. Perform excavation and prepare base area as specified in Section 31 23 16 – Excavation.
- B. Never install base in a water-filled excavation.
- C. Place base as specified in the Plans and Section 03 30 00 – Cast-In-Place Concrete. Extend base a minimum of 6 in. beyond finished sides of manhole.
- D. Manhole base shall be placed on 8 in. of compacted Type A aggregate base.
- E. Extend all pipes entirely through the manhole wall so that a joint occurs no closer than 24 in. outside the manhole wall.
- F. Pipe installed for future extensions shall have one full joint of pipe installed.
- G. After manhole is constructed, wait no less than 48 hours, then backfill per Section 31 23 23.13 – Fill and Backfill.

3.2 CAST-IN-PLACE MANHOLES

- A. Dimension and layout shall be as specified in the Plans. The top section or cone shall be concentric with the barrel unless otherwise noted.
- B. The frame shall be set as specified in the Plans.
- C. Install rubber waterstop gaskets in the walls around all pipes.
- D. Interior finish shall be smooth, free of fins or sharp edges.
- E. Invert to be constructed as specified in Plans. The bench wall shall be formed to the spring line of the inlet and outlet pipes to form a "U" as shown in the Plans.
- F. Care should be taken to prevent the end of the pipe from deflecting, due to loads imposed by the weight of the concrete.
- G. Construction joints on manholes of excessive depth shall relate to reinforcement approved by the Engineer.

3.3 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Delivery of Materials:
 1. Products shall be delivered in original, unbroken packages, containers, or bundles bearing the name of the manufacturer.
- B. Storage:

1. Products shall be carefully stored in a manner that shall prevent damage and in an area that is protected from the elements.

C. See Section 01 60 00 – Product Requirements for additional requirements.

3.4 FIELD QUALITY REQUIREMENTS

- A. Contractor shall visually inspect all materials upon delivery and set aside damaged or flawed materials and shall NOT install any damaged or flawed material.
- B. Contractor shall test for defects and leakage as specified in Section 33 31 23 – Testing Sanitary Sewer Systems.

END OF SECTION

SECTION 33 41 16 – DUCTILE-IRON GRAVITY SEWER PIPE AND FITTINGS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section Includes:
 - 1. The Work necessary to completely furnish and install Ductile-Iron gravity sewer pipe and fittings.
- B. Related Sections:
 - 1. Section 31 23 16.13 – Trenching for Site Utilities
 - 2. Section 31 23 23.16 – Trench Backfill
 - 3. Section 33 31 23 – Testing Sanitary Sewer Systems
 - 4. Section 33 39 13 – Concrete Manholes
 - 5. Section 33 41 19 – Pipe Laying
- C. GENERAL
 - 1. Like items of ductile-iron pipe provided hereinafter shall be the end products of one manufacturer to achieve standardization of appearance, operation, maintenance, and manufacturer's services.
 - 2. All pipes shall be circular and shall be of the sizes specified in the Plans and/or listed in the Unit Price Schedule. All pipes shall be new. Used pipe is prohibited.
 - 3. At the discretion of the Engineer, all pipeline and materials are subject to inspection and approval at the plant of the manufacturer.
 - 4. All materials shall equal or exceed the standards specified herein.
 - 5. During the process of unloading, all pipe materials shall be inspected by the Contractor and any damaged pipe set aside.
 - 6. After pipelines are laid, the Contractor shall test for defects and leakage as specified in Section 33 31 23 – Testing Sanitary Sewer Systems of these sections.
 - 7. Inspection of pipe at the manufacturer's plant, at the point of delivery, on the job site, or in place shall NOT relieve the Contractor of his responsibility and the material may be subject to rejection until final acceptance of the completed project.

1.2 REFERENCES

- A. ANSI/AWWA:
 - 1. C115/21.15 – Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron
 - 2. C111/A21.11 – Rubber Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
 - 3. C150/A21.50 – Thickness Design of Ductile-Iron Pipe
- B. ANSI:
 - 1. B16.1 – Gray-Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250
- C. ASTM:
 - 1. A746 – Standard Specification for Ductile-Iron Gravity Sewer Pipe
- D. AWWA:
 - 1. C153 – Ductile-Iron Compact Fittings

1.3 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Quality requirements Submittals:

1. Pipe size, class, and thickness
2. Special shipping, storage and protection, and handling instructions
3. Test procedures
4. Test results, reports, and certifications

1.4 WARRANTIES

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Ductile-iron gravity sewer pipe shall be provided to conform to materials of construction as specified in this section.

2.2 DUCTILE-IRON GRAVITY SEWER PIPE

- A. All pipe and pipe fittings furnished for underground sewer piping shall have either push-on or mechanical type joints.
- B. Flanges:
 1. Flanged DIP and DI fittings shall be used only as specified in the Plans.
 2. Flanged pipe and pipe fittings as specified in ANSI/AWWA C115/21.15, Class 250 psi.
 3. Flanged drilling as specified in ANSI B16.1, Class 125 flange.
- C. All DIP, 8 in.–36 in., shall be as specified in ANSI/AWWA C150/A21.50 (Thickness Design of Ductile-Iron Pipe) and ASTM A746 (Ductile-Iron Gravity Sewer Pipe) or ANSI/AWWA C151/A21.51 (Ductile-Iron, Centrifugally-Cast for Water).
- D. The minimum acceptable size of all gravity sewer mains shall be 8 in.
- E. DIP and DI fittings shall be designed by the pipe manufacturer based on laying condition Type 5, with an additional 4 in. initial backfill above the top of the pipe, as specified in ANSI/AWWA C150/A21.50, and the depth of bury as specified in the Plans, plus a single AASHTO H20 truck load.
- F. Pipe shall be designed for a thickness class of no less than Special Class 50. The pipe manufacturer shall check for depth of bury and furnish pipe of a heavier class if needed, as specified in ANSI/AWWA C150/A21.50.
- G. Standard laying lengths shall be 20 ft plus or minus 1 in., unless otherwise specified.

2.3 FITTINGS FOR DUCTILE-IRON GRAVITY SEWER

- A. All fittings over 3 in. shall be ductile-iron, mechanical joint fittings and as specified in AWWA C153. All fittings shall have a minimum pressure rating of 350 psi and shall be lightweight (compact) fittings unless otherwise specified in the Plans.
- B. All fittings shall be furnished with gaskets. mechanical joint fittings shall also be furnished with bolts, nuts, and iron glands. All plugs, caps, tees, and bends deflecting 22 1/2 degrees or more shall be provided with reaction backing.
- C. All casting and mating surfaces shall be smooth and of a workmanlike quality, free from cracks, holes, scale, shrinkage, distortion, grooves, scratches, and other defects. Fittings and other

castings may be rejected if found to be unacceptable by the Engineer as specified in these sections.

- D. A wye shall be installed for each anticipated future connection of sewer service.
- E. Joints:
 - 1. Mechanical joint.
 - 2. As specified in AWWA C111.
 - 3. Furnished with Mega-lug type retainer glands and gaskets.
- F. Special fittings shall be as specified in the pipe manufacturer's recommendations and as approved by the Engineer.
- G. Fittings and Appurtenances Placed on Sanitary Sewer Lines:
 - 1. As specified in the requirements of the type of pipe used.
 - 2. Install as specified in the manufacturer's recommendations and with Engineer approval.
- H. Connections between different kinds of pipe shall be detailed on the Plans and provide self-cleansing sanitary flow and watertight joints and connections.

2.4 DUCTILE-IRON PIPE JOINTS

- A. Joints shall be mechanical joints or push-on type joints as specified in ANSI/AWWA C111/A21.11 (Rubber Gasket Joints for Ductile-Iron Pressure Pipe and Fittings), unless otherwise specified.
- B. Joints shall have the same pressure rating of the pipe or fittings of which they are a part.
- C. All pipe joints other than those specified herein shall be made as strictly specified in the manufacturer's recommendations and as approved.
- D. All joints shall be made watertight as specified in the latest applicable AWWA and ASTM standards.

2.5 GASKETS FOR DUCTILE-IRON JOINTS AND FITTINGS

- A. Gaskets shall be made of vulcanized styrene butadiene rubber.
- B. Gaskets shall be marked for nominal pipe size, manufacturer, and year of manufacture.
- C. Gaskets shall be as specified in AWWA C111 (Rubber Gasket joints for Ductile-Iron Pressure Pipe and Fittings).

2.6 DUCTILE-IRON JOINT AND FITTING LUBRICANT

- A. Lubricant shall be provided by the pipe manufacturer and applied as per the manufacturer's recommendations as specified in ANSI/AWWA C111/A21.11 (Rubber Gasket Joints for Ductile-Iron Pressure Pipe and Fittings).
- B. Lubricant shall be nontoxic, shall NOT support the growth of bacteria, and shall have no deteriorating effects on the gasket or pipe material.
- C. Lubricant containers shall be appropriately identified and labeled with the manufacturer's name.
- D. Each lubricant container shall have printed instructions for usage and joint assembly.

2.7 COATINGS

A. Interior Coatings:

1. All DIP, fittings, valves, service wyes, and other appurtenances for gravity sewer or force mains shall receive interior lining treatment:
 - a. Epoxy Lining
 - 1) All DIP and DI fittings shall be lined with a high-build, multicomponent amine-cured novalac epoxy lining, containing at least 20% ceramic quartz pigment, by volume.
 - 2) The lining system shall be Protecto 401 Ceramic Epoxy, as manufactured by Vulcan Painters, Inc.
 - 3) The lining Applicator shall have a successful history of applying linings to the interior of DIP.
 - b. Condition of Ductile-Iron Prior to Surface Preparation
 - 1) All DIP and DI fittings shall have a high-build protective lining on the interior. All DIP and DI fittings shall be delivered to the application facility without any lining on the interior surface. As removal of old linings may NOT be possible, the intent of this section is that the entire interior of DIP and DI fittings shall NOT have been lined with any substance prior to the application of the lining specified herein.
 - c. Surface Preparation
 - 1) Prior to abrasive blasting, the entire area to receive the protective compound shall be inspected for oil, grease, and other substances. Any areas where oil, grease, or another substance is detected and can be removed by solvent shall be solvent-cleaned using the guidelines outlined in SSPC-SP-1 (Solvent Cleaning).
 - 2) After the surface has been made free of grease, oil, and other substances, all areas to receive the protective compounds shall be abrasive blasted with sand or grit abrasive media.
 - 3) The entire surface to be lined shall be struck with the blast media so that all rust, loose oxides, and other sources of roughness shall be removed from the surface. If rust reappears before coating, the affected areas shall be reblasted.
 - d. Lining:
 - 1) Within eight hours after surface preparation, the interior of the pipe shall receive approximately 40 mils dry film thickness of the protective lining.
 - 2) Lining shall NOT occur if the substrate or ambient temperature is below 40°F.
 - 3) The surface shall be dry and dust free before lining.
 - 4) The linings shall NOT be used on the face of any flanged pipe or fitting, unless otherwise specified.
 - 5) All fittings shall be lined with approximately 40 mils of the protective lining. The 40 mils system shall NOT be applied in the gasket grooves.
 - e. Coating Gasket and End Spigots:
 - 1) Due to the tolerances involved, the gasket area and exterior spigot end, up to 6 in. back from the end of the spigot end, shall be coated with 6 mils nominal, 10 mils maximum Protecto Joint Compound, or approved equal.
 - 2) This coating shall be applied by brush to ensure coverage. Care shall be taken so the coating is smooth, without excess buildup in the gasket groove or on the spigot end.
 - 3) All materials for the gasket groove and spigot end shall be applied after the application of the lining.
 - f. Number of Coats:
 - 1) The number of coats of lining material applied shall be as recommended by the lining manufacturer. However, in no case shall this material be applied above the dry thickness per coat recommended by the lining manufacturer

in printed literature. The time between coats shall never exceed that time recommended by the lining material manufacturer. No material shall be used for lining which is NOT indefinitely able to be recoated without roughening the surface.

- g. Touchup and Repair:
 - 1) Protecto Joint Compound, or approved equal, shall be used for touchup or repair. Procedures for touchup and repair shall be as specified in the manufacturer's recommendations.
- h. Inspection and Certification:
 - 1) Inspection
 - 2) All DIP and DI fitting linings shall be checked for thickness using a magnetic film thickness gauge. The thickness testing shall be as set forth in SSPC-PA-2 (Measurement of Dry Coating Thickness with Magnetic Gages).
 - 3) The interior lining of all pipe and fittings shall be tested for pinholes with a nondestructive 2,500 V test. Any defects shall be repaired prior to shipment.
 - 4) Each pipe joint and fitting shall be marked with the date of application of the lining system and the numerical sequence of application on that date.
 - 5) Certification
 - 6) The pipe or fitting manufacturer shall supply a certificate attesting that the Applicator met the requirements of these sections, the material used was as specified, and the material was applied as required.

B. Exterior Coatings:

- 1. All DIP and DI fittings shall have an exterior coating as set forth below.
 - a. Factory Primed Pipe:
 - 1) Unless otherwise specified in the Plans, all exposed pipe and fittings within the limits of structure walls or exposed pipe and fittings located aboveground shall be delivered to the job site factory-blasted, cleaned, and primed with one coat of Tnemec Series N140 Pota-Pox Plus, or approved equal compatible paint system.
 - b. Bituminous Coating:
 - 1) All pipe and fittings indicated for buried service shall have a petroleum asphaltic coating approximately 1 mil thick factory-applied to the outside of all pipe and fittings. The finished coating shall be continuous, smooth, neither brittle when exposed to the cold nor sticky when exposed to the sun and shall be strongly adherent to the pipe or fitting. The bituminous coating shall NOT be applied to the first 6 in. of the exterior of the spigot ends.

PART 3 - EXECUTION

3.1 GENERAL

- A. All pipe and fittings shall be installed as specified in these sections and the Plans.

3.2 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. See Section 01 60 00 – Product Requirements.
- B. Delivery of Materials:
 - 1. Products shall be delivered in original, unbroken packages, containers, or bundles bearing the name of the manufacturer.
- C. Storage:
 - 1. Products shall be carefully stored in a manner that shall prevent damage and in an area that is protected from the elements.

3.3 FIELD QUALITY REQUIREMENTS

- A. Contractor shall visually inspect all pipe and fittings upon delivery and set aside damaged or flawed materials and shall NOT install any damaged or flawed material.
- B. Contractor shall test for defects and leakage as specified in Section 33 31 23 – Testing Sanitary Sewer Systems.

3.4 INSTALLATION

- A. Installation shall be as specified in Section 33 41 19 – Pipe Laying.
- B. Pipe trenching shall be as specified in Section 31 23 16.13 – Trenching for Site Utilities.
- C. Pipe bedding and backfill shall be as specified in Section 31 23 23.16 – Trench Backfill.
- D. Pipe connections to concrete manholes and other concrete structures shall be as specified in Section 33 39 13 – Concrete Manholes.

END OF SECTION

SECTION 33 41 19 – PIPE LAYING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section Includes:
 - 1. the Work necessary to install gravity sewer, force main pipe, water pipe and appurtenances.
- B. Related Sections:
 - 1. Section 31 23 16.16 – Trenching for Water and Sewer Lines
 - 2. Section 33 31 23 – Testing Sanitary Sewer Systems
 - 3. Section 33 34 13 – Ductile Iron Force Main Pipe and Fittings
 - 4. Section 33 39 13 – Concrete Manholes
 - 5. Section 33 41 16 – Ductile Iron Gravity Sewer Pipe and Fittings

1.2 WARRANTIES

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All pipe materials shall be as specified on the Plans and conforming to these specifications.

2.2 WARNING TAPE

- A. Nonmetallic sanitary sewer marking tape shall be warning tape.
- B. Acceptable Manufacturer:
 - 1. Rhino Marking and Protection Systems
 - 2. Harris Industries, Inc.
 - 3. Or Approved Equal.
- C. Tape shall have a minimum thickness of 4 mils and manufactured with heavy metal-free polyethylene tape that is impervious to all known alkalis, acids, chemical reagents, and solvents found in soil. The minimum overall width of the tape shall NOT be less than 3 in. Standard rolls shall be 1,000 ft length.
- D. The tape for sewer lines shall be color coded GREEN and imprinted with the message:
 - 1. Caution Buried Sewer Line Below.
- E. The tape for water lines shall be color coded BLUE and imprinted with the message:
 - 1. Caution Buried Water Line Below.

2.3 TRACER WIRE

- A. Tracer wire shall be 12 GA, stranded coated copper for underground burial.
- B. Jacket color shall be GREEN and made of High Density Polyethylene (HDPE) or High Molecular Weight Polyethylene (HMWPE) designed for direct burial.

- C. Connectors shall be used for all splices or repairs. Connectors shall be moisture displacement style.
- D. Acceptable Manufacturer:
 - 1. 3M Co.; 3M DBR
 - 2. Or Approved Equal.
- E. A locate or conductivity test shall be performed prior to signing off on the project.

2.4 PIPE BEDDING AND BACKFILL

- A. Shall be as specified.

PART 3 - EXECUTION

3.1 GENERAL

- A. All pipe, fittings, bedding, backfill, and all other appurtenances shall be installed as specified in these sections and the Plans.

3.2 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Comply with Section 01 60 00 – Product Requirements.
- B. Delivery of Materials:
 - 1. Products shall be delivered in original, unbroken packages, containers, or bundles bearing the name of the manufacturer.
- C. Storage:
 - 1. Products shall be carefully stored in a manner that will prevent damage and in an area that is protected from the elements.
- D. Pipe and accessories shall be handled in such a manner that will ensure their condition after installation to be sound and undamaged. Equipment, tools, and methods used in unloading, reloading, hauling, and laying pipe and fittings shall be such that they are NOT damaged. Under no circumstances shall loading forks, or other equipment, be inserted into the barrel of the pipe or fitting.
- E. Pipe having pre-molded joint rings shall be handled in such a manner that no weight, including the weight of the pipe itself, will bear on or be supported by the spigot rings at any time. Care shall be taken to avoid dragging the spigot ring on the ground or allowing it to encounter gravel, crushed stone, rocks, or other hard objects. Joint rings which have been damaged in any way will NOT be accepted and shall NOT be incorporated in the work.

3.3 FIELD QUALITY REQUIREMENTS

- A. Provide skilled workmen to ensure embedment of pipe.
- B. Contractor shall test for defects and leakage as specified in Section 33 31 23 – Testing Sanitary Sewer Systems.

3.4 TRACE WIRE

- A. Regardless of pipe material, a trace wire shall be laid on top of the pipe and shall be looped around the pipe at least once every 10 ft and connected to all valves and fittings. At valves, the

trace wire shall be brought up into the valve box as specified in the Plans. A tracing test of trace wire will be required prior to final acceptance.

3.5 PIPE DETECTION TAPE

- A. Pipe detection tape shall be provided in all trenches for force main and water line construction. Installation shall be per manufacturer's recommendations and shall be as close as practical to finished grade while maintaining a required minimum of 18 in. between the detection tape and the top of any pipe.

3.6 LAYING PIPE

- A. Proper means and equipment shall be used for lowering pipe into the trenches.
- B. The Contractor shall have full responsibility for any diversion of drainage and for dewatering trenches.
- C. Recesses for the pipe bells are mandatory and shall be hand excavated so that the entire pipe barrel is uniformly supported by the bedding material.
- D. Pipe shall be protected from lateral displacement by means of pipe embedment material installed as provided in this specification. Under no circumstances shall pipe be laid in water and no pipe shall be laid under unsuitable weather or trench conditions.
- E. When jointed in the trench, the pipe shall form a true and smooth line. Pipe shall NOT be trimmed except for closures, and any pipe NOT making a good fit shall be removed.
- F. Unless otherwise approved by the Engineer, the laying of pipe shall begin at the lowest point, and the pipe shall be installed so that the spigot ends point in the direction of flow.
- G. Pipe which is a part of a gravity sewer line shall be aligned and constructed to grades as specified in the plans. Lines NOT conforming to these grades shall be subject to removal and replacement at the Contractor's expense. Force main pipe shall match the horizontal alignment and shall closely match the grades specified in the Plans.
- H. Pipe lines or runs intended to be straight shall be laid straight.
- I. During installation, each pipe and fitting shall be inspected for defects. All defective, damaged, or unsound pipe and fittings shall be rejected and removed from the site of the work.
- J. Dependent on type of application, gravity or pressure, place thrust blocking at all pipe fittings, including bends and reducers, as specified in the Plans.
- K. Prior to joining the pipe, the plain ends of the pipe and the bells of the pipe shall be thoroughly cleaned using a soapy water and cloth, removing all foreign materials from the bells, especially the gasket seats. Any burrs or imperfections in that part of the plain end or bell which will be in contact with the gasket shall be removed.
- L. The clean gasket shall be inserted in the bell and a thin film of lubricant shall be applied to the inside surface of the gasket.
- M. The cleaned plain end shall initially be entered in the bell straight. The plain end shall be forced inside the gasket and bell until the limit mark is just visible. The pipe may then be deflected as allowed by the manufacturer.

- N. Lubricants shall be supplied by the pipe manufacturer in sufficient quantities. No substitutes shall be made.
- O. The Contractor shall furnish such jacks, or other devices as are necessary for forcing the pipe into the bell and gasket. Care shall be exercised to avoid damage to the pipe where the pushing device or machine part contacts the pipe. A wood block or suitable pad shall be placed between the pipe and that part of the pushing device which contacts the pipe.
- P. All plain ends that enter a push on bell shall be beveled at 30° for at least 1/8 in. All cut pieces or ends of pipe of other classifications shall be so beveled.

3.7 PIPE BEDDING NONFERROUS PIPE

- A. Nonferrous pipes include PVC, Polyethylene, and FRP.
- B. Bedding material shall be as specified.
- C. Place 6 in., minimum, of bedding between excavated trench bottom or stabilized trench bottom and bottom of pipe or fitting. Provide depression in bedding for joints so that barrel of pipe or fitting rests on bedding. Place bedding in 6 in. maximum layers, compacted to 95% standard maximum density, to 6 in. over the top of pipe and fittings.
- D. Ensure bedding is contacted with the pipe in all directions, and no portion of the bedding is compacted to less than specified density, particularly the area below the springline of the pipe.
- E. Place bedding a minimum of 6 in. over the top of pipe and fittings. Bedding shall be compacted to 95% maximum density.
- F. For areas undercut, whether by Contractor's negligence or by direction of Engineer, provide and place crushed aggregate, compacted to 95% standard maximum density, to bottom elevation of pipe bedding.
- G. When used, the bottom of trench boxes will be above the level of pipe bedding before bedding is compacted. In no case shall pipe bedding be compacted against the trench box or before the trench box is raised to allow compaction of bedding.

3.8 PIPE BEDDING DUCTILE IRON PIPE

- A. Bedding material shall be as specified.
- B. Place 6 in., minimum, of bedding between excavated trench bottom or stabilized trench bottom and bottom of pipe or fitting. Provide depression in bedding for joints so that barrel of pipe or fitting rests on bedding. Place bedding in 6 in. maximum layers, compacted to 95% standard maximum density, to a minimum total depth of 3/4 (75%) of the outside diameter of the pipe as specified in Drawings.
- C. Bedding is an integral part of the pipe installation. Therefore, particular care shall be given to ensure that bedding is in intimate contact with the pipe in all directions and that no portion of the bedding shall be compacted to less than the specified density, particularly the area below the springline of the pipe.
- D. For areas undercut, whether by Contractor's negligence or by direction of Engineer, provide and place crushed aggregate, compacted to 95% standard maximum density, to bottom elevation of pipe bedding.

- E. When used, the bottom of trench boxes will be above the level of pipe bedding before bedding is compacted. In no case shall pipe bedding be compacted against the trench box or before the trench box is raised to allow compaction of bedding.

3.9 TRENCH BACKFILL

- A. Shall be as specified.

3.10 ALIGNMENT AND GRADE

- A. All pipe shall be laid straight between changes in alignment, except as specified in the Plans, and at a uniform grade between changes in grade. All lines shall be laid so that each section between manholes will lamp.

3.11 JOINTING

- A. Boltless Gasketed Joints:
 - 1. All instructions and recommendations of the pipe manufacturer, relative to gasket installation and other jointing operations, shall be observed and followed by the Contractor. All joint surfaces shall be lubricated as recommended by the manufacturer immediately before the joint is completed.
- B. Mechanical Joints:
 - 1. Mechanical joints shall be carefully assembled as specified in manufacturer's recommendations. If effective sealing is NOT obtained, the joint shall be disassembled, thoroughly cleaned, and reassembled. Overtightening bolts to compensate for poor installation practice shall NOT be permitted.

3.12 CUTTING PIPE

- A. Cutting of pipe shall be done in a neat manner, without damage to the pipe or to the lining. Pipe cuts shall be smooth, straight and at right angles to the pipe axis. All cutting of pipe shall be done with mechanical pipe cutters of an approved type except that in locations where the use of mechanical cutters would be difficult or impracticable, existing pipe may be cut with diamond point chisels, saws, or other tools which will cut the pipe without damaging impact or shock.

3.13 CLEANING

- A. The interior of all pipe shall be cleaned of all foreign matter before being installed and shall be kept clean until the work has been accepted. All lumps, blisters and excess coating shall be removed from exterior spigot and interior bell surfaces. Such surfaces shall be wire brushed and wiped clean, dry, and free from oil and grease before placing the spigot in the bell. All joint contact surfaces shall be kept clean until the jointing is completed.
- B. Every precaution shall be taken to prevent foreign material from entering the pipe while it is being installed. No debris, tools, clothing, or other materials shall be placed in the pipe.
- C. Whenever pipe laying is stopped, the open end of the line shall be sealed with a watertight plug.

3.14 WATER AND SEWER LINE CROSSINGS

- A. Water and sewer lines crossing one another shall have a minimum 24 in. vertical separation measured from edge of pipe to edge of pipe.

- B. In general water lines shall be above sewer lines, however if water line cannot be above sewer line because of cover limitations or other obstructions. The water line may be below the sewer line but either the water or sewer line shall be encased 10 ft either side of the crossing line in steel encasement.

- C. Water lines shall NOT pass through manholes.

3.15 PARALLEL WATER AND SEWER LINES

- A. Water and sewer line shall have a minimum 10 ft horizontal separation measured from edge of pipe to edge of pipe.
- B. Water and sewer lines shall NOT be installed within the same trench.

3.16 TESTING

- A. Acceptance testing for gravity lines and force mains as specified in Section 33 31 23 – Testing Sanitary Sewer Systems.
- B. Acceptance testing for water mains as specified.

3.17 CONNECTION OF NEW SEWER PIPELINES TO EXISTING SANITARY SEWERS

- A. Construct, clean, test, and obtain Engineer's approval for pipelines and manholes before connecting new pipeline to the existing sewer.
- B. If, in the opinion of the Engineer, conditions exist which require connection prior to final line acceptance, plug all lines entering the manhole connecting to the existing system until the new system is accepted. In addition, plug the line leaving the first manhole upstream. Never allow water being used to flush the new lines to enter the existing system.
- C. All new pipelines shall connect to the existing system at a new or existing manhole. If a new manhole is built over an existing sewer line, DO NOT break out the top of the existing pipe until the new line is accepted.
 - 1. Flexible pipe couplings may be used to connect existing gravity sewer line to new gravity sewer lines as approved by the Engineer.
 - 2. Acceptable Manufacturers:
 - a. Fernco
 - b. Or Approved Equal.
- D. If a new pipeline is to discharge into an existing manhole, divert the sewage flow around the existing manhole while the tie-in is under construction. Intercept the sewage flow at the existing manhole first upstream from the tie-in construction. Provide suitable pumping equipment and rerouting conduit to pump the sewage around the tie-in construction. Discharge into an appropriate manhole downstream from the construction.
- E. Connection to an existing manhole shall be made by core drilling. A concrete manhole adapter, A-LOK G3 boot system or equal, shall be installed on the sewer pipe, and the annular space grouted.
- F. Connect new pipelines to existing manholes in a neat, workmanlike manner, to ensure a watertight connection.

3.18 TRENCHING

- A. Pipe trenching shall be as specified in Section 31 23 16.16 – Trenching for Water and Sewer Lines.

3.19 CONNECTIONS TO MANHOLES

- A. Pipe connections to concrete manholes and other concrete structures shall be as specified in Section 33 39 13 – Concrete Manholes.

3.20 STEEL ENCASEMENT

- A. Pipe installed within steel encasement shall be as specified.

END OF SECTION

DIVISION 40
PROCESS INTEGRATION

SECTION 40 05 00 – PIPING SYSTEMS TESTING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Test requirements for piping systems.
- B. Related Sections:
 - 1. Section 40 23 39.1 – Process Piping Schedule

1.2 REFERENCES

- A. NFGC (National Fuel Gas Code):
 - 1. ANSI Z 223.1 or NFPA 54
- B. ASME (American Society of Mechanical Engineers):
 - 1. B31.8 – Gas Transmission and Distribution Piping Systems
 - 2. B31.1 – Power Piping
 - 3. B31.3 – Process Piping

1.3 SUBMITTALS

- A. Subject to the requirements of 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:
 - a. 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.

1.4 TESTING REQUIREMENTS

- A. General Requirements:
 - 1. Testing requirements:
 - a. As stipulated in Laws and Regulations.
 - b. As specified in Section 40 23 39.1 – Process Piping Schedule.
 - c. As specified in the sections covering the various types of piping.
 - d. As specified in this section.
 - 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 as specified in Laws and Regulations and UL requirements.
 - 4. Test Natural Gas or Gas Piping:
 - a. For less than 125 psi gauge working pressure, test as specified in National Fuel Gas Code.
 - b. For 125 psi gauge or greater working pressure, test per ASME B31.3 or ASME B31.8, whichever is more stringent.
 - 5. When testing with water for High-Head and Low-Head:
 - a. The specified test pressure is the pressure at the highest point of the piping section under test. Lower the test pressure as necessary to prevent testing the lowest point above a safe test pressure.

- b. PVC piping shall NOT be tested with air within the pipe.
 - c. Test pressures shall be 1.5 times the maximum operating pressure or rounded up to 100 psig for high head pressure testing. Low head pressure testing shall be round up to the nearest 5 psig.
 - 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 will be provided as specified in Section 01 50 00 – Temporary Facilities and Controls.
 - D. Pipes to be Tested:
 - 1. 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:
 - 1. Drain and leave piping clean after successful testing.
 - G. Test Water Disposal:
 - 1. Dispose of testing water at the facility as specified in federal, state, county, and city regulations governing disposal of waste in the location of the Project and disposal site.
- 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 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 plus or minus 1%.
 - 4. Consider test complete when the mandrel can be pulled through the piping with reasonable effort by 1 person, without the aid of mechanical equipment.

3.2 AIR TESTING METHOD FOR PRESSURE PIPING

- A. Air test piping, specified in "AM" of Section 40 23 39.1 – 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 -40°F or less. Supply temporary air dryers as necessary.
- C. Test at pressure as specified in Section 40 23 39.1– Process Piping Schedule:
 - 1. Provide temporary pressure relief valve for piping under test. Set at the lesser of 110% of the test pressure or 50 psi gauge over the test pressure.
 - 2. Air method test pressures shall not exceed 110% of the piping maximum allowable working pressure calculated as specified in ASME B31.1. ASME 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 1/2 the test pressure or 25 psi 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 min without losses.

3.3 TESTING GRAVITY FLOW PIPING

- A. Test Gravity Flow Piping as specified in "G" of the 40 23 39.1 – Process Piping Schedule:
 - 1. Unless specified otherwise, subject gravity flow piping to:
 - a. Alignment and grade tests
 - b. 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.
 - 1) maximum leakage allowances; tests are complete when leakage is equal to or less than:
 - a) For Concrete Piping with Rubber Gasket Joints:
 - i. 80 gpd per inch of diameter per mile of piping under test
 - b) Advise manufacturer of concrete piping with rubber gasket joints of more stringent than normal maximum leakage allowance.
 - c) For Vitrified Clay and Other Piping:
 - i. 500 gpd 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 Section 40 23 39.1 – Process Piping Schedule is 20 psi gauge or greater, by the high head pressure test method, specified in “HH” of Section 40 23 39.1 – 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 not 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 psi 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 show 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 ft 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 specified in Section 40 23 39.1 – 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:

$$L = \frac{S D \sqrt{P}}{148,000}$$

Where:

L = testing allowance (makeup water) (gph)

S = length of pipe tested (ft)

D = nominal diameter of the pipe (in.)

P = average test pressure during the hydrostatic test (psi gauge)

3.5 TESTING LOW-HEAD PRESSURE PIPING

- A. Test piping for which the specified test pressure is less than 20 psi gauge, by the low head pressure test method, specified in "LH" of Section 40 23 39.1 – Process Piping Schedule.
- B. General:
1. Test pressures shall be as scheduled in Section 40 23 39.1 – Process Piping Schedule.
 2. During the performance of the tests, test pressure shall not vary more than plus or minus 2 psi 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 hrs. for visible leaks test and minimum of 2 hrs. 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 specified in 40 23 39.1 – Process Piping Schedule.
 3. Before pressurizing for the tests, retain water in piping under slight pressure for the water absorption period of minimum 24 hrs.
 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 hrs. 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 as specified in Section 40 23 39.1 – Process Piping Schedule, the Procedure Shall Be:
 - a. Joint testing will be allowed only for low head pressure piping.
2. Joint testing may be performed with water or air.
3. Joint test piping after completion of backfill and compaction to the top of the trench.
4. Joint Testing with Water:
 - a. Measure test pressure at the invert of the pipe. Apply pressure of 4 ft plus the inside diameter of the pipe in water column within 0.20 ft in water column.
 - b. Maintain test pressure for 1 min.
 - c. Base the allowable leakage per joint on 80 gal/in. nominal diameter, per mile of piping, per 24 hrs. equally distributed to the actual number of joints per mile for the type of piping.
 - d. Consider the pressure test to be complete when makeup water added is less than the allowable leakage.
 - e. Successful completion of the joint test with water shall have been achieved when the observed leakage is equal or less than the allowable leakage.
5. Joint Testing with Air:
 - a. Apply test pressure of 3 psi gauge with an allowed variation of 0.00 psi – 0.20 psi.
 - b. Maintain test pressure for 2 min.
 - c. Consider the pressure test to be complete when the test pressure does not drop below 2.7 psi for the duration of the test.

3.6 PNEUMATIC TEST FOR PRESSURE PIPING

- A. Test piping as specified in pipe schedule.
- B. DO NOT perform on:
 1. PVC or CPVC pipe.
 2. Piping larger than 18 in.
 3. Buried and other nonexposed piping.
- C. Fluid:
 1. Oil-free, dry air
- D. Procedure:
 1. Apply preliminary pneumatic test pressure of 25 psig maximum to piping system prior to final leak testing, to locate visible leaks. Apply soap bubble mixture to joints and connections, examine for leakage.
 2. Correct visible leaks and repeat preliminary test until visible leaks are corrected.
 3. Gradually increase pressure in system to half of specified test pressure. Thereafter increase pressure in steps of approximately 1/10 of specified test pressure until required test pressure is reached.
 4. Maintain pneumatic test pressure continuously for minimum of 10 min. and for such additional time as necessary to conduct soap bubble examination for leakage.
 5. Correct visible leakage and retest as specified.

- E. Allowable Leakage:
 - 1. Piping system, exclusive of possible localized instances at pump or valve packing, shall show no visual evidence of leakage.
- F. After testing and final cleaning, purge with nitrogen those lines that shall carry flammable gases to assure no explosive mixtures shall be present in system during filling process.

3.7 PNEUMATIC TEST FOR GRAVITY PIPING 12 IN. AND SMALLER

- A. Equipment:
 - 1. Calibrate gauges with standardized test gauge at start of each testing day.
 - 2. Install gauges, air piping manifolds, and valves at ground surface.
 - 3. Provide pressure release device, such as rupture disc or pressure relief valve, to relieve pressure at 6 psi or less.
 - 4. Restrain plugs used to close sewer lines to prevent blowoff.
- B. Procedure:
 - 1. Require that no person enter manhole where pipe is under pressure.
 - 2. Slowly introduce air into pipe section until internal air pressure reached 4 psi greater than average back pressure of groundwater submerging pipe.
 - 3. Allow 2 min minimum for air temperature to stabilize.
- C. Allowable Leakage:
 - 1. Test section shall be considered "defective" when time required for pressure to decrease from 3.5 psi to 2.5 psi greater than average back pressure of groundwater submerging pipe is less than that computed utilizing values:

TABLE 1*					
A	B	C	D	E	F
Pipe Diameter (Inches)	Time per Foot up to Length in Col C (Seconds)	Test Length (Feet)	Test Time Between Col C & E (for any Length)	Length (Col F Applies) (Feet)	Time per Foot for Total Length (Seconds)
	0.18	636	1:54	1.114	0.10
	0.40	424	2:50	743	0.23
	0.71	318	3:47	557	0.41
10	1.11	255	4:43	446	0.63
12	1.60	212	5:40	371	0.91
15	2.50	170	7:05	297	1.42
18	3.62	141	8:30	248	2.06
21	4.92	121	9:55	212	2.81
24	6.42	106	11:20	187	3.67
EXAMPLE: 15 in. diameter pipe: For 150 ft, T = 2.50 sec (Col B) x 150 ft = 375 sec – 6:15 For 250 ft, T = 7:05 (Col D) For 500 ft, T = 1.42 sec (Col F) x 500 ft = 710 sec = 11:50					
* Based on 0.003 cfm per square foot with a minimum significant loss of 2 cfm and a maximum loss of 3.5 cfm.					

- D. Piping with groundwater infiltration rate greater than allowable leakage rate for exfiltration shall be considered "defective" even if pipe previously passed a leakage test.
- E. "Defective" Piping Sections:
 - 1. Replace or test and seal individual joints, and retest as specified.

3.8 FIELD QUALITY REQUIREMENTS

- A. Test Report Documentation:
 - 1. Test date
 - 2. Description and identification of piping tested
 - 3. Test fluid
 - 4. Test pressure
 - 5. Remarks, including:
 - a. Leaks (type, location)
 - b. Repair/replacement performed to remedy excessive leakage
 - 6. Signed by Contractor and Engineer to represent that test has been satisfactorily completed.

END OF SECTION

SECTION 40 05 06 – PROCESS PIPING SPECIALTIES

PART 1 - GENERAL

- 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. Equipment connection fittings
 - 11. Service saddles
 - 12. Annular pressure seals
 - 13. Insulating flanges, couplings, and unions
 - 14. Strainers
 - 15. Spray nozzles
 - 16. Quick couplings
 - 17. Quick disconnect cam operating couplings for chemical service
 - 18. Chemical injection quills
- B. Related Sections:
 - 1. Section 09 96 00 – High Performance Coatings
 - 2. Section 40 23 39 – Process Piping General

1.2 DEFINITIONS

- A. Firestopping (Through-Penetration Protection System):
 - 1. 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:
 - 1. Factory Mutual Insurance Company; FM Global is the communicative name of the company.
- C. WH:
 - 1. 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. D2000 – Standard Classification System for Rubber Products in Automotive Applications.
 2. E84 – Standard Test Method for Surface Burning Characteristics of Building Materials.
 3. E119 – Standard Test Methods for Fire Tests of Building Construction and Materials.
 4. E814 – Standard Test Method for Fire Tests of Penetration Firestop Systems.
 5. E1966 – Standard Test Method for Fire-Resistive Joint Systems.
 - E. EJMA Standards (Expansion Joint Manufacturers Association, Inc.):
 - F. NSF International:
 1. 61 – Drinking Water System Components – Health Effects
 2. 372 – Drinking Water System Components – Lead Content
 - G. UL:
 1. 263 – Fire Tests of Building Construction and Materials
 2. 1479 – Fire Tests of Through-Penetration Firestops
 3. 2079 – Tests for Fire Resistance of Building Joint Systems
- #### 1.4 SUBMITTALS
- A. Section 01 33 00 – Submittal Procedures: Requirements for submittals.
 - B. Product Data:
 1. Submit manufacturer catalog information for each specified product.
 2. Firestopping: Submit data on product characteristics, performance, and limitation criteria.
 3. 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.
 4. Expansion Joints: Indicate maximum temperature, pressure rating, and expansion compensation.
 - C. Shop Drawings:
 1. Identification:
 - a. Submit list of wording, symbols, letter size, and color coding for pipe identification.
 - b. Comply with ASME A13.1.
 2. Indicate restrained joint details and materials.
 3. Submit layout drawings showing piece numbers and location, indicating restrained joint locations.
 4. Indicate layout of piping systems, including flexible connectors, expansion joints and compensators, loops, offsets, and swing joints.
 - D. Firestopping Schedule:
 1. 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.
 - E. Include following Paragraph for submission of physical samples for selection of finish, color, texture, and other properties.
 - F. Manufacturer's Certificate:
 1. Certify that products meet or exceed specified requirements.

- G. Welder Certificates:
 - 1. Certify welders and welding procedures employed on Work, verifying ASME qualification within previous 12 months.
 - 2. Include separate Paragraphs for additional certifications.
 - 3. Include following Paragraph when Contractor is responsible for designing products or assemblies. List affected products when Section specifies more than one product.
- H. Delegated Design Submittals:
 - 1. Submit signed and sealed Shop Drawings with design calculations and assumptions for:
 - a. Flexible connectors.
 - b. Expansion joints.
 - c. Pipe Restraints:
 - 1) Determine restrained lengths and submit joint restraint details.
 - 2) Use joint restraint devices specifically designed for applications as described in manufacturer data.
 - d. 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.
- I. Manufacturer Instructions:
 - 1. Submit special procedures and setting dimensions.
- J. Source Quality-Control Submittals:
 - 1. Specify results of shop tests and inspections.
- K. Field Quality-Control Submittals:
 - 1. Specify results of Contractor-furnished tests and inspections.
- L. Qualifications Statements:
 - 1. Submit qualifications for manufacturer, installer, and licensed professional.
 - 2. Submit manufacturer's approval of installer.
 - 3. Welders: Qualify procedures and personnel as specified in ASME BPVC-IX.
- M. Closeout Submittals:
 - 1. Project Record Documents:
 - a. Record actual locations of piping appurtenances.
 - 2. Identify and describe unexpected variations to pipe routing or discovery of uncharted utilities.

1.5 COORDINATION

- A. Coordinate Work of this Section with installation of valves and equipment.

1.6 QUALITY ASSURANCE

- A. Materials in Contact with Potable Water:
 - 1. 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 in. 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 in. WG to achieve fire-resistance rating as indicated on Drawings for floor assembly.
- H. Surface-Burning Characteristics:
 - 1. Maximum 25/450 flame-spread/smoke-developed index when tested according to ASTM E84.

1.7 QUALIFICATIONS

- A. Coordinate following Paragraphs with requirements specified in SUBMITTALS Article.
- B. Manufacturer:
 - 1. Company specializing in manufacturing products specified in this Section with minimum three years of experience.
- C. Installer:
 - 1. Company specializing in performing Work of this Section with minimum three years of experience and approved by manufacturer.
- D. Welders:
 - 1. ASME qualified within previous 12 months for employed weld types.
- E. Licensed Professional:
 - 1. Professional engineer experienced in design of specified Work and licensed in State of Alabama.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. See Section 01 60 00 – Product Requirements for transporting, handling, storing, and protecting products requirements.

- B. Inspection:
 - 1. Accept materials on Site in manufacturer's original packaging and inspect for damage.
- C. Store materials 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. Furnish temporary end caps and closures on piping and fittings and maintain in place until installation.
 - 3. Provide additional protection according to manufacturer instructions.

1.9 EXISTING CONDITIONS

- A. Field Measurements:
 - 1. Verify field measurements prior to fabrication.
 - 2. Indicate field measurements on Shop Drawings.

1.10 WARRANTY

- A. Furnish 1-year manufacturer's warranty.
- B. See Section 01 78 36 – Warranties and Bonds for additional requirements.

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 structure, and where mechanical seals are specified:
 - a. Steel pipe
 - b. 3/16 in. minimum galvanized steel
 - c. Seep Ring:
 - 1) 3/16 in. minimum thickness center steel flange for water stoppage on sleeves in exterior or water-bearing walls.
 - 2) Outside Diameter: 3 in. 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 96 00 – High Performance 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 ft 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 Coating.
- 2. Steel or Stainless-Steel Wall Pipe:
 - a. Same material and thickness as connecting pipe, except 1/4 in. minimum thickness.
 - b. Lining: Same as connecting pipe.
 - c. Thrust Collar: Unless otherwise shown, 3 in. 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 96 00 – High Performance Coatings.
 - e. Restraint: Provide lugs for use with thrust ties as specified.

2.2 RESTRAINED JOINTS

- A. As specified in Pipe Specifications.

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°F.
 - 4. Joints: Flanged, Threaded, or Threaded with union As specified for pipe joints.
 - 5. Size: 1/4 in.–16 in.
 - 6. Maximum Offset: 1 in. 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°F.
 - 4. Joints: Flanged Threaded with union Soldered As specified for pipe joints.
 - 5. Size: 1/4 in.–4 in.
 - 6. Maximum Offset: 1 in. 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 Type – 3 in. and smaller:
1. 3 in. and smaller:
 - a. Pressure Rating: 125 psig WSP at 400°F.
 - b. Maximum Compression: 1 3/4 in.
 - c. Maximum Extension: 1/4 in.
 - d. Joint: Flanged or Welded as specified for pipe joints.
- D. External Ring-Controlled Stainless-Steel Bellows Type – 4 in. and larger:
1. Pressure Rating: 125 psig WSP at 400°F.
 2. Maximum Compression: 1 1/4 in.
 3. Maximum Extension: 3/8 in.
 4. Maximum Offset: 5/16 in.
 5. Joint: Flanged, grooved, or welded as specified for pipe joints.
 6. Accessories: Internal flow liner.
 7. Application: Steel piping 3 in. and larger.
- E. Single-Sphere Flexible Compensators:
1. Body: EPDM.
 2. Working Pressure:
 - a. 2 in.–12 in.: 150 psig.
 - b. 14 in.–36 in.: 110 psig
 3. Maximum Temperature: 250°F.
 4. Maximum Compression: 1 1/8 in. or greater.
 5. Maximum Elongation: 3/4 in. or greater.
 6. Maximum Offset: 3/4 in. or greater.
 7. Joint: Tapped steel flanges.
 8. Size: 2 in.–36 in.
 9. Accessories: Control rods.
 10. Application: Steel or Ductile Iron piping 2 in. and larger.
- F. Double-Sphere Flexible Compensators:
1. Body: EPDM.
 2. Working Pressure:
 - a. 2 in.–12 in.: 150 psig.
 - b. 14 in.–20 in.: 110 psig
 3. Maximum Temperature: 220°F
 4. Maximum Compression: 2 in. or greater
 5. Maximum Elongation: 1/4 in. or greater
 6. Maximum Offset: 3/4 in. 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 in. and larger

G. Two-Ply Bronze Bellows Type:

1. Description: Bronze with antitorque device, limit stops, and internal guides.
2. Pressure Rating: 125 psig WSP at 400°F
3. Maximum Compression: 1 3/4 in.
4. Maximum Extension: 1/4 in.
5. Application: Copper piping

H. Low-Pressure Compensators with Two-Ply Bronze Bellows:

1. Working Pressure: 80 psig
2. Maximum Temperature: 400°F
3. Maximum Compression: 1/2 in.
4. Maximum Extension: 5/32 in.
5. Joint: Soldered
6. Application: Copper or steel piping 2 in. and smaller

2.5 EXPANSION LOOPS

- A. Provide expansion loops as indicated on Drawings.

2.6 FLEXIBLE COUPLINGS

1. Manufacturers:
 - a. Fernco Shielded Couplings
 - b. Or approved equal
2. Description:
 - a. Comply with ASTM D5926
 - b. Maximum Temperature: 130°F
 - c. Material: Flexible PVC
 - d. Clamps: 316 Stainless Steel

2.7 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: Greater or equal to 12 in. diameter Steel, less than 12 in. diameter Ductile iron.
3. Followers: Greater or equal to 12 in. diameter Steel, less than 12 in. 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

2.8 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 in. & Larger)
 - b. Dresser Industries, Inc. – Style 128-W (2 in.–24 in.)
 - c. Romac – FC400 (12 in.–96 in.)
 - 2. Ductile Iron Pipe:
 - a. Smith-Blair – Series 912 (3 in.–12 in.)
 - b. Dresser Industries, Inc.; Style 128-W (3 in.–12 in.)
 - c. Romac – FCA501 (3 in.–16 in.)
 - 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.

2.9 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 in.–12 in.)
 - b. Romac – RFCA (3 in.–24 in.)
 - 2. Ductile Iron Pipe:
 - a. Smith-Blair – Model 911 (3 in.–48 in.)
 - b. Romac – RFCA (3 in.–24 in.)
- 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.

2.10 RESTRAINED DISMANTLING JOINTS

- A. Manufacturers and Products:
 - 1. Steel or Ductile Iron Pipe:
 - a. Smith-Blair – Series 975 (3 in. & Larger)
 - b. Dresser Industries, Inc. – Style 131 (2 in.–24 in.)
 - c. Romac – DJ400 (3 in.–72 in.)
- B. Pressure Rating:
 - 1. Capable of withstanding a maximum working pressure of 300 psi.

2.11 EQUIPMENT CONNECTION FITTINGS

- A. Manufacturers and Products:
 - 1. Steel or Ductile Iron Pipe:
 - a. Romac – ECF400 (3 in.–72 in.)
 - b. Ford Meter Box Company – FECF (3 in.–24 in.)

- B. Tie-Rods – 316 SST.
- C. Pressure Rating:
 - 1. Capable of withstanding a maximum working pressure of 275 psi.

2.12 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 in.–24 in.) or 366 (19.25 in.–43.15 in. O.D. range)
 - b. Dresser – Style 91 (2 in.–12 in.)
- B. Nylon-Coated Iron:
 - 1. Pressure Rating:
 - a. Capable of withstanding a maximum of 300 psi internal pressure without leakage or over stressing.
 - 2. Run Diameter:
 - a. 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 in.–14 in.) or 317 (1.25 in.–24 in.)

2.13 ANNULAR PRESSURE SEALS

- A. Provide annular isolation seals for pressure measurement where indicated on drawings or required by instrumentation specifications.
- B. Seals shall be full flange design with outside diameter matching the outside diameter of the mating flange. Seal to be retained between Class 150 pipe flanges, with flange bolts passing through sensor body and flanges.
- C. Seals shall be flow through design with flexible elastomer sensing ring around the full circumference.
- D. Seal Body:
 - 1. Carbon Steel. Provide 316 Stainless Steel if installed with stainless pipe material.
- E. Sensing Ring Material:
 - 1. Buna-N or EPDM, rated for process fluid temperature.
- F. Fill Fluid:
 - 1. Silicone oil.

- G. Manufacturers and Products:
 - 1. Ashcroft Series 81
 - 2. Winters D81
 - 3. Red Valve Series 40
 - 4. Onyx Valve PSR
- H. See Section 40 70 00 – Process and Analytical Instruments for pressure gauges, switches, and transmitters connected to pressure seals.

2.14 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 in. and Smaller: Screwed or solder-joint.
 - 2. 2 1/2 in. and Larger: Flanged, complete with bolt insulators, dielectric gasket, bolts, and nuts.
- C. Working Pressure Rating:
 - 1. 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

2.15 STRAINERS

- A. Strainers for Process Water Service, 4 in. 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 in. 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 in. and smaller. Class 150 ANSI flanged, 1 1/2 in. and larger.
 - 3. Screen: Heavy-gauge CPVC, 1/32 in. mesh, minimum 2 to 1 screen area to pipe size ratio.
 - 4. Manufacturers and Products:
 - a. Hayward Flow Control
 - b. Or Approved Equal.

2.16 SPRAY NOZZLES

- 1. Scum Spray Nozzle Type 1:
 - a. Spray Pattern: Even

- b. Spray Angle: 140° at 60 psi
 - c. Material: 316 stainless steel
 - d. Deflection Angle: 75 degrees
 - e. Capacity: 8 gpm at 40 psi
 - f. Size: 1/2 in. 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 preapproved 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° at 40 psi
 - c. Material: 316 stainless steel
 - d. Capacity: 3 gpm at 40 psi
 - e. Size: 1/4 in. 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 preapproved equal.
- 3. Scum Spray Nozzle Type 3:
 - a. Spray Pattern: Deflected flat spray pattern at low pressure
 - b. Spray Angle: 105° 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 in. 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 preapproved equal.

2.17 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

2.18 QUICK DISCONNECT CAM OPERATING COUPLINGS FOR CHEMICAL SERVICE

- A. Type:
 - 1. Twin cam arm actuated, male and female, locking, for chemical loading and transfer.
- B. Material:
 - 1. Glass-filled polypropylene and PVDF with Teflon gaskets and as recommended for the service by Manufacturer.
- C. End Connections:
 - 1. NPT threaded or flanged to match piping connections.
- D. Hose shanks for chemical installations.

- E. Plugs and Caps:
 - 1. Female dust cap for each male end, male dust plug for each female end.
- F. Pressure Rating:
 - 1. 125 psi, minimum at 70°F.
- G. Manufacturers:
 - 1. OPW – Kamlok (3/4 in.–4 in.)
 - 2. Ryan Herco – 1300 Series
 - 3. Goodall – Basic Eight

2.19 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 preapproved equal.

2.20 VENT CAPS

- A. Type:
 - 1. Mushroom-style vent cap.
- B. Material:
 - 1. Schedule 40 PVC housing and cap. Polypropylene screen.
- C. Screen Size:
 - 1. 17 by 17 mesh for sizes 2 in. and smaller. 10 by 10 mesh for sizes 3 in.–6 in.
- D. Open Area:
 - 1. Minimum 40%.
- E. End Connections:
 - 1. NPT treaded.
- F. Coatings:
 - 1. As specified in Section 09 90 00 – Painting and Protective Coatings.
- G. Manufacturer and Products:
 - 1. Gizmo (1/16 in.–8 in.)
 - 2. Or Approved Equal.

2.21 INSULATION

- A. As indicated on Drawings or pipe schedule.

2.22 FINISHES

- A. Prepare piping appurtenances for field finishes as specified in Section 09 90 00 – Painting and Protective Coating.

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 in. from pipe ends.
- E. Verify that pipe outside diameter conforms to sleeve manufacturer's requirements.

3.2 PREPARATION

- A. Cleaning:
 - 1. Thoroughly clean end connections before installation.
- B. Close pipe and equipment openings with caps or plugs during installation.
- C. Surface Preparation:
 - 1. Clean surfaces to remove foreign substances.

3.3 INSTALLATION

- A. According to ASME B31.3.
- B. Coating:
 - 1. Finish piping appurtenances as specified in Section 09 90 00 – Painting and Protective Coating.
- 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 in. clear on sides, with minimum 36 in. by 36 in. 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 in. 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 in. on both sides of building element.
 - c. Size sleeve, allowing minimum of 1 in. 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 in. on both sides of building element.
 - c. Size sleeve to allow minimum of 1 in. 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:

- 1. Install flexible couplings at connections to equipment and where specified in 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 specified in 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:

- 1. Provide vacuum breakers as specified in 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.

3.4 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:

1. Install within 18 in. or 1/2 pipe diameter, whichever is less, from the termination of any concrete backfill or concrete encasement.

C. Flexible Joints at Concrete Structures:

1. Install 18 in. 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 in. and smaller: Within 18 in. of the first joint.
 - b. Pipe Diameter Larger than 18 in.: Within one pipe diameter of the first joint.

3.5 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:
 - a. 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 nonmetallic pipe thoroughly prior to pouring collars.
 - d. Prevent concrete from entering pipe.
 - e. Extend collar a minimum of 12 in. on each side of joint with minimum thickness of 6 in. 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.

3.6 PIPING EXPANSION

A. Piping Installation:

1. 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 in. expansion per 100 LF 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 ft, from the end of the joint opposite the anchor.
 - a. Locate a similar guide approximately 30 diameters but not more than 10 ft 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 ft, and tack weld the protective saddles to the pipe.
- D. Anchors and Anchor Walls:
1. Install to withstand expansion thrust loads and to direct and control thermal expansion.

3.7 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:
1. Install in accordance with Manufacturer's written instructions.
 2. Before coupling, clean pipe holdback area of oil, scale, rust, and dirt.
 3. Remove pipe coating, if necessary, to present smooth surface.

3.8 FLEXIBLE PIPE CONNECTIONS TO EQUIPMENT

- A. Tie Bolts:
1. Tighten snug prior to applying any pressure to the system.

3.9 INSULATING FLANGES, COUPLINGS, AND UNIONS

- A. Applications:
1. Copper to ferrous metal piping connections.
 2. Cathodically protected piping penetration to buildings and watertight structures.
 3. Submerged to unsubmerged metallic piping connections.
 4. Where required for electrically insulated connection.
- B. Installation of Insulating Kits:
1. 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.

3.10 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.

3.11 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.

3.12 MISCELLANEOUS SPECIALTIES

- A. Install as specified in manufacturer's instructions.

3.13 FIELD QUALITY CONTROL

- A. After installation, inspect for proper supports and interferences.
- B. Repair damaged coatings with material equal to original coating.

3.14 CLEANING

- A. Keep equipment's interior clean as installation progresses.

END OF SECTION

SECTION 40 05 07 – HANGERS AND SUPPORTS FOR PROCESS PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section Includes:
 - 1. Pipe supports NOT explicitly detailed on Drawings or in Standard Details.
 - 2. Pipe saddles, guides, anchors, and associated attachments to supporting structures detailed on Drawings or in Standard Details.
 - 3. Layout of piping restraints and thermal expansion and contraction joints.
 - 4. The Work for Contractor to provide pipe support design by a pipe support design engineer.
- B. Related Section:
 - 1. Section 03 10 00 – Concrete Forming
 - 2. Section 03 20 00 – Concrete Reinforcing
 - 3. Section 03 30 00 – Cast-in-Place Concrete
 - 4. Section 05 50 00 - Metal Fabrications
 - 5. Section 09 90 00 – Painting and Protective Coatings
 - 6. Section 09 96 00 – High-Performance Coatings
 - 7. Section 40 05 51 – Common Requirements for Process Valves
 - 8. Section 40 23 39 – Process Piping – General
 - 9. Section 40 23 39.43 – Polyvinyl Chloride Pipe and Fittings Data Sheet

1.2 REFERENCES

- A. ASME (American Society of Mechanical Engineers):
 - 1. B31.1 – Power Piping
 - 2. B31.9 – Building Services Piping
- B. Manufacturers Standardization Society of the Valve and Fittings Industry:
 - 1. MSS SP-58 – Pipe Hangers and Supports – Materials, Design, Manufacturer, Selection, Application, and Installation.

1.3 PERFORMANCE REQUIREMENTS

- A. Delegated Design of Standalone Pipe Supports and Restraints Attached to Supporting Structures
 - 1. For attachments to supporting structures and standalone supports not explicitly detailed on Drawings or in Standard Details.
 - 2. Engage the services of an independent registered professional engineer licensed in the State of Work ordinarily engaged in the business of pipe support systems analysis and design, to analyze system piping and service conditions, identify pipe restraint types and locations, identify thermal expansion and contraction joint locations, and to develop a detailed support system design, specific to the piping material, pipe joints, valves, piping appurtenances, and supporting structural framing proposed for use on the Drawings.
 - 3. Design all supports to adequately secure the pipe against excessive dislocation due to thermal expansion and contraction, internal flow forces, and all probable external forces such as equipment, pipe, and personnel contact. Any additional aluminum members not already shown in the drawings and required to brace any piping from excessive dislocation shall be as specified in Section 05 50 00 – Metal Fabrications and shall be furnished and installed under this section.
 - 4. Design Criteria:

- a. Consider the content of the pipes in load calculations. All items shall be designed with strength and stiffness to support, restrain, and allow expansion of the respective pipes under the maximum combination of peak loading conditions to include pipe weight, liquid weight, liquid movement and pressure forces, internal air pressures, thermal expansion and contraction, vibrations, and all probable externally applied forces.
- b. Meet requirements of MSS SP 58, MSS SP 69, and MSS SP 89, as applicable.
- c. Horizontal and vertical net wind pressures shall be applied concurrently and in the direction producing the greatest load effect for each component being designed. Design using unfactored (1.0xWL) horizontal and vertical (downward or upward) net wind pressure shall be 65 psf uniformly applied to the vertically- and horizontally- projected areas of the pipe, respectively.
- d. Design unfactored (1.0xEL) horizontal and vertical seismic forces have been evaluated by the Engineer to not control the design of any delegated components, and need not be considered in the Delegated Design.
- e. Internal air pressure per Drawings.
- f. Thermal Change (Range):
 - 1) 120°F, ambient
 - 2) 180°F, material surfaces
- g. Deflection Limits:
 - 1) Fiber Reinforced Plastic (FRP): Coordinate with pipe manufacturer.
 - 2) All other pipe: Span/240
- h. Maximum Support Spacing:
 - 1) Fiber Reinforced Plastic (FRP): Shall not exceed the lesser of 10ft on-center, the maximum span determined by Delegated Design analysis, or the maximum set by pipe manufacturer.
 - 2) All other pipe: Shall not exceed the lesser of the maximum span determined by Delegated Design analysis or the maximum set by pipe manufacturer.
5. Coordinate support arrangements to eliminate interference with similar systems to be installed under Mechanical and Electrical, to maintain access for both personnel and for the removal of equipment, and to not interfere with existing equipment or structures.
6. Where supporting structures are indicated on Drawings to support piping, they shall be utilized for attachment of pipe unless determined to be unnecessary from analysis performed as part of the Delegated Design. Additional support may be required from the Delegated Design analysis and shall be the responsibility of the Contractor.
7. Saddles, guides, collars, and other fixtures interfacing with pipe shown on Drawings without explicit dimensions shall be analyzed and detailed as part of Delegated Design.
8. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components, if applicable.
9. Support pipe and appurtenances connected to equipment to prevent any strain being imposed on the equipment. Comply with manufacturer's requirements regarding piping loads being or not being transmitted to their equipment.
10. Contractor may propose minor adjustments to the piping arrangements in order to simplify the supports, or in order to resolve minor conflicts in the work. Such an adjustment might involve minor change to a pipe centerline elevation.
11. Standalone supports and restraints are shown only where specific types and locations are required; additional pipe supports may be required.
12. Design supports, hangers, anchors, and guides to prevent excessive heat from being transmitted to building structure, equipment, or piping appurtenances.
13. Point Loads:
 - a. Support plastic piping containing meters, valves, dampers, appurtenances, and other point loads on both sides.
 - b. Avoid point loads on plastic piping by providing extra wide pipe saddles.

1.4 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Product Data:
 - 1. Submit manufacturer's catalog data including load capacity for support hardware.
- C. Shop Drawings:
 - 1. Detailed structural drawings showing metal fabrications and connections to supporting structure. Indicate dimensions, sizes, material designations, and other details required for proper fabrication and installation.
 - 2. Layout of pipe support, guide, anchor, and expansion/ contraction joint locations.
 - 3. Shop Drawings shall be signed and sealed by a Professional engineer licensed in the project state responsible for the Delegated Design.
- D. Welder's Certificate:
 - 1. Submit welder's certification of compliance with ASME Section IX, verifying qualification within previous 12 months.
- E. Delegated Design Submittals:
 - 1. Design criteria for each above-ground piping system, including design loads complying with the Performance Requirements of this section, ANSI B31.3, and MSS SP-58.
 - 2. Summary of related components including joints, class, valves, appurtenances, etc.
 - 3. Verification that maximum stresses each pipe system does not exceed allowable capacities as established by pipe manufacturer and/or applicable material standards
 - 4. Resolved and resultant forces and moments at interface of each support/ restraint attachment to supporting structures.
 - 5. Verification that all aspects of the analysis and design comply with the provisions of ANSI B31.3, MSS SP 58, MSS SP 69, MSS SP 89, and the referenced standards, as applicable.
- F. Manufacturer's Instructions:
 - 1. Submit special procedures and assembly of components.
- G. Qualifications Statements:
 - 1. Submit qualifications for manufacturer, fabricator, installer, and licensed professional.
 - 2. Submit manufacturer's approval of installer.
- H. Maintenance Material Submittals:
 - 1. See Section 01 77 00 – Closeout Procedures for maintenance material requirements.
 - 2. Spare Parts:
 - a. Furnish one set of manufacturer's recommended spare parts.
 - 3. Tools:
 - a. Furnish special tools and other devices required for Owner to maintain the supplied products.

1.5 COORDINATION

- A. See Section 01 30 00 – Administrative Requirements for coordination requirements.
- B. Coordinate Work of this section with piping and equipment connections specified in other sections and in Drawings.
- C. Coordinate Work of this section with supporting metal framing as shown in Drawings and performed under Section 05 50 00 - Metal Fabrications.

1.6 QUALITY ASSURANCE

- A. Perform Work as specified in AWS D1.2 for welding and support attachments to supporting metal framing.
- B. Perform Work as specified in AWWA standards, State and Local building codes.

1.7 QUALIFICATIONS

- A. Manufacturer:
 - 1. Company specializing in manufacturing Products specified in this section with minimum three years of experience.
- B. Fabricator:
 - 1. Company specializing in fabricating products specified in this section with minimum three years of experience.
- C. Installer:
 - 1. Company specializing in performing Work of this section with minimum three years of documented experience and approved by manufacturer.
- D. Licensed Professional:
 - 1. Engineer responsible for the Delegated Design of Pipe Supports and Restraints shall have at least 5 years of experience in the analysis and design of similar systems, including the use of commercial and custom pipe supports and in the use of commercial pipe stress software programs. Engineer shall hold professional license in the project state.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. See Section 01 60 00 – Product Requirements for transporting, handling, storing, and protecting products.
- B. Inspection:
 - 1. Accept materials onsite in original factory packaging, labeled with manufacturer's identification.
- C. Protect products from weather and construction traffic, dirt, water, chemical, and damage by storing in original packaging.

1.9 AMBIENT CONDITIONS

- A. See Section 01 50 00 – Temporary Facilities and Controls for requirements on ambient condition control facilities for product storage and installation.

1.10 EXISTING CONDITIONS

- A. Field Measurements:
 - 1. Verify field measurements prior to fabrication. Indicate field measurements on Shop Drawings.

1.11 WARRANTY

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 GENERAL

- A. When pipe support products specified on Drawings or in Specifications are not available, fabricate pipe supports of correct material and to general configuration indicated.
- B. Materials:
1. Stainless Steel Plates and Shapes:
 - a. Type 316
 - b. Field welding is prohibited.
 2. Hot-Dip Galvanized Steel Plates, Shapes, and Fasteners:
 - a. Not permitted for Work.
 3. Aluminum Plates and Shapes:
 - a. Field welding is prohibited.
 - b. Where in contact with dissimilar metals and materials, protect per Section 05 50 00 - Metal Fabrications.
 4. Fasteners:
 - a. Type 316 stainless steel.
 - b. See Section 05 50 00 - Metal Fabrications.
 5. Cast-in-Place Concrete Anchors:
 - a. Permitted where indicated on Drawings only.
 - b. See Section 05 50 00 - Metal Fabrications.
 6. Post-Installed Concrete Anchors:
 - a. See Section 05 05 19 - Post-Installed Anchors
 7. Plastic, FRP, and other miscellaneous materials:
 - a. Use where specifically indicated on the Drawings.
 8. Fiberglass Resin:
 - a. Corrosion resistant premium grade vinylester.
 9. Injection Molded Components:
 - a. Polyurethane thermoplastics.
 10. Flame Spread of Fiberglass:
 - a. Vinylester Fiberglass (Series VF): Class 1, ASTM E84.
 - b. Polyurethane: V-O UL 94 V.
 11. Physical Properties of Fiberglass used for Pipe Support components, if applicable:

	Longitudinal	Transverse
Tensile Strength	37,500 psi	10,000 psi
Tensile Modules	3.0 x 10 ⁶ psi	1.0 x 10 ⁶ psi
Flexural Strength	37,500 psi	14,000 psi
Flexural Modules	2.0 x 10 ⁶ psi	1.0 x 10 ⁶ psi
Compressive Strength	37,500 psi	20,000 psi
Shear Strength	6,000 psi	5,500 psi
Izod Impact	30 ft-psi	5 ft-psi

12. Touch-Up Resin:
 - a. Manufacturers (Choose ONE):
 - 1) Krylon, 7006-Satin Polyurethane Clear Finish
 - 2) Or Approved Equal.

2.2 PREFABRICATED SUPPORT COMPONENTS

- A. Manufacturers:

1. Carpenter & Paterson, Inc.
2. Empire Industries, Inc.
3. Globe Pipe Hanger Products Incorporated
4. Haydon Corporation
5. Hilti, Inc.
6. PHD Manufacturing, Inc.
7. Anvil International
8. Substitutions: See Section 01 60 00 – Product Requirements.

B. Description:

1. Conform to MSS SP58.
2. Provide means of vertical adjustment after erection.
3. Vertical Support: Riser clamp.
4. Floor Supports: Stainless steel adjustable pipe saddle, lock nut, nipple, floor flange

C. Performance and Design Criteria:

1. Pipe Hangers:
 - a. Allow for expansion and contraction of piping while eliminating undue stress on piping appurtenances and equipment.
 - b. Provide linkage to permit lateral or axial movement where anticipated.
 - c. Where horizontal pipe movement is greater than 1/2 in., or where hanger rod deflection from the vertical is greater than 4° from cold to hot position of pipe, hanger rod and structural attachment shall be offset to maintain rod vertical in hot position.

2.3 STRUCTURAL ATTACHMENTS

A. Manufacturers:

1. ERICO International Corporation
2. Grinnell Mechanical Products
3. Unistrut; Part of Atkore International
4. Anvil International
5. Substitutions: See Section 01 60 00 – Product Requirements.

B. Mounting Brackets:

1. Stainless steel Type 316

C. Beam Clamps:

1. Manufacturers:
 - a. B-line, an Eaton Business
 - b. ERICO International Corporation
 - c. Grinnell Mechanical Products
 - d. Anvil International
 - e. Substitutions: Section 01 60 00 – Product Requirements.
2. Description:
 - a. Stainless Steel Type 316; MSS SP-58.
 - b. Clamp Size: Based on load to be supported and load configuration.
 - c. Anchoring: Locknuts and cup-point set screws
 - d. Reversible top or bottom flange

D. Riser Clamps:

1. Manufacturers:
 - a. B-line, an Eaton Business
 - b. ERICO International Corporation
 - c. Grinnell Mechanical Products

- d. Substitutions:
 - 1) See Section 01 60 00 – Product Requirements.
 - 2. Description:
 - a. Stainless Steel Type 316
 - b. Support of Copper Tubing: Provide copper-plated clamps.

- E. Offset Clamps:
 - 1. Manufacturers:
 - a. B-line, an Eaton Business
 - b. ERICO International Corporation
 - c. Grinnell Mechanical Products
 - d. Anvil International
 - e. Substitutions:
 - 1) See Section 01 60 00 – Product Requirements.
 - 2. Description: Double leg, two-piece

2.4 PIPE GUIDES

- A. General
 - 1. Galvanized steel components are not permitted.
 - 2. Metallic components supported by aluminum structure shall be isolated from direct contact with Mylar isolators or other protective system, as approved by the Engineer.
- B. Intermediate Guides:
 - 1. Pipes 6 in. and Smaller: Pipe clamp with oversize pipe sleeve
 - 2. Pipes 8 in. and Larger: U-bolts with double nuts
- C. Alignment Guides:
 - 1. Pipes 8 in. and Smaller: Spider type
 - 2. Pipes 10 in. and Larger: Roller type

2.5 NONMETALLIC PIPE SUPPORT SYSTEM

- A. Manufacturers:
 - 1. StrutTech
 - 2. Unistrut
- B. Supply all materials from one 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 in. steel and fiberglass channel framing systems.
- D. Channel Framing:
 - 1. All channel framing shall be supplied with integral notches 1 in. on center.
 - 2. Locate notches on interior flange to prevent slippage of pipe clamps and fittings after installation.
- E. Pipe Clamps:
 - 1. Adjustable Type:
 - a. Nonmetallic and nonconductive
 - 2. Fixed Type:
 - a. Pipe clamps for pipe less than 6 in. in diameter shall be nonmetallic and nonconductive.
 - b. Pipe clamps for pipe equal to and greater than 6 in. in diameter shall be fiberglass.

- F. Channel Fittings:
 - 1. Make fittings and post bases from glass-filled polyurethane or polyester.
- G. Fasteners:
 - 1. Make one type of fastener:
 - a. Glass-filled polyurethane
 - b. Vinylester fiberglass

PART 3 - EXECUTION

3.1 EXAMINATION

- A. See Section 01 60 00 – Product Requirements for installation examination requirements.
- B. Verify field dimensions as indicated on Drawings.

3.2 SUPPORT APPLICATIONS

- A. Supporting Structure Installation (Unless otherwise specified in Piping System Sections):
 - 1. Side-Beam or Channel Clamps (MSS Type 20):
 - a. For attaching to bottom flange of beams, channels, or angles.
 - 2. Center-Beam Clamps (MSS Type 21):
 - a. For attaching to center of bottom flange of beams.
 - 3. C-Clamps (MSS Type 23):
 - a. For structural shapes.
 - 4. Side-Beam Clamps (MSS Type 27):
 - a. For bottom of I-Beams.
 - 5. Steel-Beam Clamps with Eye Nuts (MSS Type 28):
 - a. For attaching to bottom of steel I-Beams for heavy loads.
 - 6. Linked-Steel Clamps with Eye Nuts (MSS Type 29):
 - a. For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 - 7. Malleable Beam Clamps with Extension Pieces (MSS Type 30):
 - a. For attaching to structural steel.
 - 8. Welded-Aluminum/ Stainless Steel Brackets:
 - a. For support of pipes from below
 - b. Use ONE for indicated loads:
 - 1) Light (MSS Type 31): 750 lbs.
 - 2) Medium (MSS Type 32): 1,500 lbs.
 - 3) Heavy (MSS Type 33): 3,000 lbs.
 - 9. Side-Beam Brackets (MSS Type 34):
 - a. For sides of aluminum.
 - 10. Plate Lugs (MSS Type 57):
 - a. For attaching to steel beams if flexibility at beam is required.
 - 11. Horizontal Travelers (MSS Type 58):
 - a. For supporting piping systems subject to linear horizontal movement where headroom is limited.
- B. Saddles and Shields Installation (Unless otherwise specified in Piping System Sections):
 - 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.
- C. Pipe Supports:

1. Install as specified in MSS SP 58.
2. Support horizontal piping as indicated on Drawings or as indicated on Shop Drawings.
3. Support riser piping independently of connected horizontal piping.
4. Provide copper-plated hangers and supports for copper piping.
5. Design supports for pipe movement without disengagement of supported pipe.
6. Support piping independently so that equipment is not stressed by piping weight or expansion in piping system.
7. Provide welded steel brackets where piping is to be run adjacent to building walls or columns.
8. Insulated Piping: Provide two bolted clamps designed to accommodate insulated piping.
9. Use offset clamps where pipes are indicated as offset from wall surfaces.

3.3 SUPPORT INSTALLATION

- A. Thermal Hanger Shield Installation:
 1. Install in shield for insulated piping.
- B. Fastener System Installation:
 1. Install fasteners according to Manufacturer's written instructions.
- C. Pipe Positioning System Installation:
 1. Install support devices to make rigid supply and waste piping connections to each plumbing fixture.
- D. Install supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- E. Equipment Support Installation:
 1. Fabricate from shop welded-stainless steel or aluminum shapes.
- F. Install 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.
- G. Install lateral bracing with pipe supports to prevent swaying.
- H. Load Distribution:
 1. Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- I. Pipe Slopes:
 1. 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.
- J. Insulated Piping Compliancy:
 1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature:
 - 1) Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature:
 - 1) 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:
 - 1) 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:
 - 1) 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. Minimum Shield Dimensions for Pipe:
 - a. NPS 1/4 to NPS 3 1/2: 12 in. long and 0.048 in. thick
 - b. NPS 4: 12 in. long and 0.06 in. thick
 - c. NPS 5 and NPS 6: 18 in. long and 0.06 in. thick
 - d. NPS 8 to NPS 14: 24 in. long and 0.075 in. thick
 - e. NPS 16 to NPS 24: 24 in. long and 0.105 in. thick
- 5. Pipes NPS 8 and Larger:
 - a. Include wood inserts.
- 6. Insert Material:
 - a. Length at least as long as protective shield.
- 7. Thermal Hanger Shields:
 - a. Install with insulation same thickness as piping insulation.

3.4 EQUIPMENT SUPPORTS

- A. Fabricate stainless-steel or aluminum stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting:
 - 1. 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 equipment supports.
- B. Fit exposed connections together to form hairline joints.
- C. Field Welding:
 - 1. Not permitted
- D. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.6 INSTALLATION

- A. General:
 - 1. Obtain permission from Engineer before using powder-actuated anchors.
 - 2. DO NOT drill or cut structural members.
 - 3. 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.
 - 4. Support piping connections to equipment by pipe support and NOT by the equipment.
 - 5. Support large or heavy valves, fittings, and appurtenances independently of connected piping.
 - 6. Support no pipe from the pipe above it.

7. Support pipe at changes in direction or in elevation, adjacent to flexible joints and couplings, and where shown.
8. DO NOT install pipe supports and hangers in equipment access areas or bridge crane runs.
9. Brace hanging pipes against horizontal movement by both longitudinal and lateral sway bracing.
10. Install lateral supports for seismic loads at all changes in direction.
11. Install pipe anchors where required to withstand expansion thrust loads and to direct and control thermal expansion.
12. Repair mounting surfaces to original condition after attachments are made.
13. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in Piping System Sections.
14. Comply with MFMA-102 for metal framing system selections and applications that are not specified in Piping System Sections.
15. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.
16. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

B. 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 Section 03 20 00 – Concrete Reinforcing for inserts carrying pipe 4 in. and larger.
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 recessed into and grouted flush with slab.

C. Insulation:

1. Provide clearance in hangers and from structure and other equipment for installation of insulation.
2. See Section 40 42 00 – Process Mechanical Insulation.

D. Equipment Bases and Supports:

1. Suspended Equipment:
 - a. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
 - b. Provide lateral bracing, to prevent swaying, for equipment supports.
2. Ground Mounted Equipment:
 - a. Provide housekeeping pads of concrete, minimum 6 in. thick and extending 6 in. beyond supported equipment and valves or as specified in Drawings. See Section 03 30 00 – Cast-in-Place Concrete.
 - b. Grouting: Place grout under supports for equipment and make smooth bearing surface.

END OF SECTION

SECTION 40 05 51 – COMMON REQUIREMENTS FOR PROCESS VALVES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Valves
 - 2. Valve actuators
- B. Related Section:
 - 1. Section 40 05 07 – Hangers and Supports for Process Piping
 - 2. Section 40 05 57 – Actuators for Process Valves and Gates
 - 3. Division 40 – Valve Specifications

1.2 REFERENCES

- A. AWWA (American Water Works Association):
 - 1. C541 – Hydraulic and Pneumatic Cylinder and Vane-Type Actuators for Valves and Slide Gates.
 - 2. C542 – Electric Motor Actuators for Valves and Slide Gates.
 - 3. C550 – Protective Interior Coatings for Valves and Hydrants.
- B. ASTM International:
 - 1. B62 – Standard Specification for Composition Bronze or Ounce Metal Castings.
 - 2. B584 – Standard Specification for Copper Alloy Sand Castings for General Applications.
- C. MSS (Manufacturers Standardization Society):
 - 1. SP-25 – Standard Marking System for Valves, Fittings, Flanges, and Unions.
- D. NEMA (National Electrical Manufacturers Association):
 - 1. 250 – Enclosures for Electrical Equipment (1,000 Volts Maximum)
- E. NFPA:
 - 1. 70 – National Electrical Code (NEC)
- F. NSF International:
 - 1. 61 – Drinking Water System Components – Health Effects
 - 2. 372 – Drinking Water System Components – Lead Content
- G. UL:
 - 1. Equipment Directory

1.3 SUBMITTALS

- A. See Section 01 33 00 – Submittal Procedures for general submittal requirements.
- B. Action Submittals:
 - 1. Product Data:
 - a. Submit manufacturer information for actuator with model number and size specified.
 - b. Submit valve cavitation limits.
 - 2. Shop Drawings:
 - a. Specify parts list, materials, sizes, position indicators, limit switches, actuator mounting, wiring diagrams, and control system schematics.

- C. Informational Submittals:
1. Valve-Labeling Schedule:
 - a. Specify valve locations and nametag text.
 2. Manufacturer's Certificate:
 - a. Certify that products meet or exceed specified requirements.
 3. Certification of Valves Larger Than 12 in.:
 - a. Furnish certified copies of hydrostatic factory tests, indicating compliance with applicable standards.
 4. Include separate Paragraphs for additional certifications.
 5. Include following Paragraph when Contractor is responsible for designing products or assemblies. List affected products when section specifies more than one product.
 6. Delegated Design Submittals:
 - a. Submit signed and sealed Shop Drawings with design calculations and assumptions for sizing of control valves.
 7. Manufacturer Instructions:
 - a. Submit installation instructions and special requirements.
 8. Source Quality-Control Submittals:
 - a. Indicate results of factory tests and inspections.
 9. Field Quality-Control Submittals:
 - a. Specify results of Contractor-furnished tests and inspections, including factory-applied coatings.
 10. Manufacturer Reports:
 - a. Certify that equipment has been installed according to manufacturer instructions.
 11. Qualifications Statement:
 - a. Submit qualifications for manufacturer and licensed professional.
 12. Closeout Submittals:
 - a. Project Record Documents:
 - 1) Record actual locations of valves and actuators.
 - b. See Section 01 77 00 – Closeout Procedures for additional requirements.

1.4 COORDINATION

- A. Coordinate Work of this section with piping, equipment, and appurtenances.

1.5 QUALITY ASSURANCE

- A. Maintain clearances as indicated on Drawings and Shop Drawings.
- B. Ensure that materials of construction of wetted parts are compatible with process liquid.
- C. Materials in Contact with Potable Water:
 1. Certified to NSF 61 and NSF 372.

1.6 QUALIFICATIONS

- A. Manufacturer:
 1. Company specializing in manufacturing products specified in this section with minimum three years of experience.
- B. Licensed Professional:
 1. Professional engineer experienced in design of specified Work and licensed in State of Work.

1.7 SOURCE QUALITY CONTROL

- A. Requirements for testing, inspection, and analysis as specified in Section 01 40 00 – Quality Requirements.
- B. Test and install valves as specified in AWWA valve standards.

1.8 EXISTING CONDITIONS

- A. Field Measurements:
 - 1. Verify field measurements prior to fabrication.
 - 2. Indicate field measurements on Shop Drawings.

1.9 WARRANTY

- A. Furnish manufacturer's warranty for valves and actuators as indicated in valve specification sections.
- B. See Section 01 78 36 – Warranties and Bonds for additional requirements.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Where a manufacturer's standard equipment name and/or model number is listed, the equipment system shall be provided and modified as required to conform to the performance, functions, features, and materials of construction as specified herein.
- B. Like items of equipment shall be the end products of one manufacturer to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer's services.
- C. Design Requirements:
 - 1. Valve class shall meet the requirements of the connecting line or as specified in the valve schedule or in Drawings.
 - 2. Bubble-tight at rated pressure, or any pressure lower than rated, applied from either side with the valve mounted in any orientation.
 - 3. Suitable for applications involving frequent throttling and applications requiring valve actuation after long periods of inactivity.

2.2 VALVES

- A. Description:
 - 1. Valves, operator, actuator, handwheel, chainwheel, extension stem, floor stand, worm and gear operator, operating nut, chain, wrench, and other accessories as required.
- B. Valve Ends:
 - 1. Compatible with adjacent piping system.
- C. Operation:
 - 1. Open by turning counterclockwise; close by turning clockwise.
 - 2. Cast directional arrow on valve or actuator with OPEN and CLOSE cast on valve in appropriate location.

- D. Valve Marking and Labeling:
 - 1. Marking: Comply with MSS SP-25.
 - 2. Provide buried valves with valve boxes, covers, and extensions.
- E. Valve Construction:
 - 1. Bodies: Rated for maximum temperature and pressure to which valve will be subjected as specified in valve Sections.
 - 2. Bonnets:
 - a. Clamped, screwed, or flanged to body and of same material and pressure rating as body.
 - b. Furnish glands, packing nuts, or yokes as specified in valve Sections.
 - 3. Stems and Stem Guides:
 - a. Materials and Seals: As specified in valve Sections.
 - b. If subject to dezincification, consider specifying bronze valve stems to conform to ASTM B62. Where dezincification is not a problem, bronze conforming to ASTM B584 may be considered.
 - c. Bronze Valve Stems: According to ASTM B62.
 - d. Space stem guides 10 ft o.c.
 - e. Submerged Stem Guides: Type 304 stainless steel.
 - 4. Nuts and Bolts: As specified in Section 05 50 00 – Metal Fabrications.

2.3 VALVE ACTUATORS

- A. As specified in Section 40 05 57 – Actuators for Process Valves and Gates.

2.4 FINISHES

- A. Valve Lining and Coating:
 - 1. Comply with AWWA C550.
- B. Exposed Valves:
 - 1. As specified in individual valve specifications. In the absence of specification, provide manufacturer's standard.
- C. Do not coat flange faces of valves unless otherwise specified.

2.5 SOURCE QUALITY CONTROL

- A. Section 01 60 00 – Product Requirements: Requirements for testing, inspection, and analysis.
- B. Testing:
 - 1. Test valves according to manufacturer's standard testing protocol, including hydrostatic, seal, and performance testing.
- C. Include one or both of following Paragraphs to require Owner's inspection or witnessing of test at factory.
- D. Owner Witnessing:
 - 1. Allow witnessing of factory inspections and test at manufacturer's test facility as requested by the Owner.
 - 2. Notify Owner at least sixty (60) days before inspections and tests are scheduled.

- E. 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.
 - 2. Specified shop tests are not required for Work performed by approved manufacturer.

PART 3 - EXECUTION

3.1 DELIVERY, STORAGE, AND HANDLING

- A. Section 01 60 00 – Product Requirements for transporting, handling, storing, and protecting products requirements.
- B. Inspection:
 - 1. Accept materials on Site in manufacturer's original packaging and inspect for damage.
- C. Store materials 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. Protect valve ends from entry of foreign materials by providing temporary covers and plugs.
 - 3. Provide additional protection according to manufacturer instructions.

3.2 EXAMINATION

- A. Verify that piping system is ready for valve installation.

3.3 INSTALLATION

- A. Install valves, actuators, extensions, valve boxes, and accessories according to manufacturer instructions.
- B. Firmly support valves to avoid undue stresses on piping.
- C. Coat studs, bolts, and nuts with anti-seizing lubricant.
- D. Clean field welds of slag and splatter to provide a smooth surface.
- E. Install valves with stems upright or horizontal, not inverted.
- F. Install brass male adapters on each side of valves in copper-piped system and solder adapters to pipe.
- G. Install 3/4 in. ball valves with cap for drains at main shutoff valves, low points of piping, bases of vertical risers, and equipment.
- H. Install valves with clearance for installation of insulation and to allow access.
- I. Provide access where valves and fittings are not accessible.
- J. Pipe Hangers and Supports:
 - 1. As specified in Section 40 05 07 – Hangers and Supports for Process Piping.

- K. Valve Applications:
 - 1. For connections at existing lines, tees, and connections to equipment less than 3 in., install ball valves for water service.
 - 2. For connections at new/existing lines containing solids (i.e., tees and connections to equipment less than 3 in.), install plug valves for wastewater service.

3.4 FIELD QUALITY CONTROL

- A. Section 01 60 00 – Product Requirements: Requirements for inspecting and testing.
- B. Valve Field Testing:
 - 1. Test for proper alignment.
 - 2. Field test equipment to demonstrate operation without undue noise, vibration, or overheating.
 - 3. Engineer will witness field testing.
 - 4. Valves may be either tested while testing pipelines, or as a separate step.
 - 5. 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 valves and applications.
 - 6. For multiturn valves, count, and record number of turns to open and close valve. Account for any discrepancies with Manufacturer's data.

3.5 MANUFACTURER'S SERVICES

- A. A Manufacturer's representative for each type of valve installed shall be present at the jobsite for the minimum person-days listed for the services herein under, travel time excluded:
 - 1. 1 person-days for installation assistance, inspection, and certification of the installation. Provide certificate.
 - 2. 1 person-days for functional and performance testing.
 - 3. 1 person-days for pre-startup classroom or job site training of Owner's personnel.
- B. Training of Owner's personnel shall be at such times and locations as requested by Owner.
- C. See Section 01 75 00 – Startup Testing and Training.

3.6 VALVE TYPE SCHEDULE

- A. The schedule lists valve identifiers and types that are referenced throughout the contract drawings and specifications. Not all valves listed are included on the project – refer to drawings and section schedules.

VALVE TYPE SCHEDULE		
Valve Type	Description	Section
V300	Metal Body Ball Valve, less than 6 in.	40 05 63 – Ball Valves
V302	Metal Body Ball Valve, 6 in. and Larger	40 05 63 – Ball Valves
V303	Instrumentation Ball Valves	40 05 63 – Ball Valves
V330	PVC/CPVC Ball Valves	40 05 63 – Ball Valves
V331	3-Way PVC Ball Valve	40 05 63 – Ball Valves

END OF SECTION

SECTION 40 05 57 – ACTUATORS FOR PROCESS VALVES AND GATES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Manual actuators
 - 2. Electric motor actuators
 - 3. Pneumatic rotary vane actuators
- B. Related Sections:
 - 1. Section 05 50 00 – Metal Fabrications
 - 2. Section 40 05 07 – Hangers and Supports for Process Piping
 - 3. Section 40 05 51 – Common Requirements for Process Valves
- C. Requirements:
 - 1. The Contractor shall coordinate between the valve actuator/control valve supplier and the control system supplier to provide a complete and fully operational system. It will be the valve/actuator supplier's responsibility to provide actuators that can send and accept the necessary signals from the control system. The valve/actuator supplier shall provide any limit switches, positioners, or other devices necessary to enable the status of the valves to be monitored and controlled by the control system.
 - 2. Valve and gate operators may be provided as part of a vendor equipment package. The Contractor shall be responsible for test, inspection, and assisting the equipment suppliers in startup services as required to place the operators into continuous, reliable operation.

1.2 REFERENCES

- A. ABMA (American Bearing Manufacturers Association):
 - 1. 9 – Load Ratings and Fatigue Life for Ball Bearings.
 - 2. 11 – Load Ratings and Fatigue Life for Roller Bearings.
- B. AWWA (American Water Works Association):
 - 1. C500 – Metal-Seated Gate Valves for Water Supply Service.
 - 2. C541 – Hydraulic and Pneumatic Cylinder and Vane-Type Actuators for Valves and Slide Gates.
 - 3. C542 – Electric Motor Actuators for Valves and Slide Gates.
- C. NFPA:
 - 1. 70 – National Electrical Code.
- D. NEMA (National Electrical Manufacturer's Association)

1.3 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Product Data:
 - 1. Submit manufacturer information for actuator with model number and size specified.

- C. Shop Drawings:
 - 1. Specify parts list, materials, sizes, position indicators, limit switches, control system, actuator mounting, wiring diagrams, control system schematics on assembly drawings.
 - 2. Submit actuator Shop Drawings with valve and gate submittal.
 - 3. Product data sheets for make and model.
 - 4. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
 - 5. Complete motor nameplate data.
 - 6. Open/close and throttle actuators sizing calculations including factor of safety used and final torques used for actuation selection.
 - 7. Operating torque calculations, including factor of safety used and final torques used for actuation selection, for each gate size, valve size and class.
 - 8. Maximum starting and normal operating torques for the operators supplied. Size operator for maximum starting torque.
 - 9. Refer to specific valve type for additional submittal requirements.
- D. Quality Control Submittals:
 - 1. Special shipping, storage and protection, and handling instructions.
 - 2. 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.
 - 3. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
- E. Manufacturer's Certificate:
 - 1. Certify that products meet or exceed specified requirements.
- F. Include separate Paragraphs for additional certifications.
- G. Manufacturer Instructions:
 - 1. Submit special procedures and placement requirements.
- H. Source Quality-Control Submittals:
 - 1. Specify results of factory tests and inspections.
- I. Field Quality-Control Submittals:
 - 1. Specify results of Contractor-furnished tests and inspections.
- J. Qualifications Statements:
 - 1. Submit qualifications for manufacturer and installer.
 - 2. Submit manufacturer's approval of installer.
- K. Closeout Submittals
 - 1. Project Record Documents:
 - a. Record actual locations and types of actuators.
 - 2. See Section 01 77 00 – Closeout Procedures for additional requirements.

1.4 COORDINATION

- A. Coordinate Work of this section with installation of valves and accessories.

1.5 QUALITY ASSURANCE

- A. Valve Actuators in NEC Class I, Group D, Division 1 or 2 Hazardous Locations:
 - 1. Provide actuators bearing agency approvals for installed hazardous location.

- B. Perform Work as specified in AWWA standards.
- C. Actuator/operator manufacturer shall coordinate with the valve/gate manufacturer and submit calculations showing the maximum and normal operating torques for the valves/gates and operators supplied.

1.6 QUALIFICATIONS

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

1.7 DELIVERY, STORAGE, AND HANDLING

- A. See Section 01 60 00 – Product Requirements for transporting, handling, storing, and protecting products.
- B. Inspection:
 - 1. Accept materials on Site in manufacturer's original packaging and inspect for damage.
- C. Supplier shall provide storage instructions to ensure that materials are stored as specified in manufacturer instructions.
- D. Protection:
 - 1. Supplier shall provide storage instructions for General Contractor.
 - 2. General Contractor's basic storage requirements include:
 - a. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
 - b. Furnish temporary end caps and closures on piping and fittings and maintain in place until installation.
 - c. Provide additional protection as specified in manufacturer instructions.

1.8 SOURCE QUALITY CONTROL

- A. See Section 01 60 00 – Product Requirements for testing, inspection, and analysis requirements.
- B. Provide shop inspection and testing of completed assemblies.

1.9 EXISTING CONDITIONS

- A. Field Measurements:
 - 1. Where required, Supplier shall verify field measurements prior to fabrication.
 - 2. Specify field measurements in Shop Drawings.

1.10 WARRANTY

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Furnish gear and power actuators with position indicators.

1. 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.
- B. Valve handles to take a padlock and wheels a chain and padlock.
- C. Worm Gear Operators:
 1. 1. Provide gearing on worm gear operators that is self-locking with gear ratio such that torque more than 160 ft-lbs. will not need to be applied to operate valve at most adverse conditions for which valve is designed.
- D. Traveling Nut Operators:
 1. Capable of requiring maximum 100 ft-lbs of torque when operating valve under most adverse condition; limit stops on input shaft of manual operators for fully open and closed positions; nonmoving vertical axis of operating nut when opening or closing valve.
- E. Open Direction Indicator:
 1. Cast arrow and legend indicating direction to rotate operator on handwheel, chain wheel rim, crank, or other prominent place.
- F. Operation:
 1. 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.
- G. Provisions for Alternate Operation:
 1. Where specified in the Drawings or elsewhere, position and equip crank or handwheel-operated geared valve operators or lifts for alternate operation with tripod mounted portable gate operators.
- H. Manual or Power Operator Size:
 1. 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.
- I. Wall Brackets or Haunches:
 1. As specified in Drawings.
- J. Stems:
 1. Stainless steel; sized to match output of operator; minimum gate or valve operating stem diameter; maximum 200 slenderness ratio.
- K. Stem Couplings:
 1. Stainless steel; internally threaded to match stem; lockable to stem by set screw.
- L. Stem Guides:
 1. Cast iron with silicon bronze bushing; maximum 200 slenderness ratio; capable of being mounted with a wall bracket; adjustable in two directions.
- M. Wall Brackets:
 1. Cast iron, capable of withstanding the output of the operator; adjustable in two directions.
- N. Stem Stuffing Boxes:
 1. Cast iron, with adjustable gland and packing.

- O. Fasteners and Anchor Bolts:
 - 1. 316 stainless steel.
- P. Geared Valve Operators:
 - 1. Provided with cut gears, either spur or worm; sized to operate valves at most adverse design condition; with maximum 40 lbs., pull at handwheel or chain wheel rim.
- Q. Geared Valve Traveling Nut Operators:
 - 1. Acceptable only where specified or as specified in Drawings.
- R. Accessory Equipment for Valves and Gates Requiring Remote Operators:
 - 1. Operating stems, stem couplings, stem guides, wall brackets, and stem stuffing boxes.

2.2 MANUAL ACTUATORS

- A. Exposed Actuators
 - 1. Valves Smaller than 6 in:
 - a. Infinite-position lever handle with memory stop.
 - 2. Valves 6 in and Larger:
 - a. Comply with AWWA C500-19.
 - 3. Drive Type:
 - a. Worm gear.
 - 4. Bearings:
 - a. Ball or roller type.
 - b. Bearing life is percent failure at rated hours; for example, L10 life at 50,000 hours means 10% of bearings may be expected to fail at 50,000 hours.
 - c. Minimum L10 Life: 100,000 hours.
 - 5. Gear-Assisted Manual Actuators:
 - a. Provide totally enclosed gears.
 - b. Maximum Operating Force: Not to exceed 40 lbs. under any operating condition, including initial breakaway, add gear reduction operator when force exceeds 40 pounds.
 - c. Bearings: Permanently lubricated bronze.
 - d. Packing: Accessible for adjustment without requiring removal of actuator from valve.
 - e. Gearing: Designed for 100% overload.
 - 6. Handwheel:
 - a. Manufacturers: One of the following, or preapproved equal:
 - 1) Rodney Hunt Company.
 - 2) Waterman Industries, Incorporated.
 - b. Minimum 24 in. diameter.
 - c. Galvanized and painted hand wheels
 - d. Mounting: Floor stand or bench stand. Unless otherwise specified in Drawings position operator 36 in. (nominal) above top of walkway surface.
 - e. Pull to Operate: Maximum 40 lbs. pull at most adverse design condition.
 - f. Stem Travel Limiting Device: Setscrew locked stop nuts above and below lift nut.
 - g. Grease Fittings: Suitable for lubrication of bearings.
 - 7. Hand-Cranked Geared Operators
 - a. Cranks on gear type operators for gates or pedestal mounted gearing.
 - b. Type: Single removable crank; fully enclosed.
 - c. Mounting: Floor and Bench Stand. Unless otherwise specified in Drawings, position the operator 36 in. (nominal) above the top of the walkway surface.
 - d. Operating Nut: When scheduled for portable operators.
 - e. Geared Lifts: Two-speed with minimum ratio of 4 to 1.
 - f. Teeth on Gears, Spur Pinions, Bevel Gears, and Bevel Pinions: Cut.
 - g. Lift Nuts: Cast manganese bronze.

- h. Exterior Surfaces on Cast Iron Lift Parts: Smooth.
- i. 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.
- j. Crank Rotation Indicator: Cast arrow with word OPEN in prominent, readily visible location indicating correct rotation of crank to open gate.
- k. Hand Cranks: 15 in. radius; requiring maximum 25 lbs., 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.
- l. 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.

B. Chain Actuators:

- 1. Description:
 - a. Chain actuators for shutoff valves mounted 6 ft, 9 in. and greater above operating floor level.
 - b. Chain guides and hot-dip galvanized operating chain extending to 5 1/2 ft above operating floor level.
 - c. Chain guides and chains shall be 316 stainless steel
- 2. Chain Wheels: Sprocket rim type.
- 3. Furnish chain storage if chains may interfere with pedestrian traffic.
- 4. Chain:
 - a. Galvanized or cadmium-plated.
- 5. Manufacturers and Products:
 - a. Clow Valve – F-5680
 - b. Walworth Co. – Figure 804
 - c. DeZURIK – G-Series

C. Buried Valves:

- 1. Comply with AWWA C500.
- 2. 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 in. square AWWA operating nut.
- 3. Buried service operators on valves larger than 2 1/2 in. shall have a 2 in. AWWA operating nut. Buried operators on valves 2 in. 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.
- 4. Design buried service operators for quarter-turn valves to withstand 450 ft-lbs. of input torque at the FULLY OPEN or FULLY CLOSED positions, grease packed and gasketed to withstand a submersion in water to 10 psi.
- 5. Buried valves shall have extension stems, bonnets, and valve boxes.
- 6. Floors:
 - a. Furnish extension stems to grade, and square nuts or floor stands with position indicators.
 - b. Cast-iron pipe extensions with valve boxes, covers, and operating keys.
 - c. Floor Boxes: Hot-dip galvanized cast iron or steel, with bronze cover.
 - d. Lid Inscription: Water.
- 7. Outdoors:
 - a. Material: Cast iron.
 - b. 12 in. Diameter Valves and Smaller: 2-piece, screw type.

- c. Valves Larger than 12 in. Diameter: 3-piece, screw type.
 - d. Lid Inscription: Water.
- D. Gate and Pedestal Mounted Valve Operators:
- a. Operator Size:
 - 1) Capable of supporting weight of suspended shafting unless carried by bottom thrust bearings; shaft guides with wall mounting brackets.
 - b. Stem Covers:
 - 1) Aluminum pipe; threaded cap on top; bolted aluminum flange on bottom; 1 in. by 12 in. slots cut at 18 in. 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.
 - c. Stem Cover Flanges, Pipes and Caps:
 - 1) Etched and anodized to produce chemical finishes as specified in AA C 22, medium matte finish, and AA A 41 clear anodic coating, or described in AA publication 45, after fabrication.
 - d. Gate Stem Covers:
 - 1) Concentric with stem
 - e. Headworks Slide Gate Operator Replacement:
 - 1) Replace manual Rotork actuator in kind
 - 2) Contractor to coordinate actuator replacement with existing Golden Harvest gate manufacturer

2.3 MOTORIZED ACTUATORS

- A. Motorized operators for gates and valves shall be the product of a single supplier for each type of gate or valve.
- B. Approved Manufacturers:
- 1. Auma
 - 2. Limitorque Company
 - 3. EIM Company
 - 4. Rotork
- C. Design:
- 1. Sized to move gates or valves from full open to closed position at minimum 12 IPM, plus or minus 10%, under maximum load.
 - 2. Actuator:
 - a. Provide with built-in device to allow motor to reach full speed before engaging valve or gate load; in manual operating mode when motor is not energized; in electrical operating mode when motor is energized.
 - b. Actuators shall be suitable for indoor and outdoor use, in an ambient temperature ranging from (-10)–160°F.
 - 3. Handwheels for Manual Operation:
 - a. Metallic with arrows to indicate “open” rotation; incapable of rotation during motor operation; unaffected by fused motor; maximum 80 lbs., pull on rim when rotating.
 - 4. Declutch Lever:
 - a. Padlockable, capable of mechanically disengaging motor and related gearing positively when motor is deenergized and freeing handwheel for manual operation.
 - 5. Position Indication:
 - a. Shall be accomplished by means of a digital display in full step at all times with valve or slide gate travel during either power or manual operation.
- D. Actuator Gearing:
- 1. Valve Actuator Gearing:

- a. Multiple reduction type with hardened alloy steel spur or helical gears and self-locking, alloy bronze worm gear set in drive train to maintain valve position.
 2. Gate Actuator Gearing:
 - a. Multiple reduction type with hardened alloy steel spur gear, bevel pinion and bevel gears; self-locking to maintain gate position.
 3. Power Gearing:
 - a. Hardened alloy steel; accurately cut to assure minimum backlash; antifriction bearing with caged balls or rollers throughout.
 4. Stem Nuts:
 - a. High tensile manganese bronze; accurately machined and mounted in heavy ball or roller bearings; minimum 2 1/4 times stem diameter for length of thread in lift nuts.
 5. Actuator Gear Housing:
 - a. Ductile iron.
 6. Lubrication:
 - a. Rotating power train components immersed in grease with provisions for inspection and relubrication without disassembly.
 - b. Lubricants:
 - 1) Suitable for ambient conditions of (-20)–150°F.
 - c. Provide seals on shafting.
- E. Motors:
1. Type: Specifically designed for valve actuator service with high starting torque, totally enclosed nonventilated construction.
 2. Motor Insulation: Minimum NEMA Class F, with a maximum continuous temperature rating of 311°F, rise plus ambient.
 3. Motor Windings: Epoxy treated.
 4. Thermal Protection: Provide winding thermal protection.
 5. Size: Sufficient to open and close valves at maximum stated torque.
 6. Voltage Tolerance: Capable of operating at within 10% of specified voltage.
 7. Motor Duty Ratings: 15-minute duty rating for open and close service; continuous duty rating for modulating service.
 8. Accessories: Internal thermal contacts, heaters in motor and switch compartment, and ground lug.
 9. Power Supply: As scheduled or as specified in Drawings.
 10. Enclosures for Motors, Switches, and Other Electrical Compartments:
 - a. Hazardous Locations: Where actuators are located within a hazardous location boundary, they shall bear agency approvals for the class, division, and group of the hazardous location defined in the contract documents.
 - b. Other Locations: Provide NEMA 4X enclosures.
- F. Controls:
1. Voltage Transformer: As required to step down power supply to control voltage.
 2. Control Station:
 - a. Integral with operator. Provide separate remote-mounted control enclosure if specified in Drawings.
 - 1) Where explosionproof construction is specified in Drawings, provide NEMA 7 enclosure.
 - 2) For other locations, provide NEMA 4X enclosure.
 - b. Provide integral LOCAL/OFF/REMOTE selector switch and OPEN/CLOSE/STOP pushbuttons.
 - 1) "LOCAL" position provides operation from push buttons.
 - 2) "REMOTE" position enables control from a remote source.
 - c. Provide OPEN/CLOSE/STOP indicating lights and 0 to 100 percent position indication.
 - d. Provide the following contacts for remote connection:

- 1) Switch in Remote Position
 - 2) Fully Closed
 - 3) Fully Open
 - 4) Fault
 3. Limit switches and associated gearing shall be integral with valve actuator.
 - a. Gearing: Intermittent type; bronze or stainless steel; grease lubricated; totally enclosed.
 - b. Contacts: Heavy duty and silver plated with wiping action.
 - c. Remote Indication Contacts: As specified in Drawings.
 - d. Switches: Adjustable; allowing for trip points from fully open to closed positions of valve travel; not subject to breakage or slippage due to overtravel; permits visible verification of switch position without disassembly.
 4. Torque Limit Switch:
 - a. Capable of interrupting control circuits in both opening and closing when valve torque overload occurs.
 - b. Silver plated contacts.
 - c. Graduated dials for both open and close directions of travel, each independently adjustable.
 - d. Positive means to limit adjustability to avoid exceeding actuator output torque capability with Belleville activating spring pack.
 - e. Permits visible verification of switch position without disassembly.
- G. Operation:
1. Open-Close Service:
 - a. Operators shall operate automatically by remote signal specified and as specified in Drawings.
 - b. When the selector switch is in the REMOTE position, the self-contained electromechanical reversing starter shall cause valve or gate to open or close on receiving a remote signal.
 - c. When the selector switch is in the ON position, the local control station will control the motorized operator.
 2. Modulating Service:
 - a. Actuator Controller:
 - 1) Microprocessor based and using proportional-integral derivative algorithm to calculate actuator response.
 - b. Controller shall compare 4 mA–20 mA direct-current analog command signal to analog feedback signal and move actuator accordingly.
 - c. A microprocessor-based controller shall control the integrally mounted solid state reversing starter.
 - d. Provide 4 mA–20 mA direct-current analog output signal for continuous remote monitoring of position.
 3. Controller System:
 - a. Rated for continuous duty.
- H. Valve Limit Switches:
1. Mechanical cam gear for remote operation, indication, and other control; compatible with associated operation and suitable for service intended; for valves specified in Drawings; with racks, gears, cam, linkage mountings, and accessories.
 2. Contact Ratings: 120 V alternating current, 20 amp at 75–100% power factor, and 24 V direct current, 5 amp minimum.
 3. Enclosures:
 - a. Watertight and oiltight for normal service.
 4. Valve box:
 - a. Large enough to contain and to allow easy adjustment of limit switch without switch's removal.

2.4 PNEUMATIC ROTARY VANE ACTUATORS

- A. Pneumatic operators for gates and valves shall be the product of a single supplier for each type of gate or valve.
- B. Approved Manufacturers:
 - 1. Kinetrol
 - 2. Rotork
- C. Description:
 - 1. Comply with AWWA C541.
- D. Materials of Construction
 - 1. Housing:
 - a. Zinc or aluminum alloy.
 - b. Corrosion resistant epoxy coating internal and external.
 - 2. Output Shaft: Stainless steel or ductile iron.
 - 3. Vane Seals: Wear resistant polyurethane or Buna-N.
- E. Actuator Position Control Capability:
 - 1. Open/Close Valves:
 - a. Actuators shall be solenoid valve operated. Coordinate operating voltage with control systems.
 - b. Provide speed control devices to allow independent adjustment of open and close cycling speed.
 - c. Provide manual override to hold valve in either the open or closed position.
 - d. Exhaust air mufflers shall be standard.
 - e. Provide SPDT position feedback limit switches for open and closed indication.
 - f. Provide visual indication of open and closed position.
 - 2. Modulating Valves:
 - a. Provide positioner designed to control the valve in any intermediate position from fully open to fully closed.
 - b. Positioners shall accept a 4 mA–20 mA control signal.
 - c. Provide 4 mA–20 mA position output signal.
 - d. Provide position feedback limit switches for fully open and closed indication.
 - 3. Mechanical Manual Override:
 - a. Actuators shall include a handwheel operated override mounted between the actuator and the valve.
 - b. Manual override shall be able to move and hold the valve in any position.
- F. Torque Capability
 - 1. The rated torque capability shall be sufficient to seat, unseat, and rigidly hold the valve disc it controls under the operating conditions specified.
 - 2. Torque safety factors shall conform to AWWA standards and in no case shall be less than 1.25 times the valve manufacturer torque requirements for open/close applications, and 1.5 times for modulating applications.
- G. Stop-Limiting Devices
 - 1. Actuators shall be equipped with adjustable mechanical stop devices to prevent overtravel of the valve disc.
- H. Pneumatic actuators shall have a working pressure of 150 psig with an overload pressure of 220 psig.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that field dimensions are as specified in Shop Drawings.

3.2 SHIPPING, STORAGE, HANDLING, AND PROTECTION

- A. As specified in Section 01 60 00 – Product Requirements.

3.3 INSTALLATION

- A. Complete equipment installation with controls, safety devices and auxiliary support systems necessary to start the equipment and verify that the equipment functions correctly under no load conditions. Turn rotating equipment by hand to check. Complete cleaning and testing of piping systems. Inspect and clean equipment, devices, piping, and structures of debris and foreign material.
- B. Securely mount actuators using brackets or hardware specifically designed for attachment to valves.
- C. Extend chain actuators to 5 1/2 ft above operating floor level.
- D. Install operators as specified in Manufacturer's instructions.
- E. Locate valve boxes where specified in Drawings.
- F. Remove temporary bracing supports and other construction debris that may damage equipment.
- G. Remove protective coatings and oils used for protection during shipment and installation.
- H. Flush, fill, and grease lubricated systems as specified in Manufacturer's instructions.
- I. Install temporary connections and devices required to fill, operate, checkout and drain the system. Provide temporary valves, gauges, piping, test equipment, and other materials and equipment necessary to conduct testing and startup.
- J. Check equipment for correct direction of rotation and freedom of moving parts.
- K. Align equipment to Manufacturer's tolerances. Adjust clearances and torques.
- L. Check installation prior to startup for conformance to Manufacturer's instructions.
- M. Adjust or modify equipment to ensure proper operation.
- N. For pneumatic actuators, furnish and install the required air tubing with fittings, connections, taps, pressure switches, electrical devices, wiring, and terminations necessary for a complete system. Each actuator shall have an isolation safety exhaust valve with locking handle provided at each branch airline to the actuator. Air tubing shall be furnished and installed from the compressor to the actuators. Slope air headers to low points and provide moisture traps with drip legs at the low points. Branch connections off main line shall be made off the top of the main line. Furnish taps, isolation valves, and pressure switches on the air piping as shown on the Plans. The contractor shall coordinate between the actuator supplier and the control system supplier to provide a complete and fully operational actuator system.

- O. Correct any deficiencies or problems noted in Manufacturer's representative's installation reports.

3.4 FIELD QUALITY CONTROL

- A. After installation, inspect for proper supports and interferences.
- B. Repair damaged coatings with material equal to original coating as specified in Section 09 96 00 – High Performance Coatings.
- C. Verify that structures, equipment, pipes, valves, fittings, and other appurtenances are compatible. Coordinate field devices, voltages, signal types, power needed, and programming with valve operator to provide proper functioning system.

3.5 MANUFACTURER'S REPRESENTATIVE

- A. The services of the manufacturer's technical representative shall be provided for pre-startup installation checks, startup assistance, training of Owner's personnel, troubleshooting, acceptance testing, and other services as required within these Contract Documents.
- B. Manufacturer's representative shall:
 - 1. Approve installation in writing to Engineer before operation.
 - 2. Verify conformance to all specified requirements.
 - 3. Fully instruct all designated personnel for the plant on proper care, maintenance, and operation of all equipment and appurtenances.
 - 4. Perform specified acceptance tests and operate system to verify satisfactory operation of all equipment in presence of Owner's personnel and Engineer.
 - 5. Check all equipment for excessive noise or vibration, proper alignment, general operation, etc.
 - 6. Operate the equipment through the design performance range consistent with available flows. Adjust, balance, and calibrate and verify that the equipment, safety devices, controls, and process system operate within the design conditions. Each safety device shall be tested for proper setting and signal. Response shall be checked for each equipment item and alarm. Simulation signals may be used to check equipment and alarm responses.
 - 7. Place each piece of equipment in the system in operation until the entire system is functioning. All components shall continue to operate without alarms or shutdowns, except as intended, for 8 consecutive hours to be considered started up.
 - 8. Submit certified written field reports as required by Section 01 33 00 – Submittal Procedures.
 - 9. Provide a certificate by the valve actuator supplier indicating proper installation and startup procedures have been followed. This certificate shall be required and included as part of the final operation and maintenance manuals to validate the specified 3-year warranty.
 - 10. Revisit job sites as often as necessary beyond minimum services specified to correct deficiencies to satisfaction of Engineer.

3.6 ACTUATOR MOUNTING

- A. Actuator Mounting Responsibility:
 - 1. Valves to be actuated shall be shipped to the manufacturer's approved Valve Automation Fabricator (see AWWA C504-94, Section 1.6, Assembly) for complete assembly, calibration, and testing to validate the warranty. A certification of the calibration, testing, and warranty shall be included in the final O&M manuals.

- B. Retrofit Actuators:
 - 1. Valves to be retrofit with new pneumatic actuators shall remain in place during retrofit process unless otherwise shown on the plans. Each size and model valve shall be field surveyed by the Valve Automation Fabricator. The survey by actuator representative shall include supervising the removal of the existing actuator if necessary in order to measure the top works of the valve. The actuator supplier shall supervise the mounting, installation, and testing of the new retrofit actuators.

3.7 ACCEPTANCE TEST

- A. Upon completion of the installation of each valve actuator, an acceptance test will be conducted to verify the satisfactory operation and performance of each actuator. Each valve shall be opened and closed using the plant control system as applicable (AUTO) and manually. The control valves shall also be tested under power loss to verify proper closure.
- B. The test shall be conducted in a manner approved by and in the presence of the Engineer. The equipment and piping will be completely checked for leakage, general operation, etc.
- C. Each valve actuator must perform in a manner acceptable to the Engineer before the Owner will make final acceptance.

END OF SECTION

SECTION 40 05 63 – BALL VALVES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section Includes:
 - 1. V300 – Metal Body Ball Valve, less than 6 in.
 - 2. V302 – Metal Body Ball Valve, 6 in. and Larger.
 - 3. V303 – Instrumentation Ball Valves.
 - 4. V330 – PVC/CPVC Ball Valves.
 - 5. V331 – 3-Way PVC Ball Valve.
- B. Related Sections:
 - 1. Section 40 05 51 – Common Requirements for Process Valves.
 - 2. Section 40 05 57 – Actuators for Process Valves and Gates.
 - 3. Section 40 23 39.1 – Process Piping Schedule.

1.2 REFERENCES

- A. AWWA (American Water Works Association):
 - 1. C507 – Ball Valves, 6 in.–60 in. (150 mm–1,500 mm).
- B. ASME International:
 - 1. B16.1 – Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
 - 2. B16.5 – Pipe Flanges and Flanged Fittings: NPS 1/2 – NPS 24 Metric/Inch Standard.
 - 3. B16.11 – Forged Fittings, Socket-Welding and Threaded.
 - 4. B16.42 – Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300.
 - 5. B1.20.1 – Pipe Threads, General Purpose, Inch.
- C. ASTM International:
 - 1. A48 – Standard Specification for Gray Iron Castings.
 - 2. D1784 – Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
 - 3. D3222 – Standard Specification for Unmodified Poly(Vinylidene Fluoride) (PVDF) Molding Extrusion and Coating Materials.
 - 4. D4101 – Standard Specification for Polypropylene Injection and Extrusion Materials.
- D. Manufacturers Standardization Society of the Valve and Fittings Industry:
 - 1. MSS SP-110 – Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.

1.3 SUBMITTALS

- A. See Section 01 33 00 – Submittal Procedures for general submittal requirements.
- B. Product Data:
 - 1. Submit manufacturer information for system materials and component equipment.
- C. Shop Drawings:
 - 1. Specify system materials and component equipment.
 - 2. Submit installation and anchoring requirements, fasteners, and other details.
 - 3. Specify valve identification number, location, service, type, size, design pressure, operator details, stem details, and loads.

- D. Manufacturer's Certificate:
 - 1. Certify that products meet or exceed specified requirements.
- E. Delegated Design Submittals:
 - 1. Submit signed and sealed Shop Drawings with design calculations and assumptions for seating and unseating pressure.
- F. Manufacturer Instructions:
 - 1. Submit detailed instructions on installation requirements, including storage and handling procedures.
- G. Source Quality-Control Submittals:
 - 1. Specify results of factory tests and inspections.
- H. Field Quality-Control Submittals:
 - 1. Specify results of Contractor-furnished tests and inspections.
- I. Manufacturer Reports:
 - 1. Certify that equipment has been installed as specified in manufacturer instructions.
 - 2. Specify activities on Site, adverse findings, and recommendations.
- J. Closeout Submittals:
 - 1. See Section 01 77 00 – Closeout Procedures.
 - 2. Project Record Documents:
 - a. Record actual locations of installed valve and components.

1.4 QUALITY ASSURANCE

- A. Materials in Contact with Potable Water:
 - 1. Certified to NSF Standard 61 and NSF Standard 372.

1.5 QUALIFICATIONS

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

1.6 SOURCE QUALITY CONTROL

- A. See Section 01 40 00 – Quality Requirements for testing, inspection, and analysis requirements.
- B. Test and install butterfly valves as specified in AWWA C507.

1.7 WARRANTY

- A. Furnish minimum three-year manufacturer's warranty for valves.
- B. See Section 01 78 36 – Warranties and Bonds for additional requirements.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Where a manufacturer's standard equipment name and/or model number is listed, the equipment system shall be provided and modified as specified in the performance, functions, features, and materials of construction.
- B. Like items of equipment provided in this section shall be the end products of one manufacturer to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer's services.
- C. Design Requirements:
 - 1. Valve class shall meet the connecting line requirements or be as specified in the valve schedule or in Drawings.
 - 2. Bubble-tight at rated pressure, or any pressure lower than rated, applied from either side with the valve mounted in any orientation.
 - 3. Suitable for applications involving frequent throttling and applications requiring valve actuation after long periods of inactivity.
- D. Operator:
 - 1. As specified in valve schedules and Section 40 05 57 – Actuators for Process Valves and Gates.

2.2 TYPE V300: METAL BODY BALL VALVE, LESS THAN 6 IN.

- A. Manufacturers:
 - 1. NIBCO:
 - a. T-585-S6-R-66-LL (available in 1/4 in.–2 in.) for threaded connections.
 - b. F-515-S6-F-66-FS (available in 1/2 in.–12 in.) for flanged connections.
 - 2. Apollo – 76 Series.
 - 3. Milwaukee Valve – F20 Series (available in 1 in.–12 in.) for flanged connections.
- B. Typical Service:
 - 1. Water
 - 2. Drain
 - 3. Sample locations
 - 4. Compressed Air
 - 5. RO Sample Panel
- C. General:
 - 1. See MSS SP 110 (threaded or socket-welded valves)
 - 2. Type: Nonlubricated and capable of sealing in either flow direction.
 - 3. Minimum Working Pressure: As specified in Section 40 23 39.1 – Process Piping Schedule.
 - 4. Maximum Process Fluid Temperature: As specified in Section 40 23 39.1 – Process Piping Schedule.
 - 5. Port: Full.
 - 6. End Connections:
 - a. Threaded or socket weld for 2 in. and smaller.
 - b. Class 150 flanged for sizes 3 in. and larger. Flanges shall be as specified ANSI/ASME B16.1 standards.
- D. Operation:

1. Operator: Hand lever unless specified otherwise in valve schedule or Section 40 05 57 – Actuators for Process Valves and Gates.

E. Materials:

1. Body:
 - a. Type: Two piece.
 - b. Materials:
 - 1) All 316 Stainless steel compatible with service designated.
 - 2) Ball: Type 316 Stainless steel.
2. Seats: PTFE.
3. Stem: 316 Stainless steel.
4. Stem Seals: PTFE or Viton
5. Bearings: Self-lubricated, corrosion resistant material that will not contaminate potable water.

F. Finishes:

1. Finish coat: Match adjoining pipe

2.3 TYPE V302: METAL BODY BALL VALVE, 6 IN. AND LARGER

A. Manufacturers and Products:

1. Henry Pratt - AWWA Rubber Seated Ball Valve (available in 4 in.–60 in.)
2. Val-Matic - Ener-G (available in 4 in.–60 in.)
3. McCANNA/MARPAC

B. General:

1. Type: Nonlubricated and capable of sealing in either flow direction.
2. Minimum Working Pressure: As specified in Section 40 23 39.1 – Process Piping Schedule.
3. See AWWA C507.
4. Stem packing: Manually adjustable while valve is under pressure.
 - a. End Connections:
 - 1) Flanged ends.
 - 2) Flanges shall be as specified ANSI/ASME B16.1 standards.

C. Operation:

1. Manually operated ball valves shall have self-locking worm gear type actuator with position indicator. Gearing shall be permanently lubricated. Provide adjustable screws to stop travel at both Open and Closed positions.
2. Operator: Hand lever unless specified otherwise in valve schedule or Section 40 05 57 – Actuators for Process Valves and Gates.

D. Materials:

1. Body: ASTM A48 cast iron and integrally cast bronze bushed trunnions.
2. Ball: 316 Stainless steel.
3. Seats: TFE
4. Stem Seals: TFE or Viton.

E. Finishes:

1. Finish coat: Match adjoining pipe.

2.4 TYPE V303: INSTRUMENTATION BALL VALVES

A. Manufacturers and Products:

1. Swagelok – 40G Series (available in 1/8 in.–3/4 in.)

2. Parker – B Series (available in 1/16 in.–1/2 in.)

B. General:

1. Stainless steel body ball valve, nylon handle.

2.5 TYPE V330: PVC/CPVC BALL VALVES

A. Manufacturers:

1. Georg Fischer – 546 Pro (available in 3/8 in.–4 in.)
2. Asahi/America, Inc.
3. NIBCO/Chemtrol –
 - a. PVC – U-45TB-V (available in 1/2 in.–2 in.)
or
S-45TB-V (available in 3 in.–6 in.)
 - b. CPVC – U-51TB-V (available in 1/2 in.–2 in.)
or
S-51TB-V (available in 3 in.–6 in.)
4. Hayward Flow Control – TBH Series True Union (available in 1/4 in.–6 in.)
5. Spears – True Union 2000 (available in 1/2 in.–8 in.)

B. Typical Service:

1. Water
2. Chemicals
3. Drain
4. Sample locations

C. General:

1. Type: Nonlubricated and capable of sealing in either flow direction.
2. Working Pressure:
 - a. 1/2 in.–2 in.–250 psi.
 - b. 2 1/2 in.–6 in.–150 psi.
3. Maximum Process Fluid Temperature: As specified in Section 40 23 39.1 – Process Piping Schedule.
4. Ports: Full size.
5. All ball valves on sodium hypochlorite lines and/or chlorine dioxide lines shall be venting type valves.
6. End Connections:
 - a. True Union:
 - 1) Solvent or heat welded to piping.
 - 2) Defer to manufacturer's recommendation for installation.

D. Operation:

1. Operator: Hand lever unless specified otherwise in valve schedule or in Section 40 05 57 – Actuators for Process Valves and Gates.

E. Materials:

1. Body and Ball:
 - a. PVC, ASTM D1784 when adjoining to PVC pipe.
 - b. CPVC, ASTM D1784 when adjoining to CPVC pipe.
2. Seats: PTFE.
3. O-rings: Viton (FKM)

2.6 TYPE V331: 3-WAY PVC/CPVC BALL VALVES

- A. Manufacturers:
 - 1. Georg Fischer – 543 Pro (available in 3/8 in.–2 in.)
 - 2. Asahi/America, Inc.
 - 3. NIBCO/Chemtrol –
 - a. S45M3-V for PVC (available in 1/2 in.–2 in.)
 - b. S51M3-V for CPVC (available in 1/2 in.–2 in.)
 - 4. Hayward Flow Control – TW Series True Union (available in 1/2 in.–2 in.)
 - 5. Spears – True Union 2000 (available in 1/2 in.–4 in.)
- B. Typical Service:
 - 1. Water
 - 2. RO Permeate Probing Connections
 - 3. Chemicals
- C. General:
 - 1. Type: Nonlubricated and capable of sealing in either flow direction.
 - 2. Working Pressure:
 - a. 1/2 in.–2 in.–150 psi.
 - b. 2 1/2 in.–4 in.–235 psi.
 - 3. Maximum Process Fluid Temperature: As specified in Section 40 23 39.1 – Process Piping Schedule.
 - 4. Ports: Full size.
 - 5. End Connections:
 - a. True union: solvent or heat welded to piping.
- D. Operation:
 - 1. Operator: Hand lever unless specified otherwise in valve schedule or Section 40 05 57 – Actuators for Process Valves and Gates.
- E. Materials:
 - 1. Body and Ball:
 - a. PVC, ASTM D1784 when adjoining to PVC pipe.
 - b. CPVC, ASTM D1784 when adjoining to CPVC pipe.
 - 2. Seats: PTFE.
 - 3. O-rings: Viton (FKM)

PART 3 - EXECUTION

3.1 DELIVERY, STORAGE, AND HANDLING

- A. Section 01 60 00 – Product Requirements for transporting, handling, storing, and protecting products requirements.
- B. Inspection:
 - 1. Accept materials on Site in manufacturer's original packaging and inspect for damage.
- C. Store materials as specified in manufacturer instructions.
- D. Protection:
 - 1. Protect materials from moisture and dust by storing them in clean, dry location remote from construction operations areas.
 - 2. Provide additional protection as specified in manufacturer instructions.

3.2 INSTALLATION

- A. Install valves as specified in AWWA C507.

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. Count and record number of turns to open and close valve, account for any discrepancies with Manufacturer's data.

3.4 MANUFACTURER'S SERVICES

- A. A Manufacturer's representative for the equipment specified in this section shall be present at the jobsite for the minimum person-days listed for the services below, travel time excluded:
 - 1. 1 person-day for installation assistance, inspection, and certification of the installation. Provide certificate.
 - 2. 1/2 person-day for functional and performance 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 times and locations specified by Owner.
- C. See Section 01 75 00 – Startup Testing and Training.

3.5 MANUFACTURER'S CERTIFICATE(S)

- A. Provide as specified in Section 01 75 00 – Startup Testing and Training.

END OF SECTION

SECTION 40 23 39 – PROCESS PIPING – GENERAL

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Basic Process Piping Materials, Methods, and Appurtenances.
- B. Related Sections:
 - 1. Section 03 30 00 – Cast-In-Place Concrete
 - 2. Section 09 96 00 – High-Performance Coatings
 - 3. Section 22 05 53 – Mechanical Identification
 - 4. Section 31 23 23.16 – Trench Backfill
 - 5. Section 33 13 00 – Disinfection of Water Systems
 - 6. Section 40 05 00 – Piping Systems Testing
 - 7. Section 40 05 06 – Process Piping Specialties
 - 8. Section 40 41 13 – Heat Tracing
 - 9. Section 40 42 00 – Process Mechanical Insulation

1.2 REFERENCES

- A. AASHTO (American Association of State Highway and Transportation Officials):
 - 1. Standard Specifications for Highway Bridges.
- B. ANSI (American National Standards Institute):
 - 1. A21.52 – Ductile Iron Pipe, Centrifugally Cast, for Gas
 - 2. B1.20.1 – Pipe Threads, General Purpose (Inch)
 - 3. B16.1 – Cast Iron Pipe Flanges and Flanged Fittings
 - 4. B16.3 – Malleable Iron Threaded Fittings
 - 5. B16.5 – Pipe Flanges and Flanged Fittings
 - 6. B16.9 – Factory-Made Wrought Steel Butt welding Fittings
 - 7. B16.11 – Forged Fittings, Socket-Welding and Threaded
 - 8. B16.15 – Cast Bronze Threaded Fittings, Classes 125 and 250
 - 9. B16.21 – Nonmetallic Flat Gaskets for Pipe Flanges
 - 10. B16.22 – Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
 - 11. B16.24 – Cast Copper Alloy Pipe Flanges and Flanged Fittings Class 150, 300, 400, 600, 900, 1500, and 2500
 - 12. B16.25 – Butt Welding Ends
 - 13. B16.42 – Ductile Iron Pipe Flanges and Flanged Fittings, Classes 150 and 300
- C. API (American Petroleum Institute):
 - 1. 5L – Specification for Line Pipe
- D. ASME (American Society of Mechanical Engineers):
 - 1. Boiler and Pressure Vessel Code, Section VITI, Division 1, Pressure Vessels.
 - 2. Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications.
 - 3. B31.1 – Power Piping
 - 4. B31.3 – Process Piping
 - 5. B31.9, –Building Services Piping
 - 6. B36.10M – Welded and Seamless Wrought Steel Pipe
- E. ASNT (American Society for Nondestructive Testing):
 - 1. SNT-TC-1A – Recommended Practice for Nondestructive Testing Personnel Qualifications.

- F. ASTM (American Society for Testing and Materials):
1. A47 – Standard Specification for Ferritic Malleable Iron Castings.
 2. A53 Rev A – Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 3. A105 – Standard Specification for Carbon Steel Forgings for Piping Applications
 4. A106 – Standard Specification for Seamless Carbon Steel Pipe for High Temperature Service.
 5. A126 – Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
 6. A135 – Standard Specification for Electric-Resistance-Welded Steel Pipe.
 7. A139 Rev A – Standard Specification for Electric-Fusion (Arc)-Welded Steel Pipe (NPS 4 and over).
 8. A153 – Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 9. A181 Rev A – Standard Specification for Carbon Steel Forgings, for General-Purpose Piping.
 10. A182 Rev C – Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
 11. A183 – Standard Specification for Carbon Steel Track Bolts and Nuts.
 12. A193 Rev A – Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.
 13. A194 – Standard Specification for Carbon Steel, Stainless Steel, and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or both.
 14. A197 – Standard Specification for Cupola Malleable Iron.
 15. A216 – Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service.
 16. A234 – Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Services.
 17. A240 – Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
 18. A276 – Standard Specification for Stainless Steel Bars and Shapes.
 19. A283 Rev A – Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
 20. A285 – Standard Specification for Pressure Vessel Plates, Carbon Steel, Low and Intermediate Tensile Strength.
 21. A307 – Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 psi Tensile Strength.
 22. A312 – Standard Specification for Seamless and Welded Austenitic Stainless-Steel Pipes.
 23. A320 – Standard Specification for Alloy Steel and Stainless-Steel Bolting Materials for Low-Temperature Service.
 24. A395 – Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
 25. A403 Rev A – Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.
 26. A409 – Standard Specification for Welded Large Diameter Austenitic Steel Pipe for Corrosive or High-Temperature Service.
 27. A536 – Standard Specification for Ductile Iron Castings.
 28. A563 – Standard Specification for Carbon and Alloy Steel Nuts.
 29. A587 – Standard Specification for Electric-Resistance-Welded Low-Carbon Steel Pipe for the Chemical Industry.
 30. A774 – Standard Specification for As-Welded Wrought Austenitic Stainless-Steel Fittings for General Corrosive Service at Low and Moderate Temperatures.
 31. A778 Rev A – Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.
 32. B32 – Standard Specification for Solder Metal.
 33. B43 – Standard Specification for Seamless Red Brass Pipe, Standard Sizes.

34. B61 – Standard Specification for Steam or Valve Bronzed Casting.
35. B62 – Standard Specification for Composition Bronzed or Ounce Metal Castings.
36. B75 – Standard Specification for Seamless Copper Tube.
37. B88 Rev A – Standard Specification for Seamless Copper Water Tube.
38. B98 – Standard Specification for Copper-Silicone Alloy Rod, Bar, and Shapes.
39. C582 – Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion Resistant Equipment.
40. D412 – Standard Testing Method for Vulcanized Rubber and Thermoplastic Elastomers-Tension.
41. D413 – Standard Testing Methods for Rubber Property-Adhesion to Flexible Substrate.
42. D1248 – Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.
43. D1784 – Standard Classification System and Basics for Specifications for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
44. D1785 – Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
45. D2000 – Standard Classification System for Rubber Products in Automotive Applications.
46. D2310 – Standard Classification for Machine-Made “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
47. D2464 – Standard Specification for Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
48. D2466 – Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
49. D2467 – Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
50. D2564 – Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.
51. D2665 – Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe for Drain, Waste, and Vent Pipe and Fittings, Schedule 40.
52. D2996 – Standard Specification for Filament-Wound “Fiberglass” (Glass-Fiber-Reinforced Thermosetting Resin) Pipe.
53. D3222 Rev A – Standard Specification for Unmodified Poly (Vinylidene Fluoride) (PVDF) Molding Extrusion and Coating Materials.
54. D3350 – Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
55. D4101 Rev B – Standard Specification for Propylene Plastic Injection and Extrusion Materials.
56. F437 – Standard Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
57. F439 Rev A – Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
58. F441 – Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
59. F491 Rev A – Standard Specification for Poly (Vinylidene Fluoride) (PVDF) Plastic-Lined Ferrous Metal Pipes, and Fittings.
60. F493 Rev A – Standard Specification for Solvent Cements for Chlorinated Poly Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
61. F714 – Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) based on outside diameter.

G. AWS (American Welding Society):

1. A5.8 – Specification for Filler Metals for Brazing and Braze Welding.
2. QC 1 – Specification for AWS Certification of Welding Inspectors.

H. AWWA (American Water Works Association):

1. C104/A21.4 – Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.

2. C110/A21.10 – Ductile-Iron and Gray-Iron Fittings, 3 in. – 48 in. for Water and Other Liquids.
3. C111/A21.11 – Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
4. C115/A21.15 – Flanged Ductile-Iron Pipe with Threaded Flanges.
5. C151/A21.51 – Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids.
6. C153/A21.53 – Ductile-Iron Compact Fittings 3 in. – 16 in, for Water and Other Liquids.
7. C200 – Steel Water Pipe – 6 in. and Larger.
8. C205 – Cement-Mortar Protective Lining and Coating for Steel Water Pipe – 4 in. and Larger-Shop Applied.
9. C207 – Steel Pipe Flanges for Water Works Service, Sizes 4 in. – 144 in.
10. C208 – Dimensions for Fabricated Steel Water Pipe Fittings.
11. C213 – Fusion Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
12. C606 – Grooved and Shouldered Type Joints.
13. M11 – Steel Pipe – A Guide for Design and Installation.

- I. MSS (Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.):
 1. SP 43 – Wrought Stainless Steel Butt-Welding Fittings Including Reference to Other Corrosion Resistant Materials.
- J. NFPA (National Fire Protection Association):
 1. 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 ft above top of liquid surface
 - f. Top of tank wall or under tank cover

1.4 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. 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.
- C. Quality Control Submittals:
 1. Manufacturer's Certification of Compliance.

2. Qualifications:
 - a. Weld Inspection and Testing Agency: Certification and qualifications.
 - b. Welding Inspector:
 - 1) 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:
 - a. Records as specified in 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 fitting.
 - b. Factory applied resins and coatings
6. Certified weld inspection and test reports
7. Test logs

1.5 QUALITY ASSURANCE

- A. Materials in Contact with Potable Water:
 1. Certified to NSF 61 and NSF 372.
- B. Weld Inspection and Testing Laboratory Qualifications:
 1. Retain approved independent testing laboratory that will provide the services of an AWS certified welding inspector qualified as specified in 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 as specified in specified standards and requirements.
 - b. Duties include, but are not limited to:
 - 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
- C. 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 as specified in 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.

- D. Certifications:
 - 1. Coal-Tar Epoxy Applicator:
 - a. 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:
 - a. Certified as specified in current American Society for Nondestructive Testing (4153 Arlingate Plaza, Columbus, OH 43228) recommended practice SNT-TC-1A, NDT Level II.
- E. Quality Control Submittals:
 - 1. Manufacturer's Certification of Compliance.
 - 2. Laboratory Testing Equipment:
 - a. Certified calibrations, Manufacturer's product data, and test procedures.
 - 3. Certified welding inspection and test results.
 - 4. Qualifications:
 - a. Weld Inspection and Testing Agency:
 - 1) Certification and qualifications.
 - b. Welding Inspector:
 - 1) 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:
 - a. Records as specified in 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. As specified in Section 01 60 00 – Product Requirements.
- B. Flanges:
 - 1. Securely attach metal, hardboard, or wood protectors over entire gasket surface.
- C. Threaded or Socket Welding Ends:
 - 1. Fit with metal, wood, or plastic plugs or caps.
- D. Linings and Coatings:
 - 1. Prevent excessive drying.
- E. Cold Weather Storage:
 - 1. Locate products to prevent coating from freezing to ground.
- F. Handling:
 - 1. Use heavy canvas or nylon slings to lift pipe and fittings.

1.7 WARRANTIES

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 PIPING

- A. As specified on Piping Data Sheet(s) and 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 836.10M.
 - 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:
 - 1. NPT taper pipe threads as specified in ANSI B 1.20. 1.
- D. Thrust Tie-Rod Assemblies:
 - 1. 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:
 - a. EBAA Iron Inc. – Megalug (3 in.– 54 in.)
- F. Flexible Mechanical Compression Joint Coupling:
 - 1. Stainless steel, ASTM A276, Type 305 bands.
 - 2. Manufacturers:
 - a. Pipeline Products Corp.
 - b. Fernco Joint Sealer Co.
- G. Mechanical connections of the high-density polyethylene pipe to auxiliary equipment (valves, pumps, tanks, and other piping systems) shall be through flanged connections consisting of:
 - 1. A polyethylene stub end thermally butt-fused to the end of the pipe.
 - 2. ASTM A240, Type 304 stainless steel backing flange, 125 lbs., 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. Retorque 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 as specified in Section 09 96 00 – High Performance Coatings.
- B. Flexible Couplings:
 1. Manufacturers and Products:
 - a. Steel Pipe:
 - 1) Dresser – Style 38 (1/2 in. & Larger)
 - 2) Smith-Blair – Style 411 (1/2 in.–60 in.)
 - 3) Romac – 501 (2 in.–24 in.)
 - b. Ductile Iron Pipe:
 - 1) Dresser – Style 38 (14 in. & Larger)
 - 2) Smith-Blair – Style 411 (1/2 in.–60 in.)
 - 3) Romac – 501 (2 in.–24 in.)
- C. Transition Couplings:
 1. Manufacturers and Products:
 - a. Dresser – Style 62 (3 in.–24 in.)
 - b. Smith-Blair – Style 413 (2 in.–48 in.)
 - c. Romac – RC501 (3 in.–24 in.)
- D. Flanged Coupling Adapters:
 1. Manufacturers and Products:
 - a. Steel Pipe:
 - 1) Smith-Blair – Series 913 (3 in. & Larger)
 - 2) Dresser Industries, Inc. – Style 128-W (3 in.–24 in.)
 - 3) Romac – FC400 (12 in.–96 in.)
 - b. Ductile Iron Pipe:
 - 1) Smith-Blair – Series 912 (3 in.–12 in.)
 - 2) Dresser Industries, Inc. – Style 128-W (3 in.–24 in.)
 - 3) Romac – FCA501 (3 in.–16 in.)
- E. Dismantling Joints:
 1. Manufacturers and Products:
 - a. Steel or Ductile Iron Pipe:
 - 1) Smith-Blair – Series 975 (3 in. & Larger)
 - 2) Dresser Industries, Inc. – Style 131 (4 in.–24 in.)
 - 3) Romac – DJ400 (3 in.–72 in.)

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 pipelines. When connecting to existing pipelines 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 in. Diameter and Larger:
 - 1. Vent connections shall be 3/4 in. with V300 ball valve. Drain connection shall be 1 in. with V300 ball valve, unless shown otherwise.
- B. Pipeline 2 in. Diameter and Smaller:
 - 1. Vent connections shall be 1/2 in. with V300 ball valve. Drain connection shall be 1 in. 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 as specified in 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.
 - 1. Threaded flanges shall be individually fitted and machine tightened on matching threaded pipe by the Manufacturer.

2.10 FINISHES

- A. Factories prepare, prime, and finish coat as specified in Pipe Data Sheet(s), Piping Schedule, and Section 09 96 00 – High Performance 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:
 - 1. 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:
 - 1. Repair using original coating and lining materials as specified in 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 as specified in 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:
 - 1. Mark each weld with symbol identifying welder.
- C. Pipe End Preparation:
 - 1. Machine Shaping:
 - a. Preferred
 - 2. Oxygen or Arc Cutting:
 - a. Smooth to touch, true, and slag removal by chipping or grinding.
 - 3. Beveled Ends for Butt Welding:
 - a. 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:
 - a. As stated in qualified welding procedure.
 - 3. Minimum Spacing of Circumferential Butt Welds:

- a. Minimum four times pipe wall thickness or 1 in., 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°F.
 - 2. Stainless Steel and Alloy Piping:
 - a. If the ambient is below 32°F, local preheating to a temperature warm to the hand is required.
- G. Tack Welds:
 - 1. 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:
 - 1. Chip or grind out those affecting soundness of weld.
- I. Weld Passes:
 - 1. As required in welding procedure.
- J. Weld Quality:
 - 1. 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 as specified in 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:
 - a. 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:
 - a. Install annular ring filler gasket at joints of raised-face flange.
 - 5. Raised-Face Flanges:
 - a. 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 noncorrosive 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 as specified in 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:
 - 1) Flexible couplings, transition couplings, and flanged coupling adapters.
 - b. Nonmetallic Piping Systems:
 - 1) Teflon bellows connector
 - c. Concrete Encased Couplings:
 - 1) Sleeve type coupling
 - d. Corrosive Service Piping:
 - 1) Elastomer bellows connector
 - e. Grit Slurry Piping:
 - 1) Elastomer bellows connector
- G. Pipe Connections at Concrete Structures:
1. As specified 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. Nonwatertight 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:
 - a. Cut pipe with milling type cutter, rolling pipe cutter, or abrasive saw cutter.
 - b. DO NOT flame cut.
 2. Dressing Cut Ends:
 - a. General:
 - 1) As required for the type of joint to be made.

- b. Rubber Gasketed Joints:
 - 1) Remove sharp edges or projections.
- c. Push-On Joints:
 - 1) Bevel, as recommended by pipe Manufacturer.
- d. Flexible Couplings, Flanged Coupling Adapters, and Grooved End
- e. Pipe Couplings:
 - 1) 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:
 - 1. 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:
 - 1. 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 more than 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:
 - a. Minimum of 7 ft, 6 in., 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:
 - a. Minimum 3 ft, 0 in., measured from equipment extremity and extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
 - 3. From Adjacent Work:
 - a. Minimum 1 in. 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 on Drawings.
 - 2. Concrete Encased or Embedded Pipe:
 - a. 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:
 - a. 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:
 - a. 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:
 - a. Maximum 2 in.
 - 2. Deflection from Vertical Grade:
 - a. Maximum 1/4 in.
 - 3. Joint Deflection:
 - a. Maximum of 75% of Manufacturer's recommendation.
 - 4. Horizontal position of pipe centerline on alignment around curves maximum variation of 1.75 ft from position shown.
 - 5. Pipe Cover:
 - a. Minimum 5 ft, unless otherwise shown on Drawings.

3.7 THRUST RESTRAINT

- A. Location:
 - 1. Buried Piping:
 - a. At pipeline tees, plugs, caps, bends, and other locations where unbalanced forces exist.
 - 2. Exposed Piping:
 - a. 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:
 - 1. 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:
 - a. 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 as specified in Section 03 30 00 – Cast-In-Place Concrete.

3.8 BRANCH CONNECTIONS

- A. DO NOT install branch connections smaller than 1/2 in. 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:
 - a. Connect only with service saddle or at a tapping boss of a fitting, valve body, or equipment casting.
 - 2. Welded Steel or Alloy Piping:
 - a. Connect only with welded thread-o-let or half-coupling as specified on Piping Data Sheet.
 - 3. Limitations:
 - a. 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 fps minimum flushing velocity until foreign matter is removed.

- B. Blow clean of loose debris in 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 fps or blow at 4,000 fpm 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 in. and larger or by removing spools and valves from piping.

3.11 DISINFECTION

- A. Disinfect pipelines intended to carry potable water (W1).
- B. See Section 33 13 00 – Disinfection of Water Systems.

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 96 00 – High Performance Coatings.

3.13 PIPE IDENTIFICATION

- A. As specified in Section 09 96 00 – High Performance Coatings.
- B. As specified in Section 22 05 53 – Mechanical Identification.

3.14 INSULATION

- A. As specified in Section 40 42 00 – Process Mechanical Insulation.

3.15 HEAT TRACING

- A. As specified in Section 40 41 13 – Heat Tracing.

3.16 FIELD QUALITY CONTROL

- A. Pressure Leakage Testing:
 - 1. As specified in 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 as specified in 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 3. Examine, progressively, two additional welds for each tracer examination found to be unsatisfactory.

3.17 SUPPLEMENTS

- A. The supplements listed below are a part of this section.
 1. Section 40 23 39.1 – Process Piping Schedule.
 2. Data Sheets:
 - a. Section 40 23 39.43 – DS – Polyvinyl Chloride (PVC) Pipe and Fittings
 - b. Section 40 23 39.61 – DS – Fiber Reinforced Pipe and Fittings

END OF SECTION

SECTION 40 23 39.1 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, Odorous	ALPO	Exposed	ALL	FRP	None	40 23 39.61	110	10	15, AM		6
Plant/Process Drain	PD	Exposed Buried	ALL	PVC	None	40 23 39.43	Ambient	10	15, LH		
Sanitary Sewer	SS	Buried	ALL	CELDI	CTP	40 23 39.13	Ambient	5	G	Green	
Vent	V	ALL	ALL	PVC	None	40 23 39.43	Ambient	10	15, LH		
Water (Potable)	W1	Buried Exposed- Outdoors	<3 in. <3 in.	HDPE PVC	None None	40 23 39.56 40 23 39.43	Ambient	100	150, HH	Blue	4

Notes:

- | | |
|---|---|
| <ol style="list-style-type: none"> 1 Encased – Buried piping under concrete slabs, and/or structures shall be concrete encased per standard detail D40/2400-009 unless specified otherwise in Drawings.
Exposed – Inside/Outside
Submerged – Below Liquid Surface 2 Buried – Directly into Soil
> Greater Than
< Less Than
<= Less Than or Equal To
>= Greater Than or Equal To 3 BS – Black Steel
CELDI – Ceramic Epoxy Lined Ductile Iron
CLDI – Cement Lined Ductile Iron
CPVC – Chlorinated Polyvinyl Chloride
GLDI – Glass Lined Ductile Iron
CU – Copper
DWV – Drain Waste Vent
HDPE – High Density Polyethylene
MDPE – Medium Density Polyethylene
STL – Carbon Steel (AWWA C222)
SST – Stainless Steel
FL PVC – Flanged Polyvinyl Chloride Pipe
PO PVC – Push on Joint Polyvinyl Chloride Pipe
CLSTL – Cement Lined Welded Steel (AWWA C205)
SW PVC – Solvent Weld Polyvinyl Chloride Pipe
PTFE – Polytetrafluoroethylene
FRP – Fiberglass Reinforced Pipe | <ol style="list-style-type: none"> 4 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 requirements.
Pipe testing required as specified above. 5 See Section 09 96 00 for required painting.
For buried piping, no color shall be required; coordinate for proper coatings, as necessary.
Where no color is specified, color to be selected by Owner.
For exposed piping not coated, provide colored banding and identification. 6 General – Deviations from this schedule are specified in Drawing notes. 7 General – The piping material shall be specified by requirements for the service listed being drained or vented. 8 EPP – Epoxy and Polyurethane Coating System
HSE – High Solids Epoxy
CTP – Coal Tar Pitch
HT – High Temperature |
|---|---|

Remarks:

- 1 Where buried piping transitions to exposed PVC piping, the buried piping shall be extended at least 6 in. above the floor before transitioning to exposed PVC piping.
- 2 Natural gas piping shall be tested as specified in Section 406 of the International Fuel Gas Code.
- 3 FL PVC, PO PVC, or SW PVC where shown.
- 4 Heat trace and insulate all outside piping as specified in Section 40 41 13 – Heat Tracing.
- 5 Buried is flexible tubing in PVC carrier.
- 6 Provide 316 SS unless connection with existing piping is 304 SS. In the case that the connection with existing piping is 304 SS, provide 304 SS.
- 7 Make sure of chemical compatibility for all CPVC welding agents.

END OF SECTION

**SECTION 40 23 39.13
DUCTILE IRON PIPE AND FITTINGS**

Item	Description
Pipe	Buried Liquid Service: Push-On, Mechanical, or Proprietary Restrained Joints as specified in AWWA C115/A21.15, AWWA C151/A21.51, and AWWA C150 and bear the mark of Underwriters' Laboratories (UL) approval. Use a minimum Pressure Class 250 for water and sewer lines less than or equal to 20 in. diameter. For 24 in. and larger, design for project-specific hydraulics to meet test pressure as shown in the pipe schedule. Use minimum Pressure Class 350 for pipes in casing or trenchless construction and for flanged pipe. Exposed Pipe: Grooved End or Flanged Joints compliant with AWWA C115/A21.15 and AWWA C151/A21.51 and have a thickness of Class 53 minimum.
Coating	Buried Pipe: Exterior coating used under normal conditions shall be zinc applied to a mass of 200 g/m2 of pipe surface conforming to ISO 8179 along with an approved bitumastic or coal tar top coating. Exposed Pipe: Shall be as specified in the piping schedule.
Encasement	Polyethylene encasement as specified in AWWA C105/A21.5 shall be used on all underground ductile iron pipe, fittings, valves, and appurtenances. See Section 40 42 13.16 – Polyethylene Encasement for Ductile Iron and Cast Iron Pipe.
Lining	Lining shall be Cement-Mortar as specified in AWWA C104/A21.4 unless noted otherwise. Linings shall be applied at a thickness per manufacturer's recommendation. All linings for potable water service shall be NSF 61 Certified. Ceramic Epoxy: Permax CTF, Tnemec Permashield or equal shall be used where indicated in the pipe schedule. Protecto 401 shall not be accepted. Glass Lining: As specified in ASTM B1000 – Standard Practices for Casting Preparation and Test Procedure of Porcelain Enamel-lined Pipe, Fittings, and Valves for Use in the Municipal Wastewater, Sewage, and Water Treatment Industry and shall be used where indicated in the piping schedule. Linings for fittings shall be as indicated in "Fittings" section.
Joints	Push-On: 250 psi minimum working pressure, as specified in AWWA C153/A21.53 and C111/A21.11. Mechanical: 250 psi minimum working pressure as specified in AWWA C111. Proprietary Restrained: 150 psi minimum working pressure. Grooved End: Rigid type radius cut as specified in AWWA C606, 250 psi minimum working pressure. Flanged: 125-lb. flat face, 250-lb. flat face, ductile iron, threaded as specified in AWWA C115/A21.15.
Fittings	For all fittings: Lining and coating shall match connecting pipe unless otherwise noted below.

Fittings (Cont.)	Push-On: As specified in AWWA C153/A21.53 and C111/A21.11, gray or ductile iron, 350 psi minimum working pressure. Mechanical Joint: For Buried Service. As specified in AWWA C111/A21.11 and C153/A21.53 ductile iron, 250 psi minimum working pressure. Coating/lining shall be Fusion-Bonded Epoxy meeting AWWA C116. Proprietary Restrained Joint: As specified in AWWA C153/A21.53, ductile iron, 250 psi minimum working pressure. Coating/lining shall be Fusion-Bonded Epoxy meeting AWWA C116. Proprietary Restrained River Crossing: Clow Ball and Socket; U.S. Pipe M-Flex, or approved equal. Coating/lining shall be Fusion-Bonded Epoxy meeting AWWA C116. Grooved End: As specified in AWWA C606 and C110/A21.10 for center-to-end dimensions, C110/A21.10 or AWWA C153 for wall thickness, ductile iron, 250 psi minimum working pressure. Flange: As specified in AWWA C110/A21.10 and ANSI B16.1, ductile iron, faced and drilled, 125-lb. flat face or 250-lb. flat face. Gray cast iron will not be allowed.
Grooved End Couplings	Grooved End Couplings: Ductile iron housing per ASTM A536. 250 psi maximum working pressure for sizes through 18 in., 150 psi for 20 in and larger. Grooved End Adapter Flanges: Ductile iron per ASTM A536. 250 psi through 12 in. and 150 psi for 14 in. and larger. Must allow for direct connection to ANSI Class 125 flanged components.
Bolting	Buried Mechanical and Proprietary Restrained: 316 stainless steel T-head bolts and hardware Exposed Grooved End Joints and 125-lb. Flanges: ASTM A307 Grade A carbon steel hex head bolts and ASTM A563 Grade A steel hex head nuts. Exposed 250 lb. Flanges: ASTM A307 Grade B carbon steel hex head bolts and ASTM A563 Grade A carbon steel heavy hex head nuts. Additional Requirements: 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 rods shall be 316 stainless steel.
Gaskets	Mechanical Joints, Water and Sewage: Styrene-butadiene rubber (SBR) gaskets produced as specified in ANSI/AWWA C111, Table 4 are acceptable for use in a mechanical joint mechanism. (SBR) rubber gaskets shall be rated for the same working pressure as the pipe. Locking gaskets produced as specified in AWWA C111 are acceptable for use as a joint restraint mechanism for buried joints. Locking gaskets shall be a high-visibility color and rated for the same working pressure as the pipe. Mechanical and Proprietary Restrained Joints, Air: Viton, Fluorel, or Manufacturer's standard for high temperature air service, rated to 300°F minimum, conforming to ANSI/AWWA C111/A21.11 Grooved End Joints: Halogenated butyl as specified in ASTM D2000 and AWWA C606. Gaskets for air service shall be pressure-responsive synthetic rubber, rated to 300°F minimum, as specified in ASTM D2000.

Gaskets (Cont.)	Flanged, Water and Sewage Services: 1/8 in. thick, unless otherwise specified, homogenous black rubber (EPDM), hardness 60 (Shore A), rated to 212°F, as specified in ANSI B16.21 and ASTM D1330 Steam Grade or full face per ANSI/AWWA C111/A21.11. Flanged, Air Service: 1/8 in. thick, unless otherwise specified, Teflon, PTFE, or compressed inorganic fiber with nitrile binder, rated to 300°F minimum, as specified in ANSI B16.21 and ASTM D1330. Additional Requirements: 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 shall be equal to the pressure rating of the connecting pipe or fitting. NSF61-listed gaskets are required for potable water service.
Joint Lubricant	Manufacturer's Standard

END OF SECTION

**SECTION 40 23 39.43
POLYVINYL CHLORIDE PIPE AND FITTINGS**

Item	Size	Description
Pipe	All	Schedule 80 PVC: Type I, Grade I or Class 23447-B as specified in ASTM D1785-05. Threaded Nipples: Schedule 80 PVC.
Fittings	All	Schedule 80 PVC: as specified above and in ASTM D2467.
Joints	All	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	All	One-piece, molded hub type PVC flat face flange as specified in Fittings above, 125 lb. ANSI B16.1-89 drilling.
Bolting	All	Flat Face Mating Flange or In Corrosive Areas: ASTM A193 Rev A-94 Type 316 stainless steel Grade B8M hex head bolts and ASTM A194-94 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	All	Flat Face Mating Flange: Full faced 1/8 in. thick. Raised Face Mating Flange: Flat ring 1/8 in. 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	All	As specified by the pipe and fitting manufacturer and in 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	All	Teflon Tape

END OF SECTION

**SECTION 40 23 39.56
HIGH DENSITY POLYETHYLENE (HDPE) PIPE AND FITTINGS**

Item	Size	Description
Pipe	All	DR 17 HDPE: as specified in ASTM D3350-05 with a cell classification of PE445574E.
Fittings	All	DR 17 HDPE: as specified above, meeting FMRC standards.
Joints	All	Thermo-weld joints with butt fusion technique, as specified in ASTM F2620 and in Plastic Pipe Institute TR-33.
Flanges	All	One piece, molded hub type HDPE flat face flange as specified in Fittings above, 125-lb. ANSI B16.1-89 drilling.
Bolting	All	Flat Face Mating Flange or In Corrosive Areas: ASTM A193 Rev A-94 Type 316 stainless steel Grade B8M hex head bolts and ASTM A194-94 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	All	Flat Face Mating Flange: Full faced 1/8 in. thick. Raised Face Mating Flange: Flat ring 1/8 in. 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.
Thread Lubricant	All	Teflon Tape

END OF SECTION

**SECTION 40 23 39.61
FIBER REINFORCED PIPE AND FITTINGS**

Item	Size	Description
Pipe	All	FRP Type 1, Grade 2 RTRP, Class E for ASTM D2310 and D2996. 7 in. minimum static pressure.
Fittings	All	FRP as above. Butt and wrap joint type connections.
Joints	All	Butt and wrap joint type connections. All joints per SMACNA Standards.
Flanges	All	One-piece integral flange or flange on pipe fabrication. 150 lb. per Standard ASA B16.5.
Bolting	All	Flat Face Mating Flange or In Corrosive Areas: ASTM A193 Rev A-94 Type 316 stainless steel Grade B8M hex head bolts and ASTM A194-94 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	All	Flat Face Mating Flange: Full faced 1/8 in. thick. Raised Face Mating Flange: Flat ring 1/8 in. 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.
Resin	All	Corrosion resistant Class 1 pipe retardant polyester or vinyl ester.
Thread Lubricant	All	Teflon Tape

END OF SECTION

SECTION 40 41 13 – HEAT TRACING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section Includes:
 - 1. Heating Cables
 - 2. Control Panels
 - 3. Temperature Sensors
 - 4. Temperature Controllers
 - 5. Contactors
 - 6. Enclosures
 - 7. All other auxiliary equipment and controls required.
- B. Related Sections:
 - 1. Section 40 42 00 – Process Mechanical Insulation

1.2 REFERENCES

- A. ANSI
- B. ASTM International:
 - 1. B193 – Standard Test Method for Resistivity of Electrical Conductor Materials.
 - 2. D2633 – Standard Test Methods for Thermoplastic Insulations and Jackets for Wire and Cable.
- C. Factory Mutual Research Corp
- D. IEEE:
 - 1. P515 – Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications.
 - 2. 622 – Design & Installation of Electric Heat Tracing SY.
- E. IEC
- F. NEMA:
 - 1. 1CS1-110
- G. NFPA:
 - 1. 70 – National Electric Code
- H. OSHA
- I. Underwriters' Laboratories, Inc:
 - 1. UL 746B – Polymeric Materials – Long Term Property Evaluations.

1.3 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Action Submittals:
 - 1. Product Data:
 - a. Catalog number, wattage output, voltage rating, and product data.
 - b. Installation instructions

- c. Warranty
- 2. Shop Drawings:
 - a. Include isometric drawings for each heat traced pipe showing installation details, and size and type of heat tracing cable.

1.4 QUALITY ASSURANCE

- A. Regulatory Requirements and Reference Standards:
 - 1. The electric heat tracing system shall conform to this specification and shall be designed, manufactured and tested as specified in 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.

1.5 WARRANTY

- A. Cables:
 - 1. All cables shall be warranted for a period of 10 years for manufacturing defects.
- B. See Section 01 78 36 – Warranties and Bonds for additional requirements.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Design Requirements:
 - 1. General: Heat tracing applications up to a maintain temperature of 250°F and intermittent exposure to 420°F 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% of its original power when tested as specified in UL 746B.

2.2 HEAT TRACING CABLE

- A. Self-regulating and self-limiting, 5 watts per foot, 120 V, 60 Hz, flexible twin 16 AWG copper bus wires, with tinned copper braid overshield.
- B. Manufacturers:
 - 1. nVent/Raychem – Chemelex Auto-Trace
 - 2. Chromalox – Type SLR Rapid Trace
 - 3. Thermon – BSX
 - 4. Emerson/Nelson – CLT or LT
 - 5. Or Approved Equal.

2.3 CONTROLLER

- A. Manufacturer:
 - 1. nVent/Raychem – Elexant 4010i
 - 2. Chromalox – ITC2
 - 3. Or Approved Equal.

- 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 power supply shall accept supply voltage as shown on Drawings with adjustable ground fault detection. Possible supply voltages include 120 VAC, 208 VAC, 240 VAC, and 277 VAC.
 - 2. A minimum of two (2) dry contacts shall be provided: one (1) for a heat trace controller fault, and one (1) for ground fault.
 - 3. Controller shall have double pole solid state switching, temperature control from (-40)°F–125°F and a 30 amp rating from (-40)°F–125°F, ambient temperature.
 - 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. Approved 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 heat tracing cable on piping subject to freezing as specified in Drawings and:
 - 1. Nutrient Tank
 - 2. Recirculation Pump
 - 3. Bio-trickling Filter Sump Pump
 - 4. Exposed Outdoor Water Piping
 - 5. Exposed Outdoor Nutrient Feed Piping
 - 6. Exposed Outdoor Recirculation Piping
 - 7. Exposed Outdoor Drain Piping
- B. Wrap heat tracing tape with aluminum tape prior to installing insulation.

- C. Install pipe insulation as specified in Section 40 42 00 – Mechanical Insulation.
- D. Install heat tape and controls as specified in manufacturer's published installation instructions.
- E. Thermostat:
 - 1. Thermostat shall be powered by 120 VAC.
 - 2. One single 120 V power source shall be provided to the heat tracing control system panel as specified in Drawings.
 - 3. Thermostats shall be powered from the control panel box by the Contractor.

3.2 FIELD QUALITY REQUIREMENTS

- A. Manufacturer's Field Service.
 - 1. Inspect installed systems for proper installation.
 - 2. Instruct Owner's personnel on operations and maintenance of the systems.

Location	Pipe Service	Pipe Diameter (in)	Length (ft)	Min Temp (°F)
Facility 10	W1 (including the W1/recirculation pipe to the top of the BTF tank)	2	35	40
Facility 10	Nutrient Feed	1	5	40
Facility 10	PD	3	7	40
Facility 10	PD	2	68	40
Facility 20	PD	2	88	40

Note: Heat tracing schedule is not representative of all bends and valves present in each heat traced pipeline and serves to approximate the heat tracing criteria. Contractor to verify final lengths, valves, and fittings of all heat traced piping prior to procurement of heat tracing equipment.

END OF SECTION

SECTION 40 42 00 – PROCESS MECHANICAL INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section Includes:
 - 1. Insulation, jackets, and accessories for piping and related systems.
- B. Related Sections:
 - 1. Section 09 90 00 – Painting and Protective Coatings
 - 2. Section 22 05 29 – Process Supports and Anchors
 - 3. Section 22 05 53 – Mechanical Identification
 - 4. Section 23 07 13 – Mechanical Insulation
 - 5. 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:
 - 1. Piping that is installed below buildings, foundations or finish grade, either in soil or encased in concrete in soil.

- B. Concealed:
 - 1. Piping above suspended ceilings and within walls, partitions, shafts, or service spaces and spaces NOT normally exposed to view but NOT buried.
- C. Exterior:
 - 1. Piping that is installed outside a building or within a pipe trench or tunnel.
- D. Flame Spread and Smoke Density:
 - 1. Burning characteristics determined as specified in ASTM E84. No units apply to value.
- E. Interior:
 - 1. Piping that is installed inside a building.
- F. K Factor:
 - 1. Thermal conductivity determined as specified in ASTM C177 or C518 and expressed in units of Btu/hr-ft² – °F.
- G. Mineral Fiber:
 - 1. Fibers manufactured of glass, rock, or slag processed from a molten state, with or without a binder.
- H. Water Vapor Permeance:
 - 1. Water vapor transmission determined as specified in ASTM E96 and expressed in units of perm-inch.

1.4 SUBMITTALS

- A. Submittals shall be made as specified in Section 01 33 00 – Submittal Procedures.
- B. Product Data:
 - 1. Insulation Properties: Include K factor, thickness, density, operating temperature limits, tensile strength, compressive strength, moisture absorption, flame spread, and smoke developed as specified in ASTM E84 and corrosivity to stainless steel piping as specified in ASTM C795.
 - 2. Jacket Properties: Include covering material, cover thickness, tensile strength, tear strength, permeability as specified in ASTM E96, flame spread, and smoke developed as specified in ASTM E84, closure type or devices, and accessories.
 - 3. Insulating Blankets: Include materials, performance characteristics, method of attaching to equipment, listing of locations where insulating blankets shall be installed.
- C. Manufacturer's Application Instructions:
 - 1. Include assembly and application drawings and detailed instructions.
- D. Laboratory Report:
 - 1. 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 as specified in 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.
- C. See Section 01 78 36 – Warranties and Bonds for additional requirements.

PART 2 - PRODUCTS

2.1 PIPE INSULATION, GENERAL REQUIREMENTS

- A. Insulation Thicknesses:
 - 1. Provide insulation thickness in inches as specified in the "Required Insulation Thicknesses" table. Insulation thickness shown is nominal manufacturing tolerance of 15% variation is permissible.

Required Insulation Thicknesses					
SERVICE TEMPERATURE RANGE (As designated in insulation schedule at end of this Section.)	Nominal Pipe Diameters (Inches)				
	≤1	1.25–2	2.5–4	5–10	>10
Greater than 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
Less than 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
Aeration Air Pipes	0.5	0.5	1.0	1.0	1.0

2.2 PIPE INSULATION

- A. Insulation Types:
 - 1. Provide as specified in the insulation types listed and scheduled.
- B. Insulation, Type 1:
 - 1. Insulation Material:
 - a. Closed cell elastomeric insulation
 - 2. Minimum Temperature Range: (-40)°F–220°F.
 - 3. K Factor at 75°F: NOT more than 0.27 BTU-in/hr-ft²-°F.
 - 4. Fire Ratings:
 - a. Flame Spread: 25 or less
 - b. Smoke Density: 50 or less for insulation thicknesses up to 1.5 in.
 - 5. Joints: Seal with manufacturer's recommended contact adhesive to form continuous water barrier.

6. Manufacturers (Choose ONE):
 - a. Armacell Engineered Systems – AP/Armaflex
 - b. Or Approved Equal.
- C. Insulation, Type 2:
1. Insulation Material:
 2. 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:
 - a) White kraft paper bound to aluminum foil meeting ASTM C1136, Type I.
 - 2) Longitudinal Lap Seals:
 - a) Pressure sensitive, self-sealing longitudinal lap strip with factory applied adhesive.
 - 3) Circumferential Butt Seals:
 - a) 4 in. wide tape or similar properties or 4 in. wide overlap with adhesive seal.
 - 4) Vapor Barrier Permeability:
 - a) 0.02 perms or lower
 - 5) Vapor Barrier Flame Spread Rating:
 - a) 25 or less
 3. Minimum Temperature Range:
 - a. 0°F – 850°F
 4. K Factor at 75°F:
 - a. NOT more than 0.23 BTU-in/hr-ft²-°F
 5. Average Insulation Density:
 - a. 3.3 lbs/ft³
 6. Maximum Moisture Absorption, Volume Percent:
 - a. 0.2%
 7. Manufacturers (Choose ONE):
 - a. Owens Corning
 - b. Johns Manville
 - c. Knauf Insulation
 - d. Or Approved Equal.
- D. Insulation, Type 3:
1. Insulation Material:
 - a. Rigid polyisocyanurate foam as specified in ASTM C591, Type IV.
 2. Temperature Range:
 - a. (-297)°F–300°F
 3. K Factor at 75°F:
 - a. NOT more than 0.19 BTU-in/hr-ft²-°F
 4. Minimum Average Density:
 - a. 4.0 psi
 5. Maximum Moisture Absorption, Volume Percent:
 - a. 0.7%
 6. Minimum Compressive Strength:
 - a. 25 psi
 7. Moisture Permeability:
 - a. 4.00 perm-inch
 8. Manufacturers (Choose ONE):
 - a. ITW Insulation Systems.
 - b. Kingspan Insulation LLC/Dyplast
 - c. Other Approved Equal.

- E. Insulation, Type 4:
1. Insulation Material:
 - a. Rigid cellular glass as specified in ASTM C553, Type II.
 2. Temperature Range:
 - a. (-450)°F–900°F
 3. K Factor at 75°F:
 - a. NOT more than 0.32 BTU-in/hr-ft²-°F
 4. Minimum Average Density:
 - a. 7.5 lbs/ft³
 5. Maximum Moisture Absorption, Volume Percent:
 - a. 0.2%
 6. Minimum Compressive Strength:
 - a. 87 psi
 7. Moisture Permeability:
 - a. 0.00 perm-inch
 8. Manufacturers (Choose ONE):
 - a. Owens Corning – Foamglas, Ultra-CUF
 - b. Or Approved Equal.
- F. Insulation, Type 5:
1. Insulation Material:
 - a. Asbestos free, rigid calcium silicate as specified in ASTM C533; Type 1 for process temperatures up to 1,200°F.
 2. K Factor at 500°F:
 - a. 0.55 for Type 1
 3. Maximum Average (Dry) Density:
 - a. 14.5 lbs/ft³
 4. Compressive Strength:
 - a. 100 psi, to produce a 5% compression.
 5. Manufacturers (as specified in ASTM C533 Type I, and choose ONE):
 - 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/yd² polyvinyl chloride on polyester fabric; total thickness 0.028 in. 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: 1 in. minimum at joints and fittings
 5. Joint Seal: Self-sealing lap tape
 6. Fittings: Factory made with full thickness insulation
 7. Manufacturers (Choose ONE):
 - 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: 1 in. 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 (Choose ONE):
 - 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 in. (26 gauge) minimum thickness.
 - 2. Overlap: Overlap circumferential joints 4 in. minimum; overlap longitudinal joints 1 in. minimum; longitudinal joints oriented to minimize water entry.
 - 3. Bands: 0.5 in. wide, 0.0508 in. (16 gauge) thick aluminum, same alloy as jacket or 0.0179 in. thick Type 304 stainless steel; install on 18 in. 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 (Choose ONE):
 - 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 in. wide tape or 4 in. overlap with adhesive seal.
 - 6. Manufacturers (Choose ONE):
 - 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 (Choose ONE):
 - 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:
 - 1. 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:
 - 1. Use removable insulating blankets for equipment and piping appurtenances 3 in. in nominal size and larger. Insulate equipment and piping appurtenances less than 3 in.

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 (Choose ONE):
 - 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°F:
 - 1. Use: For service temperatures up to 800°F.
 - 2. Insulation: Fiberglass fiber, K factor 0.27 at 75°F.
 - 3. Cover: 17oz fabric with both sides covered with silicone impregnated glass cloth suitable for temperatures up to 800°F.
 - 4. Dover Fasteners (Use ONE the systems below):
 - a. Grommets in the blanket and stainless-steel wire
 - b. 1 in. wide straps with stainless steel rectangular ring buckles and Velcro on strap tail.
- E. High temperature insulating blankets rated up to 1,400°F:
 - 1. Rated for sustained service temperatures up to 1,400°F.
 - 2. Insulation: Ceramic fiber, K factor 0.50 at 600°F, insulation material suitable for up to 2,300°F, thickness to match adjacent piping insulation specified thickness.
 - 3. Cover: 17oz silicone impregnated fiberglass cloth suitable for temperatures up to 1,400°F.
 - 4. Cover Fasteners (Use ONE of systems below):
 - a. Grommets in the blanket and stainless-steel wire
 - b. 1 in. wide straps with stainless steel rectangular ring buckles and Velcro on strap tail.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Verification of Conditions:
 - 1. 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 as specified in 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 in.
- H. Valves:
 - 1. Insulate valves 3 in. 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 watertight 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°F 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	3	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. This Section Includes:
 - 1. The Work to furnish 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 63 43 – Programmable Logic Controllers
 - 3. Section 40 66 33 – Fiber Optic Communication Systems
 - 4. Section 40 67 23 – Control Panels
 - 5. Section 40 70 00 – Instrumentation for Process Systems

1.2 DEFINITIONS:

- A. SCADA: Supervisory Control and Data Acquisition
- B. HMI: Human Machine Interface (Graphical Screens, Text Displays)
- C. OIT: Operator Interface Terminal
- D. PLC: Programmable Logic Controller
- E. I/O: Input/Output
- F. VFD: Variable Frequency Drive
- G. SSRVS: Solid State Reduced Voltage Starter (“Soft Starter”)
- H. RTU: Remote Telemetry Unit
- I. MTU: Master Telemetry Unit
- J. MCC: Motor Control Center
- K. Operating Program: Operating system, SCADA, or other core software.
- L. Integrated Operating Platform: System of installed, connected, and configured hardware, operating programs, and networking equipment.
- M. PLC and HMI Programming: Software configuration of operating programs to implement process control strategies.
- N. Control System Specialist: A company specializing in process control hardware and software, including instrumentation, PLCs, networking, installation, and configuration.
- O. Application Engineer: A company performing the PLC and HMI programming to implement process control strategies.

1.3 SUBMITTALS

- A. Subject 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:
 - 1. Shall be submitted for approval by the Engineer.
 - 2. The Contractor shall submit to the Engineer, for approval, Shop Drawings of the equipment to be installed to meet the sections. 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.
 - 3. The information required on the Shop Drawings shall include, but is not necessarily limited to:
 - 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.
 - 4. Control panels:
 - a. Panel and subpanel 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
 - a. See Section 01 78 36 – Warranties and Bonds for additional requirements.
 - 4. Automation Control Service, LLC to provide 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 section.

1.4 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.

1.5 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, except for those services specifically excluded herein to be provided directly to the Owner by the Application Engineer.
 - 1. The Control System Specialist shall be one of the following:
 - a. Prism Systems
 - b. Revere Control Systems
 - c. Electric Machine Control
 - d. Prime Controls
 - e. Hargrove
- B. The Control System Specialist shall be responsible for providing all instrumentation, PLC control panels, networking equipment, and other control system hardware as specified for a complete process control system installation.
- C. The Contractor shall be responsible for:
 - 1. Installation, field wiring and termination of all instrumentation, control panels, networking equipment and other hardware as specified.
 - 2. Modification to existing control panels as required.
- D. Items specifically excluded from the Control System Specialist's scope of work, and to be provided by the Application Engineer, include:
 - 1. Programmable Logic Controller (PLC) programming
 - 2. Human Machine Interface (HMI) graphics development and configuration
 - 3. SCADA network integration
- E. The Application Engineer providing PLC and HMI programming services for this project, under separate contract with the Owner, is Automation Control Service, LLC. The Control System Specialist shall provide support services to the Application Engineer as defined herein.
- F. In general, the Control System Specialist shall:
 - 1. Furnish, configure, and calibrate instrumentation as detailed on the drawings and in the sections.
 - 2. Fabricate all control panels as specified in Drawings, except for those provided as part of a vendor-supplied equipment package.
 - 3. 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.
 - 4. Execute the testing procedures outlined in this document.
- G. 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 hardwired I/O. Refer to the associated 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.

- H. Vendor system packages may include instrumentation or control panels that shall be installed and by the Contractor as specified in vendor instructions. Upon satisfactory installation, configuration, and calibration, the Contractor shall coordinate with each vendor to inspect finished work. The Contractor shall submit documentation indicating that the vendor has inspected and approved the installation.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Storage and Protection:
 - 1. Delivery, storage, and handling shall be as specified in Manufacturer's recommendation and the requirements of other sections herein.

1.7 PROJECT AND SITE CONDITIONS

- A. Environmental Requirements:
 - 1. 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 ambient conditions below:
 - a. Temperature:
 - 1) (-25)°C–80°C
 - b. Pressure:
 - 1) 650 mm Hg – 800 mm Hg
 - c. Relative Humidity:
 - 1) 20%–100% condensing
 - d. Vibration Frequency:
 - 1) 10 Hz–2,000 Hz
 - e. Vibration Position:
 - 1) 1.5 mm peak-to-peak
 - f. Vibration Acceleration:
 - 1) 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 Hz–2,000 Hz.).
- C. Operating Environmental Conditions:
 - 1. 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 mA – 20 mA 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 as specified in 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 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.

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:
 - 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 Contractor

shall document all wiring checks and signoff on completed wiring termination sheets. Submit signed documentation to Owner and Engineer.

3.3 TESTING AND INSTALLATION REQUIREMENTS

A. Testing and Installation Requirements:

1. 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 signoff 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 as specified in 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 30 days in advance of the test.
2. The purpose of this test is for the Control System Specialist to verify:
 - 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 for the Application Engineer 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%, 25%, 50%, 75%, 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%, 25%, 50%, 75%, and 100% of span. Observe that the connected equipment properly responds.

11. 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, the Application Engineer will 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 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. This testing will be primarily performed by the Application Engineer, with support from the Control System Specialist and Contractor as needed.
4. The Control System Specialist and Contractor shall be present during the functional testing to support the Application Engineer in the event that any hardware, wiring, or instrumentation modifications are required and 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 Application Engineer, 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:

1. 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 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 startup. 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.

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 2 years from and after the date of Final Acceptance of the work by the Owner, and any such defects which appear within the stipulated guarantee 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:
 - 1. 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/May Not Include:
 - 1. 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. The Contractor shall engage the services of a Control System Specialist to furnish all materials, equipment, labor and services required for a complete and fully functional process control system. PLC programming, HMI graphics development and configuration, and SCADA network integration shall be provided by the Application Engineer under a separate contract with the Owner. Refer to Section 40 61 13 – Process Control Descriptions – General for division of work between Contractor, Control System Specialist, and Application Engineer. These descriptions are provided as part of the contract documents for the Contractor's reference.
- D. Related Sections:
 - 1. Section 40 61 13 – Process Control System General Provisions

1.2 DEFINITIONS

- A. Integrated Operating Platform:
 - 1. System of installed, connected, and configured hardware, operating programs, and networking equipment.
- B. PLC and HMI Programming:
 - 1. Software configuration of operating programs to implement process control strategies.
- C. Control System Specialist:
 - 1. A company specializing in process control hardware and software, including instrumentation, PLCs, networking, installation, and configuration.
- D. Application Engineer:
 - 1. A company performing the PLC and HMI programming to implement process control strategies.

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. Some of these strategies describe three position selector control switches which may be LOCAL-OFF-REMOTE, HAND-OFF-AUTO, ON-OFF-AUTO, or some other variation in the field. See contract P&ID's and control schematic drawings for specific switch details.

B. Constant Speed Motors/Pumps

1. The motor will be capable of LOCAL MANUAL control from the motor control panel 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 motor control panel 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, the motor is started and stopped 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 motor operations based on the automatic control strategy described herein.

C. Adjustable Speed Motors/Pumps

1. The motor will be capable of LOCAL MANUAL control from the motor control panel or 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 motor 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 or VFD keypad.
 - 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 in terms of percent on the HMI. Allowable percentage range shall be coordinated with the process equipment to ensure operation is not allowed in ranges that would result in damage to the equipment or undesirable process outcomes.
 - b) In AUTO mode, the PLC program will control motor operations based on the automatic control strategy described herein.

D. Discrete Valve Actuators

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 open and close commands come from SCADA. Certain actuators may also include a remote STOP command to stop the actuator mid-transition. Refer to contract drawings for details.
 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 Valve Actuators
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 0–100%.
 - 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:
 - a. These PLC calculated alarms will be generated for all analog input signals.
 - b. High Alarm:
 - 1) PLC generated alarm if the value exceeds operator high value alarm setpoint.
 - c. Low Alarm:
 - 1) PLC generated alarm if the value falls below operator low value alarm range setpoint.
 - d. Out of Range:
 - 1) 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.
 - e. Broken Loop:
 - 1) PLC generated alarm if signal broken loop is detected. PLC shall hold last good value while broken loop is active.
 2. Equipment Alarms:
 - a. These PLC calculated alarms will be generated for all equipment with PLC control. All alarm delay timers and deadbands shall be operator-adjustable. These alarms only apply to remote SCADA control and will not be generated when equipment is in a LOCAL control state.
 - b. Pumps/Motors:
 - 1) Command Fail:
 - a) PLC generated alarm if setpoint is not achieved within a deadband before a set time-delay once a command is given.
 - 2) Fail to Start:

- a) PLC generated alarm if running feedback is not received before a set time-delay after run command is given.
 - 3) Fail to Stop:
 - a) PLC generated alarm if running feedback is not lost before a set time-delay after run command has been removed.
 - 4) Uncommanded Change Alarm:
 - a) PLC generated deviation alarm if equipment changes states (running, speed) without being given a command.
- c. Gates/Valves:
 - 1) Command Fail:
 - a) PLC generated alarm if position setpoint is not achieved within deadband before a set time-delay after a position command is given (modulated only).
 - 2) Fail to Open:
 - a) PLC generated alarm if open feedback not received before a set time-delay after open command is given.
 - 3) Fail to Close:
 - a) PLC generated alarm if closed feedback not received before a set time-delay after close command is given.
 - 4) Uncommanded Change Alarm:
 - a) PLC generated deviation alarm if equipment changes states (open/close status, position) without being given a command.
- 3. PLC Diagnostic Alarms:
 - a. These PLC calculated alarms will be generated for all new PLCs provided as part of the project.
 - b. PLC Card Fault:
 - 1) The PLC shall generate an alarm for any I/O card faults as available from the platform.
 - c. PLC Heartbeat:
 - 1) The PLC shall have an alternating "heartbeat" bit for use in communications diagnostics.
 - d. PLC Communications Fault:
 - 1) A PLC that receives peer-to-peer data from another controller over the network must monitor the heartbeat of the supplying controller. If the heartbeat bit remains unchanged for a specified period, a communications fault alarm will be triggered. The alarm delay should be set appropriately to accommodate anticipated communication delays or poll rates, including any delays associated with radio communications. This alarm should serve as a failure condition for any control strategies that depend on receiving the data.

END OF SECTION

SECTION 40 61 96.1 – PROCESS CONTROL DESCRIPTIONS – ODOR CONTROL

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section Includes:
1. Control strategies and expected functionality for a specific process area or facility in the project. It provides detailed descriptions to understand and configure the control systems concerning a specific process. These descriptions complement the Process Control Descriptions - General specification, which covers universal control descriptions and serves as a foundation for the detailed facility strategies. Refer to the General PCD for typical equipment and instrument control strategies.
- B. Related Section:
1. Section 40 61 13 – Process Control System General Provisions
 2. Section 40 61 96 – Process Control Descriptions – General

1.2 REFERENCES

- A. Drawing Number 08-I201 – Headworks Process and Instrumentation Diagram

1.3 EQUIPMENT AND INSTRUMENTATION

- A. Dampers:

Equipment Tag	Name	Existing/Proposed	Operator	Remote Operation
20FCD101	Flow Control Damper #1	Proposed	MO	MOD
20FCD102	Flow Control Damper #2	Proposed	MO	MOD
20FCD201	Flow Control Damper #3	Proposed	MO	MOD
20FCD202	Flow Control Damper #4	Proposed	MO	MOD
20FCD203	Flow Control Damper #5	Proposed	MO	MOD
20FCD204	Flow Control Damper #6	Proposed	MO	MOD
20FCD205	Flow Control Damper #7	Proposed	MO	MOD
20FCD206	Flow Control Damper #8	Proposed	MO	MOD
20FCD301	Flow Control Damper #9	Proposed	MO	MOD
20FCD302	Flow Control Damper #10	Proposed	MO	MOD
20FCD303	Flow Control Damper #11	Proposed	MO	MOD
20FCD304	Flow Control Damper #12	Proposed	MO	MOD
20FCD401	Flow Control Damper #13	Proposed	MO	MOD
20FCD402	Flow Control Damper #14	Proposed	MO	MOD
20FCD403	Flow Control Damper #15	Proposed	MO	MOD
20FCD404	Flow Control Damper #16	Proposed	MO	MOD
MAN = Manual MO = Electric Motor-Operated PO = Pneumatic-Operated HO=Hydraulic-Operated OC = Open/Close OSC = Open/Stop/Close MOD = Modulating				

B. Instruments:

1. Analog Instruments:

Equipment Tag	Name	Existing/ Proposed	Nominal Range
20AIT101	H2S Transmitter No.1	Proposed	0-50 ppm
20AIT102	H2S Transmitter No.2	Proposed	0-50 ppm
20AIT103	H2S Transmitter No.3	Proposed	0-50 ppm
20AIT104	H2S Transmitter No.4	Proposed	0-50 ppm
20AIT105	H2S Transmitter No.5	Proposed	0-50 ppm
20AIT106	H2S Transmitter No.6	Proposed	0-50 ppm
20AIT107	H2S Transmitter No.7	Proposed	0-50 ppm
20AIT108	H2S Transmitter No.8	Proposed	0-50 ppm
20AIT109	H2S Transmitter No.9	Proposed	0-1000 ppm
20AIT110	H2S Transmitter No.10	Proposed	0-1000 ppm
20AIT111	H2S Transmitter No.11	Proposed	0-1000 ppm
20AIT112	H2S Transmitter No.12	Proposed	0-1000 ppm

C. Controllers:

Equipment Tag	Name
20RIO1	Headworks RIO Panel

1.4 PROCESS DESCRIPTION

- A. The odor control system includes work at the headworks facility and the odor control facility.
1. The headworks facility consists of a series of motorized flow control dampers. Foul air will flow from the headspace in the headworks, through the dampers, and to the odor control facility. The motorized dampers will have two operation setpoints as determined by the TAB (Testing, Adjusting, and Balancing) contractor.
 - a. At low flows, the motorized dampers will open to operation setpoint 1.
 - b. At high flows, the motorized dampers will open to operation setpoint 2.
 - c. All motorized dampers will be controlled by 20RIO1.

1.5 HMI CONTROLS

- A. Alarms
1. The following table lists the expected alarms that will be added to 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
Control Damper Valve Fault	Fault generated by the damper actuator.
High H2S alarm	RIO generated alarm if the H2S levels from 20AIT101 - 20AIT108 exceed 50 ppm

1.6 FAILURE MODES

- A. The following table lists potential failures and the expected process control system response.

Failure	Process Control System Response
Headworks RIO	If a loss of communication with the Headworks RIO is detected, all process equipment shall continue to run at the last communicated setpoint.

1.7 COMMUNICATION INTERFACES

- A. Data will be communicated over the SCADA network from 20RIO1 to 89-CP-1 for data needed to monitor the Headworks Facility. Data will be communicated from Headworks RIO to existing Headworks PLC. See 90-T101 for more information. The following table identifies the major items expected to be communicated.

Field	Controller
20RIO1	91-CP-1

END OF SECTION

SECTION 40 63 43 – PROGRAMMABLE LOGIC CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section Includes:
 - 1. The work for furnishing all materials, labor, equipment, tools, supplies, and incidentals necessary for the installation and testing of all programmable logic controllers (PLCs).
- B. Related Sections:
 - 1. Section 40 61 13 – Process Control System General Provisions
 - 2. Section 40 66 13 – Networking Equipment
 - 3. Section 40 66 33 – Fiber Optic Communication Systems
 - 4. Section 40 67 23 – Control Panels
 - 5. Section 40 70 00 – Instrumentation for Process Systems

1.2 DEFINITIONS

- A. SCADA: Supervisory Control and Data Acquisition
- B. HMI: Human Machine Interface (Graphical Screens, Text Displays)
- C. OIT: Operator Interface Terminal
- D. PLC: Programmable Logic Controller
- E. I/O: Input/Output
- F. RTU: Remote Telemetry Unit
- G. MTU: Master Telemetry Unit
- H. Operating Program: Operating system, SCADA, or other core software.
- I. Integrated Operating Platform: System of installed, connected, and configured hardware, operating programs, and networking equipment.
- J. PLC and HMI Programming: Software configuration of operating programs to implement process control strategies.

1.3 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Refer to section 40 61 13 – Process Control System General Provisions for submittal requirements.

1.4 QUALITY ASSURANCE

- A. Manufacturer's Support:
 - 1. The PLC system manufacturer shall maintain, as a part of a national network, engineering service facilities within 100 miles of the project, to provide startup service, emergency service calls, repair work, service contracts, maintenance, and training. Emergency service shall be available within 24 hrs. of notification.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Storage and Protection:
 - 1. Delivery, storage, and handling shall be as specified in Manufacturers' recommendation and the requirements of other sections herein.

PART 2 - PRODUCTS

2.1 PROGRAMMABLE LOGIC CONTROLLERS

- A. Plant-wide RIO Systems:
 - 1. The RIO included in a control panel as part of the SCADA process control system provided by the Control System Specialist shall meet the following requirements:
 - a. Manufacturer:
 - a) Allen-Bradley ControlLogix
 - 2) Ethernet Module
 - a) 1756-EN2TR
 - b. The following I/O modules as required for the application.
 - 1) **1756-IA16:** 16-Channel AC Digital Input Module
 - 2) **1756-IB16:** 16-Channel DC Discrete Input Module
 - 3) 1756-OB16E: 16-Channel Relay Output Module
 - 4) 1756-IF8I: 8-Channel Analog Input Module
 - 5) 1756-OF8I: 8-Channel Analog Output Module
 - 6) 1756-FPD: Field Potential Distributor Module
 - c. Network Interface Module
 - 1) Manufacturer:
 - a) ProSoft Technology
 - 2) Module:
 - a) MVI56E-MNETC/MNETCXT
- B. Equipment Manufacturer Supplied PLC Systems:
 - 1. PLCs included in a control panel as part of a mechanical equipment package shall be ControlLogix or CompactLogix.
- C. Features:
 - 1. Each PLC shall be installed with a minimum of 25% spare I/O points of each type utilized in its I/O structure. Each spare I/O point shall be wired to interposing relays and terminal blocks in same fashion as other I/O points.
 - 2. Each PLC shall have a removable nonvolatile memory card installed with capacity greater than or equal to processor internal memory. The controller shall be configured to load a copy of the program from nonvolatile memory whenever there is no project in the controller and power is applied.
 - 3. The PLCs shall be capable of and shall be configured to provide stand-alone operation in the event of a communications link failure.
 - 4. The necessary interface cables, communications cables, power cables, bus extension cables, modular card slot fillers, and other ancillary parts shall be furnished and installed as integral parts of the control system.
 - 5. Nameplates shall be provided for each module, device, and other equipment with appropriate data such as the equipment number, rating, serial number, and manufacturer.
 - 6. All I/O cards shall be furnished with removable terminal blocks to simplify card wiring and replacement.
- D. Spare Parts:
 - 1. See Section 40 67 23 – Control Panels.

PART 3 - EXECUTION

3.1 GENERAL

- A. The Contractor shall utilize personnel who are skilled and experienced in the installation, setup, and configuration of the PLCs being furnished under this contract.
- B. Any PLC, furnished by the Control System Specialist or as part of an equipment manufacturer package, shall be accessible for future program monitoring and revisions. If password protection of any kind is implemented, the manufacturer vendor or Contractor shall supply all passwords or other security information to the Owner and the Engineer.
- C. The Contractor shall furnish the Owner final as-built copies of all documented PLC programs, including manufacturer equipment packages, on electronic media, suitable for future troubleshooting or modifications by others.
- D. All components and assemblies shall be installed as specified in the manufacturer's installation instructions.

END OF SECTION

SECTION 40 66 13 – NETWORKING EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Switches.
 - 2. Media Converters.
- B. Related Requirements:
 - 1. Section 40 66 33 – Fiber Optic Communication Systems

1.2 DEFINITIONS

- A. WAN:
 - 1. Wide Area Network
- B. (V)LAN:
 - 1. (Virtual) Local Area Network
- C. Ring Topology:
 - 1. Each node is connected to two other nodes in a circular path.
- D. Star Topology:
 - 1. All nodes are connected to a single central node such as a switch.
- E. OSI model:
 - 1. 7-layer network model for Open System Interconnection
- F. IOP:
 - 1. Integrated Operating Platform

1.3 SUBMITTALS

- A. Section 01 33 00 – Submittal Procedures specifies requirements for submittals.
- B. Product Data:
 - 1. All user and installation manuals.
- C. Source Quality-Control Submittals:
 - 1. Indicate results of shop tests and inspections.
- D. Field Quality-Control Submittals:
 - 1. Indicate results of Contractor furnished tests and inspections.
- E. Qualifications Statements:
 - 1. Submit qualifications for installer.
- F. Closeout Submittals:
 - 1. Section 01 77 00 – Closeout Procedures specifies requirements for submittals.
 - 2. Project Record Documents:
 - a. Record of actual locations of installed devices and their corresponding IP address.
 - b. Drawing indicating equipment rack layout and cable management plan.
 - c. Test and evaluation reports for field testing of communication equipment.

- d. Copies of all Product Data.
- 3. Operation and Maintenance Data:
 - a. Submit (2) backup copies of software configurations for each networked device.
 - b. Submit (2) copies of a schedule that lists all networked equipment, devices, and instruments, including but not limited to the business network, DMZ/SCADA network, process control system network, surveillance network, and telemetry network. The spreadsheet shall include tag number, description, location, address, and communication protocol for each item listed. Spreadsheet shall be in a format that may be viewed and/or modified using Microsoft Excel.
 - c. Submit (2) copies of a network diagram that graphically shows all networked equipment, devices, and instruments, including but not limited to the business network, DMZ/SCADA network, process control system network, surveillance network, and telemetry network. The network diagram shall include tag number and address for each networked device, as well as detailed VLAN configurations.
- G. Maintenance Material Submittals:
 - 1. Section 01 77 00 – Closeout Procedures specifies requirements for maintenance materials.
 - 2. Spare Parts:
 - a. Fiber and UTP patch cables: Provide five (5) spares of each type.
- 1.4 COORDINATION
 - A. Section 01 30 00 – Administrative Requirements specifies requirements for coordination.
 - B. Coordinate router configurations with internet service provider, Engineer, and Owner's IT staff or designated IT representative.
 - C. Coordinate network equipment software configurations, addresses, with Engineer and Owner's IT staff or designated IT representative.
- 1.5 QUALITY ASSURANCE
 - A. Perform Work as specified in networking industry standards.
- 1.6 QUALIFICATIONS
 - A. Installer:
 - 1. Company specializing in performing Work of this Section with minimum three years of documented experience.
- 1.7 DELIVERY, STORAGE, AND HANDLING
 - A. Section 01 60 00 – Product Requirements specifies requirements for transporting, handling, storing, and protecting products.
 - B. Deliver materials in manufacturer's packaging including application instructions.
 - C. Store as specified in manufacturer's instructions.
- PART 2 - PRODUCTS
- 2.1 EQUIPMENT
 - A. Switches:

1. Din-Mount Network Switches:
 - a. Manufacturer and Product List:
 - 1) Cisco
 - 2) Rockwell Automation
 - 3) Moxa
 - 4) Or Approved Equal.
 - b. Description:
 - 1) Provide 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) Type: Managed, Layer 2
 - 3) Ports: Minimum of 4 with Gigabit Ethernet on switches greater than 4 ports
 - 4) Security: Port security, secure connections (SSH and HTTPS)
 - 5) Features: Support VLANs, SNMPv3, Rapid Spanning Tree (RSTP), and Quality of Service (QoS)
 - 6) Power: 24 VDC
 - 7) Modular Design: Accepts small form-factor pluggable (SFP) media modules.
 - 8) PoE: 802.3at PoE+ (as required)
- B. Media Converters:
 1. Manufacturer and Product List:
 - a. Cisco
 - b. Moxa
 2. Description:
 - a. 10/100/1000 Base-TX to 100Base-FX autosensing media converter.
 - b. Equipped with one RJ-45 Base-TX port and one LC or SC type Base-FX port.
 - c. Shall comply with IEEE 802.3.
 - d. Power supply: 24 V or 120 VAC. Provide power supply sized for the converter if required.
- C. Patch Cables:
 1. Fiber-optic Patch Cables:
 - a. Cable operating range: (-40)°C–70°C, (-40)°F–158°F
 - b. Standard factory tests shall be performed on all cable.
 - c. All cable elements shall be stranded together to maintain flexibility. Stiff central elements such as wire, or dielectrics epoxy glass rods shall not be permitted.
 - d. Jacket shall be PVC and rated for indoor and outdoor installation. Jacket shall be fungus-resistant, UV inhibited, flame retardant, and contain a rip cord for easy removal. Tape separators are not allowed.
 2. Unshielded Twisted Pair (UTP) Patch Cables:
 - a. Provide four each individually twisted pair, 23 AWG–24 AWG conductors, 100 ohm, NFPA 70 CMP rated with PVC jacket for indoor applications and NFPA 70 CMR/CMX rated for outdoor applications.
 - b. Individual pairs shall be constructed to contain minimum two twists per foot per each pair.
 - c. Patch cords shall consist of factory assembled, 4 pair, 100 ohm UTP, Category 6 cables and equivalent eight-position, RJ-45 wiring connectors at each end.
 - d. Shall meet or exceed Category 6 requirements.
 - e. Provide patch cords as indicated plus 25% spare.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation:
 - 1. As specified in manufacturer's instructions.

3.2 MAINTENANCE

- A. Section 01 77 00 – Closeout Procedures specifies requirements for maintenance service.

END OF SECTION

SECTION 40 66 33 – FIBER OPTIC COMMUNICATION SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section Includes:
 - 1. 50/125 multi-mode, outdoor optical fiber cable (OM3).
 - 2. Optical fiber cable connecting hardware, patch panels, and splices.
 - 3. Cabling identification products.
- B. Related Requirements:
 - 1. Section 40 66 13 – Networking Equipment

1.2 DEFINITIONS

- A. BICSI:
 - 1. Building Industry Consulting Service International.
- B. Cross-Connect:
 - 1. A facility enabling the termination of cable elements and their interconnection or cross-connection.
- C. RCDD:
 - 1. Registered Communications Distribution Designer.

1.3 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Action Submittals:
 - 1. Product Data:
 - a. For each type of product
 - 2. Shop Drawings:
 - a. Reviewed and stamped by RCDD
 - b. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
 - c. System Labeling Schedules:
 - 1) Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
 - d. Cabling administration drawings and printouts.
 - e. Wiring diagrams to show typical wiring schematics including:
 - 1) Telecommunications rooms plans and elevations
 - 2) Telecommunications pathways
 - 3) Telecommunications system access points
 - 4) Telecommunications grounding system
 - 5) Cross-connects
 - 6) Patch panels
 - 7) Patch cords
 - f. Cross-connects and patch panels
 - 1) Detail mounting assemblies and show elevations and physical relationship between the installed components.
 - 3. Optical fiber cable testing plan
- C. Informational Submittals:

1. Qualification Data: For RCDD, Installer, installation supervisor, and field inspector.
 2. Source quality-control reports
 3. Product Certificates: For each type of product
 4. Field quality-control reports
- D. Closeout Submittals:
1. Maintenance Data: For optical fiber cable, splices, and connectors to include in maintenance manuals.
- E. Maintenance Material Submittals:
1. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - a. Patch-Panel Units: One (1) of each type
 - b. Plugs: Ten (10) of each type
 - c. Jacks: Ten (10) of each type

1.4 QUALITY ASSURANCE

- A. The Contractor shall designate in writing the qualified Fiber 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 Fiber System Specialist shall be subject to approval of the Owner and the Engineer.
- B. The minimum qualifications for the Fiber System Specialist shall include:
1. An established firm in operation as a fiber optic design and installation company.
 2. Staffed with experienced personnel capable of executing all aspects of the project.
 3. BICSI RCDD certification for design of the fiber optic system.
 4. BICSI Installer certification for installation of the fiber optic system.
 5. Demonstrated experience with design and installation of multi-mode fiber optic installations.
- C. Installer Qualifications:
1. Cabling Installer must have personnel certified by BICSI on staff.
 2. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings by an RCDD.
 3. Installation Supervision: Installation shall be under the direct supervision of Technician, who shall be present at all times when Work of this Section is performed at Project site.
 4. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- D. Testing Agency Qualifications:
1. Testing agency must have personnel certified by BICSI on staff.
 2. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD.

1.5 SCOPE

- A. The scope of the optical fiber cabling installation for this project includes:
- B. Treatment Plant Multi-Mode Fiber Optic System
1. Provide a 12-strand multimode fiber optic cabling system between buildings at the treatment plant as depicted on the contract drawings, to provide a communication link between buildings for process control and SCADA HMI networks.
 2. The scope of the Fiber System Specialist will include all items, as needed, up to and including fiber patch panel enclosures. This shall include all cabling, splices, boxes, taps, patch panels, testing, and other items as required for a complete system.

3. The Fiber System Specialist shall be responsible for the design and selection of cabling and hardware required to achieve a reliable communication link without the use of fiber amplifiers or compensators.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site
 1. Test optical fiber cable to determine the continuity of the strand end to end.
 2. Test optical fiber cable while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector, including the loss value of each. Retain test data and include the record in maintenance data.

1.7 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and cabling with water pipe.

1.8 WARRANTIES

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. General Performance:
 1. Backbone cabling system shall comply with transmission standards in TIA-568-C.1, when tested as specified in test procedures of this standard.
- B. Surface-Burning Characteristics:
 1. As determined by testing identical products as specified in ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 2. Flame-Spread Index: 25 or less
 3. Smoke-Developed Index: 50 or less
- C. Telecommunications Pathways and Spaces:
 1. As specified in TIA-569-D.
- D. Grounding:
 1. As specified in TIA-607-B.

2.2 50/125 MICROMETER MULTI-MODE, OUTDOOR OPTICAL FIBER CABLE (OM3)

- A. Description:
 1. Multimode, laser-optimized 50/125-micrometer, 12 fibers, tight buffer, optical fiber cable, listed for the application.
- B. Manufacturers (Subject to requirements):
 1. 3M
 2. Belden
 3. CommScope
 4. Corning Cable Systems
 5. General Cable
 6. Superior Essex
 7. Or Approved Equal.

- C. Standards:
 - 1. As specified in TIA-492AAAC for detailed specifications.
 - 2. As specified in TIA-568-C.3 for performance specifications.
 - 3. As specified in ICEA S-87-640 for mechanical properties.
- D. Maximum Attenuation:
 - 1. 2.3 dB/km at 850 nm; 0.6 dB/km at 1,300 nm.
- E. Minimum Overfilled Modal Bandwidth-Length Product:
 - 1. 1,500 MHz-km at 850 nm; 500 MHz-km at 1,300 nm.
- F. Armor:
 - 1. Corrugated steel armor underneath outer jacket for crush protection.
- G. Jacket:
 - 1. Jacket Color: Aqua.
 - 2. Cable cordage jacket, fiber, unit, and group color shall be as specified in TIA-598-D.
 - 3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 in.
- H. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as specified in UL 444, UL 1651, and NFPA 70.

2.3 FIBER OPTIC SPLICING

- A. Provide fiber optic splices along the fiber optic route at required intervals due to spool length limitations.
- B. All splices shall be fusion type with a maximum attenuation loss of 0.5 dB.
- C. Splices shall be made within a fiber splice closure located in a below grade box to protect the splice from physical damage. The closure shall be designed for use in below grade applications to protect against moisture intrusion.

2.4 OPTICAL FIBER CABLE HARDWARE

- A. Standards:
 - 1. As specified in Fiber Optic Connector Intermateability Standard (FOCIS) specifications of the TIA-604 series.
 - 2. As specified in TIA-568-C.3.
- B. Cross-Connects and Patch Panels:
 - 1. Modular panels housing multiple-numbered, duplex cable connectors.
 - 2. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.
- C. Patch Cords:
 - 1. Factory-made, dual-fiber cables in 36-inch lengths.
- D. Connector Type:
 - 1. Type LC
- E. Plugs and Plug Assemblies:
 - 1. Male; color-coded modular telecommunications connector designed for termination of a single optical fiber cable.

2. Insertion loss not more than 0.75 dB
3. Marked to indicate transmission performance

F. Jacks and Jack Assemblies:

1. Female; quick-connect, simplex and duplex; fixed telecommunications connector designed for termination of a single optical fiber cable.
2. Insertion loss not more than 0.25 d
3. Marked to indicate transmission performance.
4. Designed to snap-in to a patch panel or faceplate

2.5 GROUNDING

- A. As specified in TIA-607-B.

2.6 IDENTIFICATION PRODUCTS

- A. As specified in TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.7 SOURCE QUALITY CONTROL

- A. Testing Agency:
1. Engage a qualified testing agency to evaluate cables.
- B. Factory test multimode optical fiber cables as specified in TIA-526-14-B and TIA-568-C.3.
- C. Factory test pre-terminated optical fiber cable assemblies as specified in TIA-526-14-B and TIA-568-C.3.
- D. Cable will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

- A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.2 WIRING METHODS

- A. Wiring Method:
1. Install fiber cable in conduit
- B. Wiring within Enclosures:
1. Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.3 INSTALLATION OF OPTICAL FIBER BACKBONE CABLES

- A. As specified in NECA 1, NECA 301, and NECA/BICSI 568.
- B. General Requirements for Optical Fiber Cabling Installation:

1. As specified in TIA-568-C.1 and TIA-568-C.3.
2. As specified in BICSI ITSIMM, Ch. 6, "Cable Termination Practices."
3. Terminate all cables; no cable shall contain unterminated elements. Make terminations only at specified outlets, terminals, cross-connects, and patch panels.
4. Secure and support cables at intervals not exceeding 30 in. and not more than 6 in. from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
6. Bundle, lace, and train cable to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
7. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
8. Pulling Cable: As specified in BICSI ITSIMM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
9. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

C. Group connecting hardware for cables into separate logical fields.

3.4 GROUNDING

- A. Install grounding as specified in BICSI ITSIMM, "Grounding (Earthing), Bonding, and Electrical Protection" Chapter.
- B. As specified in TIA-607-B and NECA/BICSI-607.

3.5 IDENTIFICATION

- A. Identify system components, wiring, and cabling as specified in TIA-606-B.
- B. Cabling Administration Drawings:
 1. Show plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications pathways and cables.
- C. Cable and Wire Identification:
 1. Label each cable within 4 in. of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as specified.
- D. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with TIA 606-B:
 1. Flexible vinyl or polyester that flexes as cables are bent

3.6 FIELD QUALITY CONTROL

- A. Testing Agency:
 1. Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service:
 1. Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Tests and Inspections:
 1. Visually inspect optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations for compliance with color-coding for pin assignments and inspect cabling connections for compliance with TIA-568-C.1.

2. Visually inspect cable placement, cable termination, grounding and bonding, equipment, and patch cords, and labeling of all components.
 3. Optical Fiber Cable Tests:
 - a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - b. Link End-to-End Attenuation Tests:
 - 1) Horizontal and multimode backbone link measurements: Test at 850 or 1,300 nm in one direction as specified in TIA-526-14-B, Method B, One Reference Jumper.
 - 2) Attenuation test results shall be less than those calculated as specified in the equation in TIA-568-C.1.
 - D. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
 - E. Remove and replace cabling where test results indicate that it does not comply with specified requirements.
 - F. End-to-end cabling will be considered defective if it does not pass tests and inspections.
 - G. Prepare test and inspection reports.
- 3.7 DEMONSTRATION
- A. System Demonstration and Final Acceptance Test:
 1. The Contractor shall conduct a 10-day Final Acceptance test of the completed installation. The test shall start after the Engineer has received marked record (as-built) drawings from the Contractor and when directed by the Owner/Engineer.
 2. The system shall operate with 100% reliability during the test period. Failure of hardware shall require repair or remedy of the defect to the satisfaction of the Engineer within a two-hour period. 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.
 3. The Contractor shall complete the Operations and Maintenance Manuals including all updated documentation of programmable devices to the satisfaction of the Engineer.
 4. The Contractor will be allowed two attempts at successfully completing the Final Acceptance Test. After that time, the Contractor will become responsible to reimburse the Owner for liquidated damages.
 - B. 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 startup. 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.
 - C. Maintenance Instruction:
 1. Operating and maintenance instructions, along with a separate parts list, shall be furnished in three 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.

2. Warranty: All equipment and workmanship furnished under this contract shall be guaranteed to be free of defects in materials and workmanship for a period of 2 years from and after the date of Final Acceptance of the work by the Owner, and any such defects which appear within the stipulated guarantee 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 66 34 – COPPER DATA COMMUNICATION CABLING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes requirements for twisted pair data communication cabling for Ethernet networks.
- B. Related Sections:
 - 1. Section 40 66 13 – Networking Equipment.

1.2 DEFINITIONS

- A. UTP: Unshielded twisted pair
- B. F/UTP: Unshielded Twisted Pair with overall foil shield.

1.3 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Product Data:
 - 1. Provide for each material or equipment item specified.
- C. Shop Drawings:
 - 1. Point-to-point wiring diagrams for cables installed under this Section.
 - 2. Detailed plan views and elevations of telecommunications spaces showing termination equipment, and cable paths.
 - 3. Minimum Scale for Details: 1/4 in.
- D. Termination Schedule:
 - 1. Cable identification number.
 - 2. Room location.
- E. Assurance/Control Submittals:
 - 1. Certificates: Manufacturer's certificate that Products meet or exceed specified requirements.
 - 2. Qualification Documentation: Submit documentation of experience as specified in qualification requirements.
- F. Certification:
 - 1. Comprehensive test results for specified category per specifications of TIA/EIA 568A. Test results shall be furnished in electronic PDF format.
- G. Project Record Documents:
 - 1. Cable pulling schedules in electronic format.
 - 2. Labeling shall be as specified in ANSI/TIA/EIA-606 guidelines.

1.4 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Manufacturer: Company specializing in manufacturing Products specified with minimum 5 years of documented experience.

2. Installer: Company specializing in the installation of structured wiring systems with minimum 5 years of documented experience.
- B. Regulatory Requirements:
1. See requirements of NFPA 70.
 2. Products: Listed and classified by Underwriter's Laboratories Incorporated as suitable for the purpose specified.
- C. Preinstallation Meetings:
1. Convene a preinstallation meeting one week prior to commencing Work of this Section.
 2. Require attendance of parties directly affecting Work of this Section.
 3. Review conditions of operations, procedures, and coordination with related work.
 4. Agenda:
 - a. Tour, inspect, and discuss conditions relating to communications cable.
 - b. Review exact location of each item within building construction, casework, and fixtures and their requirements.
 - c. Review required submittals, both completed and yet to be completed.
 - d. Review Drawings and Specifications.
 - e. Review and finalize construction schedule and verify availability of materials, personnel, equipment, and facilities needed to make progress and avoid delays.
 - f. Review cable routing and support.
- 1.5 DELIVERY, STORAGE, AND HANDLING
- A. Transport, handle, store, and protect products.
- B. Deliver as specified in NEMA WC 26.

1.6 REFERENCES

- A. TIA/EIA (Telecommunication Industry Association / Electronic Industries Association):
1. 568-A – Commercial Building Telecommunications Cabling Standard
 2. 569 – Commercial Building Standard for Telecommunications Pathways
 3. 606 – Administration Standard for the Telecommunications Wiring Standard
 4. 607 – Commercial Building Grounding and Bonding Requirements for Telecommunications
- B. IEC (International Electrotechnical Commission):
1. 61918 – Industrial Communication Networks – Installation of Communication Networks in Industrial Premises.
- C. NEMA (National Electrical Manufacturer's Association):
1. WC 26 – Wire and Cable Packaging.
- D. NFPA (National Fire Protection Association):
1. 70 – National Electrical Code.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturers subject to project requirements:
1. CommScope
 2. Panduit
 3. Belden

4. Siemon
5. Approved Equal

2.2 UNSHIELDED TWISTED PAIR (UTP) CABLE

- A. Category: 6a
- B. Conductors:
 1. Bulk Cable:
 - a. Four-pair balanced twisted pair – 23 AWG, solid copper.
 2. Patch Cables:
 - a. Four-pair balanced twisted pair, straight through type – 26 AWG minimum, stranded copper.
- C. Jacket:
 1. PVC jacket rated for 300V.
 - a. Provide riser rated jacket for bulk cable.
 - b. Provide plenum rated jacket when installed in plenum spaces.
 - c. Provide UV-resistant, weatherproof jacket for outdoor installations.
- D. Separator:
 1. Integrated spline separator.
- E. Connector Requirements:
 1. RJ45 modular plug connectors.
 2. Strain-relief boot.
- F. Performance:
 1. Cable shall meet TIA-568.2-E requirements.
 2. Connections meet TIA-568B connection requirements.
 3. UL Listed.
 4. Suitable for PoE and PoE+ applications.

2.3 SHIELDED TWISTED PAIR (F/UTP) CABLE

- A. Category: 6a
- B. Conductors:
 1. Bulk Cable:
 - a. Four-pair balanced twisted pair – 23 AWG, solid copper.
 2. Patch Cables:
 - a. Four-pair balanced twisted pair, straight through type – 26 AWG minimum, stranded copper.
- C. Shielding:
 1. Overall foil shield to protect against electrical interference.
- D. Jacket:
 1. PVC jacket rated for 300V or 600V as required for the application.
 - a. Provide riser rated jacket for bulk cable.
 - b. Provide plenum rated jacket when installed in plenum spaces.
 - c. Provide UV-resistant, weatherproof jacket for outdoor installations.
- E. Separator:
 1. Integrated spline separator.

- F. Connector Requirements:
 - 1. RJ45 modular plug connectors for shielded cable.
 - 2. Strain-relief boot.
 - 3. Industrial vibration-resistant construction.
- G. Performance:
 - 1. Cable shall meet TIA-568.2-E requirements.
 - 2. Connections meet TIA-568B connection requirements.
 - 3. UL Listed.
 - 4. Suitable for PoE and PoE+ applications.
 - 5. Comply with TIA-1005-A MICE ratings for industrial environments.
 - a. Mechanical Severity: M2.
 - b. Ingress Severity: I2.
 - c. Climatic/Chemical Severity: C2.
 - d. Electromagnetic Severity: E2.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify existing conditions before starting work.
- B. Report in writing to the Engineer prevailing conditions that will adversely affect satisfactory execution of the Work of this Section. DO NOT proceed with Work until unsatisfactory conditions have been corrected.

3.2 COLOR CODING

- A. Provide cable colors as follows unless otherwise indicated:
 - 1. Industrial Operational Technology (OT) Networks:
 - a. PLC/Device Level: Blue
 - b. SCADA Level: Yellow
 - 2. Information Technology (IT) Networks: White.
 - 3. Security Systems: Gray.
 - 4. Life Safety Systems: Red.

3.3 CABLE APPLICATIONS

- A. Finished Spaces:
 - 1. Provide Category 6a UTP cable.
 - 2. UTP cabling shall maintain separation from:
 - a. Variable frequency drive output conductors.
 - b. Motor feeders.
 - c. High-Voltage conductors.
 - d. Sources of electromagnetic interference.
- B. Unfinished Process Spaces:
 - 1. Provide Category 6a F/UTP shielded cable with MICE ratings specified in Part 2.
 - 2. Cables shall be provided with an insulation rating that meets or exceeds the operating voltage of all conductors within the same enclosure or installed within 12 inches.

3.4 INSTALLATION

- A. Cross electrical cables with communications cable at 90 degrees only.

- B. Run communication cables and power cables in separate conduits.
- C. Limit cable runs to a maximum of 300 ft.
- D. See cable manufacturers minimum bend radius requirements:
 - 1. DO NOT stretch, stress, tightly coil, bend or crimp cables.
 - 2. Replace cables that are severely stressed during installation at no additional cost to Owner.
- E. Furnish and install machine generated labels.
 - 1. Communications Cables:
 - a. Display cable identification number in black uppercase lettering on permanent adhesive white label stock covered with water resistant sealer.
 - b. Place labels on each end of cable, maximum 6 in. from cable termination.
- F. Components installed in industrial areas shall comply with IEC 61918 installation practices for:
 - 1. EMC mitigation.
 - 2. Cable routing.
 - 3. Separation from power conductors.
 - 4. Industrial grounding and bonding systems.
- G. Dress and secure patch cords to maintain orderly installation within cabinets and racks.
- H. For shielded cable, connect the foil shield to ground at one end only unless the connected device manufacturer specifically requires another arrangement.
- I. Factory manufactured patch cabling is required for connecting cables within racks, enclosures, and control panels. Field-constructed patch cords utilizing bulk cabling are not acceptable.

3.5 CONSTRUCTION

- A. Interface with Other Work:
 - 1. Provide information to affected trades regarding requirements and responsibilities for preparation of Work of a particular trade for installation of Work installed under this section.

3.6 FIELD QUALITY REQUIREMENTS

- A. Field testing and inspection.
 - 1. Any bulk cabling or field constructed patch cabling shall be inspected during installation and at completion of installation.
 - 2. Perform end-to-end tests of each cable as follows:
 - a. Pair/conductor for proper pinouts and continuity.
 - b. Ground fault.
 - c. Proper termination, shorts, and crossed pairs.
 - d. Channel attenuation per ANSI/TIA/EIA-568-A, Annex E or later.
 - e. Channel bidirectional worst case near end cross talk (NEXT) at frequencies up to 250 MHz, per ANSI/TIA/EIA-568-A, Annex E or later.
 - f. Measured effective cable run length.
 - g. Insertion and return loss.

END OF SECTION

SECTION 40 67 23 – CONTROL PANELS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section Includes:
 - 1. All control panels provided as part of the project, including those provided as part of a manufacturer supplied system specified in other Divisions.
 - 2. The Work to furnish and install functional control panels to operate control systems manually or automatically as specified in this and related sections.
- B. Related Sections:
 - 1. Section 40 61 13 – Process Control System General Provisions
 - 2. Section 40 63 43 – Programmable Logic Controllers
 - 3. Section 40 66 13 – Networking Equipment

1.2 REFERENCES

- A. NEMA
 - 1. Standard ICS 2 – 2000 Industrial Control and Systems
- B. NFPA
 - 1. 70 – National Electrical Code (NEC)
 - 2. 70E – Standard for Electrical Safety in the Workplace
 - 3. 79 – Electrical Standard for Industrial Machinery
- C. UL
 - 1. 508/508A – Industrial Control Enclosures
- D. All equipment components and completed assemblies specified in this Section shall bear the appropriate label of Underwriters Laboratories.

1.3 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Action Submittals:
 - 1. Shop Drawings and Product Data:
 - a. 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. Specify special identifications for devices as required by the mechanical equipment manufacturer or as may be specified in Drawings.
 - b. Equipment outline drawings showing elevation, plan and interior views, front panel arrangement, dimensions, weight, shipping splits, conduit entrances and anchor bolt pattern. Specify all options, special features, ratings, and deviations from this Section.
 - c. Power and control schematics including external connections. Show wire and terminal numbers and color-coding.

- d. Custom networking diagrams for each panel. Depict all Ethernet (copper or fiber) devices in the panel and how they are connected. Show all interconnecting cables, including those leaving the enclosure with destination label.
- e. Instruction and replacement parts books, including manufacturer's part numbers and selections of component ratings.
- f. As-built final drawings.
- g. Documentation that the panel assembly facility is a UL-508 certified facility.
- h. Furnish complete Bill of Materials specifying manufacturer's name and part numbers.
- i. 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.
- j. Assembly Ratings:
 - 1) Short-circuit rating
 - 2) Voltage
 - 3) Continuous current
- k. Major Component Ratings:
 - 1) Voltage
 - 2) Continuous current
 - 3) Interrupting ratings
- l. Cable terminal sizes
- m. Instruction and renewal parts books.

C. Informational Submittals:

- 1. Factory Tests:
 - a. Submittals shall be made for factory tests specified herein.
- 2. Field Test Reports:
 - a. Submittals shall be made for field tests specified herein.
- 3. Operation and Maintenance Manuals:
 - a. Include Manufacturer's contact address and telephone number for parts and service.
 - b. Include Instruction books and/or leaflets.
 - c. Include Recommended renewal parts list.
 - d. Include Record Documents for the information required by the Submittals paragraph above.

1.4 QUALITY ASSURANCE

- A. Submittals shall contain information on related equipment to be furnished under this section 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 unreviewed.
- 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. 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.
- F. 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.
- G. 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.
- H. 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.
- I. Control panels submitted shall fit within the space shown on the Drawings. Equipment which does not fit within the space is not acceptable.
- J. 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 as specified in manufacturer's instructions. Two 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 2 years 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.
- B. See Section 01 78 36 – Warranties and Bonds for additional requirements.

PART 2 - PRODUCTS

2.1 RATINGS

- A. The service voltage shall be as specified and as shown on the Drawings. The overall short circuit withstand and interrupting rating of the equipment and devices shall be not less than 22,000 amperes RMS symmetrical for panels operating at 480/277 V, 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 amps RMS symmetrical for panels operating at 120 VAC.
- 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 NEC.
- E. The control panel enclosure shall be NEMA rated as specified in this section.
- F. Motor controllers, including associated devices, shall be designed for continuous operation at rated current in a 50°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 specifies 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:
- 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 specified. Panel meters shall be 4mA – 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 specified 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. No field instruments or device signals shall interface directly with PLC input or output modules without the use of an interposing relay. Devices shall be PLC-RSC series as manufactured by Phoenix Contact or equal. Provide pullup or pulldown 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 V 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, 120 VAC 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. Power supplies shall be provided as a redundant pair where indicated on the drawings. These power supplies must be wired in parallel through a redundancy diode to ensure that a single power supply failure does not result in a loss of DC power. Each power supply shall be independently capable of meeting all DC power load requirements of the panel. Redundancy diodes shall be of the same manufacturer as the power supplies.
- 8. Surge Protection:
 - a. Provide a surge protection device installed on the incoming power source to protect control panel components from electrical surge damage. Surge device shall be rated for the voltage and phase of the incoming power source.
- 9. Phase Monitor:
 - a. For control panels powering three phase motors with across-the-line or reduced voltage starters, provide a phase monitoring relay wired into the motor start circuits to stop motors during a loss of phase condition. Motor Saver Model 460 or equivalent.
- 10. Motor Control Reset:
 - a. For panels controlling motors:
 - 1) Provide a physical reset button on the face of the panel that resets all controllers, overloads, and interlock circuits.
 - 2) Provide an automatic reset feature whereby any electronic motor controller or fail-safe interlock circuit is automatically reset when power is lost and subsequently restored to the panel.
- 11. Manual Operation
 - a. Where control panels are provided with programmable logic controllers (PLCs) in conjunction with motor starting equipment, the panel shall be provided with the capability to run all motors in a manual mode in the event of PLC failure.
- 12. Interior Lighting:
 - a. Each control panel provided with a PLC shall contain an LED lighting fixture to illuminate internal control panel components. The fixture shall be mounted near the top of the control panel in manner that does not inhibit access to DIN rail mounted devices and shall be marketed for such application by the manufacturer.
 - b. The lighting fixture shall be 120 V rated and automatically illuminate when panel door(s) is(are) opened.
- 13. Intrusion Detection:
 - a. Each control panel provided with a PLC shall contain intrusion switches capable of determining the open/close state of the enclosure door(s). The switch(es) shall be wired to a compatible digital input I/O point, whether or not indicated on the drawings.
- 14. High Temperature Detection:
 - a. Each control panel provided with a PLC shall contain a temperature switch, regardless of installation location or the presence of environmental conditioning. The switch shall be located in a manner to read the highest internal ambient

temperature present within the control panel enclosure. The switch shall be wired to a compatible digital input I/O point, whether or not indicated on the drawings.

- b. The temperature switch shall have an adjustment range of 90°F–140°F. The switch shall be set to change state at 105°F unless otherwise indicated in drawings.

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 freestanding 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 able to be padlocked.

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 in. by 24 in. and below). All others 3-point latch.
- g. Manufacturers
 - 1) Hoffman Comline Series
 - 2) EMF Company
 - 3) NEMA Enclosures Company
 - 4) Hammond Company
 - 5) Or 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 in. by 24 in. and below). All others 3-point latch.
- g. Manufacturers
 - 1) Hoffman Comline Series
 - 2) EMF Company
 - 3) NEMA Enclosures Company
 - 4) Hammond Company
 - 5) Or 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 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-airconditioned space.
 - 1) Enclosure heaters shall be energized from 120 V, 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°F–90°F. 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 V rated, powered at 120 V 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 1/2 in. stainless steel condensate drain.
- D. Internal Wiring:
- 1. Power and control wiring shall be tinned stranded copper, minimum size No. 16 AWG, with 600 V, 90°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 600V 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 4mA – 20 mA signals or low voltage analog signals are routed in the same wire trough as power conductors carrying greater than 120V.

6. Both AC and DC power distribution within the panel shall be provided with 20% spare termination points to simplify the supplying of power to future device.
 7. All control panel wiring shall use color coding:
 - 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: 480 V AC 3-phase – phase A
 - k. Orange: 480 V AC 3-phase – phase B
 - l. Yellow: 480 V 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 like 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 V except for control and instrumentation circuits, or 4 mA – 20 mA analog signal conductors.
 2. Provide 600 V rated terminal blocks for any conductor carrying any voltage over 120 V to ground.
 3. Provide 600 V 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% 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 V and below, and 4 mA – 20 mA analog signal conductors shall be terminated with manufacturer's recommended insulated connectors.
9. Current Loop Surge Protection Devices: The 4 mA – 20 mA 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. Group and organize all I/O field termination terminal blocks, relays, and analog surge suppressors by their associated I/O module. Discrete inputs, discrete outputs, analog inputs, and analog outputs must be grouped together, in order of their channel on the I/O card, and separated by terminal block flags indicating the respective rack and slot for that group. For example, if a card is located in rack 1, slot 2, the flag should be labeled "R1S2" or similar. Each I/O group should include the appropriate number of terminal block-style interposing relays for discrete inputs and outputs, and analog signal surge suppressors for analog inputs and outputs.
11. Fused terminal blocks shall be used for all DC branch circuits within the panel and any controls signals leaving the enclosure carrying panel power and returning (e.g., conductors on the wet side of dry contacts in the field). AC and DC fused terminal blocks must be grouped separately. Fused terminal blocks shall be Phoenix Contact UT 4-HESILA 250 or approved equivalent.
12. All wiring to hazardous locations shall terminate in intrinsically safe barrier devices.
13. Provide an AC ground bar bonded to the panel enclosure (if metal) with 20% spare terminals.
14. Provide ground terminal blocks for each twisted-shielded pair drain wire.

2.3 MAIN CIRCUIT PROTECTIVE DEVICE

- A. For panels operating at 480 VAC, unless otherwise shown on the Drawings, the main circuit protective device shall be a molded case (MCCB), 3 Pole, 600 V, 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 specified in 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 1,400% of rated continuous current and a trip test feature. MCPs shall be labeled as specified in UL489. NEMA starter sizes and breaker trip ratings shall be as required for the horsepower specified 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 V 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, 600V, 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 120V 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 V, 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 V 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 300V, industrial rated, plugin socket type, housed in a transparent polycarbonate dust cover, designed as specified in UL Standard 508 for motor controller duty. Continuous contact rating shall be 10 amps resistive, 1/4 HP at 120 VAC, operating temperature -10°C–55°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 V, 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.** As specified in Division 26 – Electrical for variable frequency drives (VFDs), where VFDs are provided for motor starting and control.

2.6 INSTRUMENTATION DEVICES

- A. Where instrumentation devices are specified in Drawings, see Instrumentation sections of Division 40 – Process Integration.

2.7 REMOTE MONITORING AND CONTROL INTERFACE

- A. General:
 - 1. 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 form C relays with contacts rated at 120 V 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:
 - 1. Where specified in Drawings or within an equipment section, an OIT shall be mounted on the front of the control panel for display and control of process-specific graphics.
 - 2. OITs shall:
 - a. Allen-Bradley Panelview Plus 7.
 - b. Minimum Screen Size: 10 in. diagonal.
 - c. Provide Ethernet/IP communication capability compatible with Allen-Bradley family PLCs.
 - d. Provide devices with 2GB memory card.
 - e. Provide nonglare screen protector. For HMIs installed outdoors, provide hinged weatherproof cover.
 - f. OITs may also be referred to throughout contract documents as Human Machine Interface (HMI).

2.10 NETWORK DEVICES

- A. Refer to Section 40 66 13 – Networking Equipment for network device requirements.
- B. Media Converters:
 - 1. Provide copper to fiber media converters where specified in Drawings or where required to interface with external cabling.
- 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. A "UPS OK" discrete signal shall be wired to a compatible digital input I/O point, whether or not indicated on the drawings.

- B. The UPS shall provide backup power:
1. True sine wave output with online double conversion configuration
 2. Fault, overload, and replace batteries indicators.
 3. Voltage input: 120 VAC single phase
 4. Voltage output: 120 VAC single phase
 5. Output power capacity: 1,000 watts/1,500VA minimum
 6. Internal or external bypass.
 7. Hot-swap batteries $\geq$ 2min. (at 25°C, full load = 600W, p.f. between 0.6 – 0.75)
 8. UPS to be manufactured by Allen Bradley, or equal.
- C. To ensure the preservation of battery health, UPS batteries shall not be connected, nor the UPS activated, prior to installation in the field. Upon installation, manufacturer instructions shall be followed to connect the batteries and activate the UPS system. Any premature activation or connection of the UPS batteries before field installation could result in reduced battery performance and lifespan and shall result in the replacement of batteries at no additional cost to the Owner.

2.12 INDICATING BEACONS AND HORNS

- A. Headworks remote IO control panel for H₂S gas detection and monitoring and odor control damper control shall be supplied with an indicating beacon and horn.
- B. Manufacturers:
1. Federal Signal SLM500
 2. Approved equal.
- C. Description: Method of both visually and audibly alerting staff to the presence of hydrogen sulfide. Beacon and horn may be integral unit or supplied separately and field-mounted in same location. Supply bypass switch such that beacon and horn does not provide false signal during gas detector calibration and testing.
- D. Beacon Features:
1. Enclosure: Rated for outdoor installation with direct exposure to elements.
 2. Operating Voltage: 120VAC.
 3. Color: Red.
 4. Mounting: 3/4" NPT for installation on rigid electrical conduit.
- E. Horn Features:
1. Enclosure: Rated for outdoor installation with direct exposure to elements.
 2. Operating Voltage: 120VAC.
 3. Minimum Sound Level: 100dbA.
 4. Mounting: 3/4" NPT for installation on rigid electrical conduit.

2.13 SPARE PARTS

- A. Provide spare parts in the quantities specified:
1. One PLC I/O modules of each type furnished.
 2. One communication module of each type furnished.
 3. Six replacement fuses, all types and sizes.
 4. One replacement lamp of each color, for pilot lights.
 5. One of each color replacement lens caps for pilot lights.
 6. One starter coil for each NEMA size furnished.
 7. One, 3-pole set of replacement overload heaters of each size range used.
 8. One, 3-pole set of starter contacts of each NEMA size used.

- B. 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.
- C. 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.

2.14 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 be subject to the latest applicable requirements of ANSI, IEEE, UL, and NEMA standards, and 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 of 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 specified 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 1,000 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. Touchup 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. This Section Includes:
 - 1. The PLC and HMI programming work to be performed by the Application Engineer, 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.
- B. Related Sections:
 - 1. Section 40 61 96 – Process Control Descriptions

1.2 REFERENCES

- A. ANSI/ISA:
 - 1. 18.2-2016 – Management of Alarm Systems for the Process Industries.

1.3 DEFINITIONS

- A. SCADA:
 - 1. Supervisory Control and Data Acquisition
- B. HMI:
 - 1. Human Machine Interface
- C. OIT:
 - 1. Operator Interface Terminal
- D. PLC:
 - 1. Programmable Logic Controller
- E. I/O:
 - 1. Input/Output
- F. VFD:
 - 1. Variable Frequency Drive
- G. SSRVS:
 - 1. Solid State Reduced Voltage Starter ("Soft Starter")
- H. RTU:
 - 1. Remote Telemetry Unit
- I. MTU:
 - 1. Master Telemetry Unit
- J. MCC:
 - 1. Motor Control Center
- K. ETM:
 - 1. Elapsed Time Meter

- L. IOP:
 - 1. Integrated Operating Platform – System of installed, connected, and configured hardware, operating programs, and networking equipment.
- M. PLC and HMI Programming:
 - 1. Software configuration of operating programs to implement plant control strategies.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 SCOPE

- A. The Application Engineer shall be responsible for design of the PLC and HMI programs to achieve process control as specified in Drawings and sections. The Application Engineer shall fully coordinate all components and details of the control system with all other equipment on the project.
- B. The Application Engineer shall coordinate all PLC and HMI programming, testing, and startup activities throughout the duration of the project.
- C. Before Final Acceptance, the Application Engineer 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 Application Engineer. 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 Application Engineer 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 Application Engineer 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 Drawings show the expected I/O points. Some I/O points on the input/output list may exist and therefore not specified in 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 Application Engineer 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 minimum, the security configuration shall consist of four access levels (Coordinate additional access levels and restrictions with Owner):
1. Engineer:
 - a. 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 use a User Configuration popup 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 popup 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. 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. Preconfigure 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 are 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. Popup 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 popup 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 Unsuspending
 - 4. Stopping and Stopped
 - 5. Aborting, Aborted, and Clearing
 - C. A PID popup 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 setpoint, and real time trend with setpoint, 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 set up initially with the basic functionality as specified in Section 40 61 96 – Process Control Descriptions. These descriptions shall be used as a guide for controlling various items by location and the Application 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 Application Engineer shall coordinate the functionality of each item in the control description with the Contractor, Owner, and Operator. The Application Engineer 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. This Section Includes:
 - 1. The Work for 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.
- B. Related Sections:
 - 1. Section 40 61 13 – Process Control System General Provisions
 - 2. Division 40 – Process Integration Instrumentation Sections

1.2 REFERENCES

- A. ISA:
 - 1. S20 – Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves
 - 2. S50.1 – Compatibility of Analog Signals for Electronic Industrial Process Instruments
 - 3. S51.1 – Process Instrumentation Terminology
 - 4. 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. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Product Data:
 - 1. Submit manufacturer information for system materials and component equipment, including connection requirements.
- C. Shop Drawings:
 - 1. Specify system materials and component equipment.
 - 2. Submit installation requirements and other details.
- D. Manufacturer's Certificate:
 - 1. Certify that products meet or exceed specified requirements.
- E. Source Quality-Control Submittals:
 - 1. Specify results of factory tests and inspections.
- F. Field Quality-Control Submittals:
 - 1. Specify results of Contractor-furnished tests and inspections.
- G. Manufacturer Reports:
 - 1. Certify that equipment has been installed as specified in manufacturer instructions.

- H. Qualifications Statement:
 - 1. Submit qualifications for manufacturer.
- I. Closeout Submittals
 - 1. See Section 01 77 00 – Closeout Procedures for requirements.
 - 2. Project Record Documents:
 - a. Record actual locations and final orientation of equipment and accessories.

1.5 QUALITY ASSURANCE

- A. Make sure that materials of construction of wetted parts are compatible with process liquid.
- B. Materials in Contact with Potable Water:
 - 1. Certified to NSF 61 and NSF 372.

1.6 QUALIFICATIONS

- A. Manufacturer:
 - 1. Company specializing in manufacturing products specified with minimum three years of documented experience.

1.7 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 specifying that Work performed at manufacturer's facility conforms to Contract Documents.
- C. Similar instruments shall be by the same Manufacturer to the extent practical.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Section 01 60 00 – Product Requirements: Requirements for transporting, handling, storing, and protecting products.
- B. Inspection:
 - 1. Accept materials on Site in manufacturer's original packaging and inspect for damage.
- C. Store equipment as specified in 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 as specified in manufacturer instructions.

1.9 WARRANTY

- A. See 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:
 - 1. Each field mounted instrument or control device shall be identified by its unique tag number as it appears in the contract documents. The tag number shall be stamped on a 1 in. by 2 in. 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 Section Sheet.
- B. Sunshades:
 - 1. Furnish stainless steel sunshades for all outdoor instruments not shaded by adjacent or integral equipment.
- C. Process Tubing:
 - 1. Stainless Steel, ASTM A 269, TP316, seamless, annealed, 1/2 in. by 0.065 in. W.T. minimum.
- D. Pneumatic Supply Tubing:
 - 1. Stainless Steel, ASTM A 269, TP316, seamless, annealed, 1/2 in. by 0.065 in. W.T., 3/8 in. by 0.049 in. W.T. and 1/4 in. by 0.035 in. W.T. minimum.
- E. Fittings:
 - 1. 316 Stainless Steel ferrule type, Swagelok or equal.
- F. Pipe Stand Type Supports for Instrumentation:
 - 1. Pipe stands shall be stainless steel using welded fabrications with 2 in. schedule 40 pipe, 2 in. square tube by 0.188 in. thick, 3/8 zinc/cadmium plated hardware, 1/2 in. expansion anchors, 12 gauge mounting channel and 1/4 in. 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:
 - 1. 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 specified in calibration sheets indicating certification of traceability to National Institute of Standards and Technology (NIST). Instruments shall be ranged as specified in the specification or as directed by Engineer.

2.5 FABRICATION

- A. Materials of Construction:
 - 1. Provide 316 Stainless Steel for wetted and other parts unless otherwise specified.

2.6 HAZARDOUS LOCATION APPROVALS

- A. Where installed within a hazardous location, instruments shall bear agency approvals for the identified class, division, and group of the hazardous location.
- B. 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.
- C. Provide intrinsically safe wiring methods for connection of instruments located within a hazardous location.

2.7 DIAPHRAGM PRESSURE SEALS

- A. Provide diaphragm type pressure seals with all pressure instrumentation including gauges, switches, and transmitters, for all process applications other than filtered water (unless specified to be provided with an annular style seal).
- B. Seals shall be 316L stainless steel housing and include a flushing port in the lower housing.
- C. Manufacturers and Products:
 - 1. Ashcroft Model 201, or equal.

2.8 ANNULAR PRESSURE SEALS

- A. Where specified in Drawings, provide annular style isolation ring pressure seals installed in-line with process piping for pressure instrumentation connection.
- B. See Section 40 05 06 – Process Piping Specialties for requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Section 01 77 00 – Closeout Procedures for installation and examination requirements.
- 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. Cables from sensors to transmitters shall be installed in conduit where subject to physical damage, and exposed cabling shall be limited to no more than 6 ft. Provide conduit cord connector fitting when transitioning from conduit to exposed cable. Provide strain relief grips where required for vertical cable support. Factory cords shall be trimmed to length to avoid excessive cable loops.
- D. Install transmitters 4 ft, 6 in. 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.
- E. Surge Protection
 - 1. 2-wire Loop Powered Instruments: Furnish and install surge protector, Emerson EDCO SS65 or equal, in each 4 mA–20 mA current loop, adjacent to each respective instrument.
 - 2. 4-wire Separately Powered Instruments: Furnish and install 120 VAC/24 VDC combination surge protector, EDCO SLAC-12036 or equal, adjacent to each respective instrument.
- F. Steel supports shall be as specified in this Section and all other sections.
- G. Process connections for instrumentation shall be as specified in piping sections and other section requirements.
- H. 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 in. OD 316 SS tubing or as specified in Drawing details.
- I. 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.
- J. 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.
- K. 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 onsite 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:
 - 1. Provide the 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.

END OF SECTION

SECTION 40 71 13 – MAGNETIC FLOW METERS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section Includes:
 - 1. Full bore magnetic flow meters
 - 2. Transmitters
- B. Related Section:
 - 1. Section 40 70 00 – Instrumentation for Process Systems

1.2 REFERENCES

- A. AWWA (American Water Works Association):
 - 1. M6 – Water Meters – Selection, Installation, Testing, and Maintenance
 - 2. M33 – Flowmeters in Water Supply
- B. ASME International:
 - 1. ASME B16.1 – Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

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.
- B. Closeout Submittals:
 - 1. Refer to Section 40 70 00 – Instrumentation for Process Systems for requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Refer to 40 70 00 – Instrumentation for Process Systems for requirements.

1.6 WARRANTY

- A. Furnish five-year manufacturer's warranty for magnetic flow meters and appurtenant devices.
- B. See Section 01 78 36 – Warranties and Bonds for additional requirements.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Furnish sensors, transmitters, and interconnecting cables as required for application.

2.2 MAGNETIC FLOW METERS

- A. Manufacturers:
 - 1. Siemens FM Mag 5100W
 - 2. Endress+Hauser Promag W400
 - 3. ABB FER Series

4. McCrometer Ultra Mag

B. Description:

1. Low-frequency, electromagnetic induction-type flow meter, producing a linear signal directly proportional to flow rate, consisting of flow tube, signal cable, and transmitter.

C. Performance and Design Criteria:

1. Design: According to AWWA M33.
2. Provide models that require a maximum of one upstream straight pipe diameter and zero downstream straight pipe diameters.

D. Flow Rate Range:

1. As specified in schedule.

E. Size:

1. As specified in Drawings.

F. Flow Tubes:

1. Material: Type 304 stainless steel with polyurethane or hard rubber liner.
2. End Connections: Flanged, ASME B16, carbon steel. Provide stainless steel flanges if connecting to stainless steel piping.
3. Pressure Ratings: Meter assembly and flanges shall match or exceed the pressure rating of the connecting pipe system. Refer to Section 40 23 39.1 – Process Piping Schedule for maximum operating pressures.

G. Electrodes:

1. Type 316L stainless steel
2. Self-cleaning

H. Accuracy:

1. Plus or minus 0.5% of actual flow rate over a 10:1 range.

I. Provide adjustment for zero and span.

J. Accessories:

1. Grounding rings and electrodes
2. Furnish cable between transmitter and receiver.

2.3 TRANSMITTERS

A. Transmitter Output:

1. 4 mA–20 mA dc analog signal
2. Accuracy: Plus or minus 0.2% of full scale

B. Power Supply:

1. 120 VAC, 60 Hz

C. Housing Material:

1. Cast aluminum, IP67 or NEMA 4X

D. HMI:

1. Touchscreen programming, functioning through enclosure window without opening enclosure.
2. Display:
 - a. Backlit graphical LCD display.

- b. Key touch programming.
 - c. User-selectable engineering units.
 - d. Readout of diagnostic error messages.
 - e. Sun shield cover for LCD display.
- E. Mounting:
 - 1. Integral or remote mounting from flow meter as specified in Drawings.
 - 2. Mounting Locations Less Than 4 ft above Grade: Provide stainless-steel mounting posts.
- F. Accessories:
 - 1. Current signal output simulation.
 - 2. Empty pipe detection.
 - 3. Bidirectional flow measurement.
 - 4. Self-diagnostics.
 - 5. Automatic zero adjustment.
 - 6. Sunshield.
 - 7. Signal Cable: Provided by flow meter manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Refer to Section 40 70 00 – Instrumentation for Process Systems for requirements.

3.2 INSTALLATION

- A. Mount magnetic flowmeters according to manufacturer's instructions. Install grounding rings and ground magnetic flowmeters according to manufacturer's instructions.
- B. Refer to Section 40 70 00 – Instrumentation for Process Systems for additional requirements.

3.3 FIELD QUALITY CONTROL

- A. Testing:
 - 1. Test and calibrate flow meter to demonstrate that it meets specified accuracy requirements.
 - 2. Comply with AWWA M6.
- B. Refer to Section 40 70 00 – Instrumentation for Process Systems for additional requirements.

3.4 DEMONSTRATION

- A. Refer to Section 40 70 00 – Instrumentation for Process Systems for requirements.

3.5 ATTACHMENTS

- A. Flow Meter Schedule:

Instrument Tag	Application	Measurement Range
10FIT001*	Recirculation Pump discharge flow	*
10FIT002*	Nutrient Pump discharge flow	*

* Provided as part of Odor Control Manufacturer scope of supply. Measurement range as recommended by manufacturer.

END OF SECTION

SECTION 40 72 76 – LEVEL SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section Includes:
 - 1. Tilting Float Level Switches
- B. Related Section:
 - 1. Section 40 70 00 – Instrumentation for Process Systems

1.2 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. See Section 40 70 00 – Instrumentation for Process Systems for requirements.

1.3 COORDINATION

- A. See Section 40 70 00 – Instrumentation for Process Systems for requirements.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. See Section 40 70 00 – Instrumentation for Process Systems for requirements.

1.5 WARRANTY

- A. Furnish one-year manufacturer's warranty for tilting float switches.
- B. See Section 01 78 36 – Warranties and Bonds for additional requirements.

PART 2 - PRODUCTS

2.1 TILTING FLOAT SWITCHES

- A. Manufacturers:
 - 1. Siemens
 - 2. Anchor Scientific
 - 3. Madison
 - 4. Or Approved Equal.
- B. Type:
 - 1. Direct acting tilt float switch
- C. Materials:
 - 1. Rigid, Teflon coated
 - 2. Mercury free
- D. Electrical Contacts:
 - 1. One normally open or normally closed contact, as specified in Drawings.
 - 2. Rated 1A, 120 VAC minimum.
- E. Furnished with required length of cable and weight kit for cable suspension, as required.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. See Section 40 70 00 – Instrumentation for Process Systems for requirements.

3.2 INSTALLATION

- A. Hang level switch cords with strain relief devices to prevent cord damage.
- B. See Section 40 70 00 – Instrumentation for Process Systems for additional requirements.

3.3 FIELD QUALITY CONTROL

- A. See Section 40 70 00 – Instrumentation for Process Systems for requirements.

3.4 DEMONSTRATION

- A. See Section 40 70 00 – Instrumentation for Process Systems for requirements.

3.5 ATTACHMENTS

- A. Float Switch Schedule:

Instrument Tag	Application	Mounting Height
10LSH101*	Biotrickling Filter High Level Switch	*
10LSL101*	Biotrickling Filter Low Level Switch	*
10LSL001*	Nutrient Feed Tank Low Level Switch	*

* Provided as part of Odor Control Manufacturer scope of supply. Measurement range as recommended by manufacturer.

END OF SECTION

SECTION 40 73 13 – PRESSURE GAUGES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section Includes:
 - 1. Pressure Gauges
- B. Related Sections:
 - 1. Section 40 70 00 – Instrumentation for Process Systems

1.2 REFERENCES

- A. ASME International:
 - 1. B40.100 – Pressure Gauges and Gauge Attachments.

1.3 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. See Section 40 70 00 – Instrumentation for Process Systems for requirements.

1.4 COORDINATION

- A. See Section 40 70 00 – Instrumentation for Process Systems for requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. See Section 40 70 00 – Instrumentation for Process Systems for requirements.

1.6 WARRANTY

- A. Furnish five-year manufacturer's warranty for pressure gauges.
- B. See Section 01 78 36 – Warranties and Bonds for additional requirements.

1.7 SPARE PARTS

- A. Furnish 20% spare gauges, with a minimum of one gauge for each range used.

PART 2 - PRODUCTS

2.1 PRESSURE GAUGES

- A. Manufacturers:
 - 1. Ametek
 - 2. Ashcroft
 - 3. Omega
 - 4. Winters
- B. Dials:
 - 1. Nominal Diameter: 6 in.
 - 2. Face: White, laminated plastic dials with black graduations.
 - 3. Scale: Extend over arc not less than 270°

4. Ranges and Graduation Units: As specified in 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 in.
 - c. Provide gasket.
- D. Connection:
1. Location: Bottom
 2. Socket:
 - a. 1/4 in. or 1/2 in. NPT male thread
 - b. Material: Brass forging
 - c. Extend minimum 1 1/4 in. below gauge cases
 - d. Provide wrench flats.
 3. Mounting: As specified in Drawings.
- E. Measuring Element:
1. Bourdon Tubes:
 - a. Material: Phosphorous bronze to brass socket.
 - b. Provided welded, stress-relieved joints.
 2. Movement:
 - a. Rotary geared
 - b. Material: Stainless steel
 3. Accuracy:
 - a. As specified in ASME B40.100.
 - b. Plus and minus 0.5% 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. See 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. Make sure that gauges are located to be easily read during operation and easily accessible for maintenance.

- C. Where a 90° fitting is required, install a tee-fitting with a plug.
- D. See Section 40 70 00 – Instrumentation for Process Systems for additional requirements, including requirements for seal assemblies.

3.3 FIELD QUALITY CONTROL

- A. See Section 40 70 00 – Instrumentation for Process Systems for requirements.

3.4 DEMONSTRATION

- A. See Section 40 70 00 – Instrumentation for Process Systems for requirements.

END OF SECTION

SECTION 40 73 26 – DIFFERENTIAL AND GAUGE PRESSURE TRANSMITTERS

GENERAL

1.1 SUMMARY

- A. This Section Includes:
 - 1. Differential and gauge pressure transmitters
- B. Related Sections:
 - 1. Section 40 70 00 – Instrumentation for Process Systems

1.2 COORDINATION

- A. See Section 40 70 00 – Instrumentation for Process Systems for requirements.

1.3 SUBMITTALS

- A. See Section 40 70 00 – Instrumentation for Process Systems for requirements.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. See Section 40 70 00 – Instrumentation for Process Systems for requirements.

1.5 WARRANTY

- A. See Section 01 78 36 – Warranties and Bonds for requirements.

PART 2 - PRODUCTS

2.1 PRESSURE MEASUREMENT DEVICES

- A. Manufacturers:
 - 1. Endress+Hauser PMC71 (gauge) PMD75 (differential)
 - 2. Siemens Sitrans P320
 - 3. Rosemount 3051
- B. Description:
 - 1. Digital pressure measurement device for with integral transmitter and display, for gauge and differential pressure applications in liquids and gases.
- C. Measuring Range:
 - 1. As specified in schedule.
- D. Features and Performance:
 - 1. Power Supply: 24V DC
 - 2. Accuracy: Plus or minus 0.05%
 - 3. Output Signal: 4 mA DC–20 mA DC
 - 4. Process Temperature Range: (-4)°F–250°F
 - 5. Materials: Type 316 stainless steel
 - 6. Location: As specified in Drawings.
 - 7. Local digital display, NEMA 4X rated
- E. Accessories:
 - 1. Providing mounting hardware accessories as required for mounting application.

2. Furnish cable, field preamplifiers, and signal conditioners as required to maintain accuracy from sensor to terminal device.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. See Section 40 70 00 – Instrumentation for Process Systems for requirements.

3.2 INSTALLATION

- A. Mount meters as specified in manufacturer's instructions and compatible with installed location.
- B. Coordinate location and orientation of transmitters with final piping and equipment installations.
- C. Locate transmitters to be easily read during operation and easily accessible for maintenance.
- D. Provide pulsation dampeners in pressure transmitter sensing lines when located at pump discharge.
- E. Provide with remote pressure compensation tube when required for supplied instrument with length as required.
- F. See Section 40 70 00 – Instrumentation for Process Systems for additional requirements.

3.3 FIELD QUALITY CONTROL

- A. Testing:
 1. Test and calibrate meters to demonstrate that it meets manufacturer's specified accuracy.
- B. See Section 40 70 00 – Instrumentation for Process Systems for additional requirements.

3.4 DEMONSTRATION

- A. See Section 40 70 00 – Instrumentation for Process Systems for requirements.

3.5 ATTACHMENTS

- A. Pressure Transmitter Schedule:

Instrument Tag	Application	Measurement Range
10PDI101*	Fan No. 1 Pressure Differential Indicator	*
10PDI102*	Fan No. 2 Pressure Differential Indicator	*
10PDI103*	Fan No. 3 Pressure Differential Indicator	*
10PDIT101*	Biotrickling Filter Pressure Differential Transmitter	*
10PDIT001*	Mist Eliminator Pressure Differential Transmitter	*
10PDIT002*	Carbon Unit Pressure Differential Transmitter No. 1	*
10PDIT003*	Carbon Unit Pressure Differential Transmitter No. 2	*

* Provided as part of Odor Control Manufacturer scope of supply. Measurement range as recommended by manufacturer.

END OF SECTION

SECTION 40 73 36 - PRESSURE AND DIFFERENTIAL PRESSURE SWITCHES

GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Pressure switches.
- B. Related Requirements:
 - 1. Section 40 70 00 – Instrumentation for Process Systems.

1.2 REFERENCE STANDARDS

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 Specification 40 70 00 for requirements.

1.4 SUBMITTALS

Refer to Specification 40 70 00 for requirements.

1.5 CLOSEOUT SUBMITTALS

- A. Refer to Specification 40 70 00 for requirements.

DELIVERY, STORAGE, AND HANDLING

- A. Refer to Specification 40 70 00 for requirements.

1.7 WARRANTY

Furnish a one-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.

Type: Diaphragm actuated.

- C. Materials:
 - 1. Diaphragm: Buna-N.
 - 2. Housing: Epoxy-coated aluminum
 - 3. Process Connection: Type 316L Stainless Steel.

- 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: 1/2-inch NPT Female.
 - 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 VAC (minimum), 1A at 30 VDC (minimum).
 - 3. 3/4-inch NPT Female
- I. Enclosures: NEMA 250 Type 4X.
- J. Operation:
 - 1. Control Power Wiring: As specified in Section 26 27 26 – Wiring Devices

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Refer to Specification 40 70 00 for requirements.

3.2 INSTALLATION

- A. Refer to Specification 40 70 00 for requirements.

3.3 FIELD QUALITY CONTROL

- A. Refer to Specification 40 70 00 for requirements.

3.4 DEMONSTRATION

- A. Refer to Specification 40 70 00 for requirements.

3.5 ATTACHMENTS

- A. Pressure Switch Schedule:

Instrument Tag	Application	Measurement Range
10PSH101*	Fan No. 1 High Pressure Switch	*
10PSH102*	Fan No. 2 High Pressure Switch	*
10PSH103*	Fan No. 3 High Pressure Switch	*

* Provided as part of Odor Control Manufacturer scope of supply. Measurement range as recommended by manufacturer.

END OF SECTION

SECTION 40 76 20 – TOXIC GAS DETECTION SYSTEM

GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Toxic gas sensors.
- B. Related Requirements:
 - 1. Section 40 70 00 – Instrumentation for Process Systems

1.2 COORDINATION

- A. Refer to Specification 40 70 00 for requirements.

1.3 SUBMITTALS

- A. Refer to Specification 40 70 00 for requirements.

1.4 CLOSEOUT SUBMITTALS

- A. Refer to Specification 40 70 00 for requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Refer to Specification 40 70 00 for requirements.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Furnish gas detectors, controller unit, and interconnecting cables and accessories as required for application. Complete system to be provided by one manufacturer.

2.2 FIXED TOXIC GAS DETECTORS

- A. Manufacturers:
 - 1. MSA
 - 2. Rosemount
 - 3. Or approved equal.
- B. Description: Instruments for continuous monitoring of hydrogen sulfide gas levels on top of the headworks area for personnel safety.
- C. Performance and Design Criteria:
 - 1. Measuring Range: 0-100PPM (Hydrogen Sulfide)
 - 2. Detection Limit: ± 3 PPM (Hydrogen Sulfide), $\pm 0.5\%$ Oxygen Content
 - 3. Operating Temperature: -4-122 deg F
 - 4. Operating Humidity: 15-90% non-condensing
- D. Sensor Features:
 - 1. Intrinsically Safe CSA DIV1
 - 2. 316 Stainless Steel
 - 3. Electrochemical

4. Provide quantity of sensors required for application.

E. Transmitter Unit Features

1. NEMA 4X
2. LCD or LED Display
3. Rated for use in Class I, Division I
4. Hot-swappable electrochemical sensor with end-of-life diagnostic
5. Power: 24VDC, or 120VAC, 1-phase, 60 Hz if 24VDC is not available.
6. 4-20mA output for each sensor/transmitter.
7. Programmable relay.

F. Accessories:

1. Provide manufacturer recommended calibration kit.
2. Mounting hardware

2.3 HYDROGEN SULFIDE IN-CHANNEL MONITORING SENSORS

A. Manufacturers:

1. Hach GS2440EX sensor with CAx440EX field transmitter.
2. Or approved equal.

B. Description: Instruments for continuous monitoring of hydrogen sulfide gas levels in headworks channels.

C. Performance and Design Criteria:

1. Measuring Range: 0-1000PPM (Hydrogen Sulfide)
2. Detection Limit: $\pm 5\%$
3. Operating Temperature: 0-40 deg C
4. Operating Humidity: 0-100%

D. Sensor Features:

1. Class I, Division I rated
2. 316 Stainless Steel enclosure
3. Provide quantity of sensors required for application.

E. Transmitter Unit Features

1. 4-20mA output for each sensor/transmitter.

F. Accessories:

1. Provide manufacturer recommended calibration kit.
2. Sensor cables and cable guards.
3. Air flow cell,
4. Mounting hardware.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Refer to Specification 40 70 00 for requirements.

3.2 INSTALLATION

- A. Mount sensors and controllers according to manufacturer's instructions.

- B. Refer to Specification 40 70 00 for additional requirements.

3.3 FIELD QUALITY CONTROL

- A. Test and calibrate gas detection system to demonstrate that it meets specified detection requirements.
- B. Refer to Specification 40 70 00 for additional requirements.

3.4 DEMONSTRATION

- A. Refer to Specification 40 70 00 for requirements.

3.5 ATTACHMENTS

- A. Gas Sensor Schedule:

Instrument Tag	Application	Measurement Range
20AIT101	H2S Sensor No. 1	0-50 PPM
20AIT102	H2S Sensor No. 2	0-50 PPM
20AIT103	H2S Sensor No. 3	0-50 PPM
20AIT104	H2S Sensor No. 4	0-50 PPM
20AIT105	H2S Sensor No. 5	0-50 PPM
20AIT106	H2S Sensor No. 6	0-50 PPM
20AIT107	H2S Sensor No. 7	0-50 PPM
20AIT108	H2S Sensor No. 8	0-50 PPM
20AIT109	H2S Sensor No. 9	0-1000 PPM
20AIT110	H2S Sensor No. 10	0-1000 PPM
20AIT111	H2S Sensor No. 11	0-1000 PPM
20AIT112	H2S Sensor No. 12	0-1000 PPM

END OF SECTION

DIVISION 44
POLLUTION CONTROL EQUIPMENT

SECTION 44 11 29 – BIO-TRICKLING FILTER ODOR CONTROL SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. This Section Includes:

1. The work necessary to design, furnish, and install one Biotrickling Filter odor control system as specified herein. The Headworks shall be treated with one Bio-Trickling Filter Tower (10BTF1) and one Carbon Adsorber Tank (10CP1). Each odor control system consists of Biotrickling Filter (BTF) tower, Carbon Adsorber Tank, fan(s), flow control dampers, internal structural members, media with support grating, mist eliminator, internal piping, liquid distributor(s), and Process Controls. Each Process Control system shall include: a nutrient feed system, electrical controls, irrigation valves, recirculation pump, nutrient storage tank, water control panel, and all necessary accessories as described in this specification and the contract drawings.

B. Related Sections:

1. Section 01 40 00 – Quality Requirements
2. Section 05 05 19 - Post-Installed Anchors
3. Section 05 50 00 - Metal Fabrications
4. Section 23 33 00 - Air Duct Accessories
5. Section 40 61 96 - Process Control Descriptions - General
6. Section 40 61 96.1 - Process Control Descriptions - Odor Control
7. Section 44 61 16 - Carbon Adsorber Odor Control System

1.2 REFERENCES:

A. ASTM International:

1. C581 – Determining Chemical Resistance of Thermosetting Resins used in Glass Fiber Reinforced Structures Intended for Liquid Service.
2. C582 – Contact-Molded Reinforced Thermosetting Plastic Laminates for Corrosion Resistant Equipment.
3. D638 – Test for Tensile Properties of Plastics.
4. D695 – Test for Compressive Properties of Rigid Plastics.
5. D746 – Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
6. D790 – Test for Flexural Properties of Plastic.
7. D883 – Standard Nomenclature Relating to Plastics.
8. D1505 – Test Method for Density of Plastics by the Density Gradient Technique.
9. 1693, Test Method for Environmental Stress Cracking of Ethylene Plastics.
10. D2310 – Machine Made Reinforced Thermosetting Resin Pipe.
11. D2563 – Recommended Practice for Classifying Visual Defects in Glass Reinforced Laminated Parts.
12. D2583 – Test for Indentation Hardness of Plastics by Means of a Barcol Impresser.
13. D2996 – Filament Wound, Reinforced Thermosetting Polyester Chemical Resistant Tanks.
14. D3299 – Filament Wound Glass Fiber Reinforced Polyester Chemical Resistant Tanks
15. D4097 – Contact Molded Fiber Reinforced Thermoset Chemical Resistant Tanks.

B. NBS Voluntary Product Standard:

1. PS15-69 Custom Contact Molded Reinforced Polyester Chemical-Resistant Process Equipment.

1.3 DESCRIPTION

- A. System Description: It is the intent of this specification that one complete Biotrickling Filter system be provided by a single Manufacturer having complete system responsibility. Each system shall include, but NOT be limited to:
1. Biotrickling Filter Tower 10BTF1
 2. Carbon Adsorber Tank 10CP1
 3. Fans 10F1, 10F2, 10F3
 4. Control Dampers 10CD1 - 10CD7
 5. Recirculation Pump 10P1
 6. Nutrient Feed & Dilution System 10P2
 7. Water Control Cabinet 10LCP1
 8. Electrical Control Cabinet 10CP1
 9. Nutrient Storage Tank
 10. Mist Eliminator Attachments of tanks to ends of piping.
 11. Lateral bracing for vertical pipe segments at BTF tower.
 12. Aluminum Ladder and Platform for BTF Tower.
 13. Aluminum Ladder and Platform for Carbon Adsorber Tank
- B. The components listed above shall be installed to form a complete and operational biological odor control system in accordance with the requirements specified in this section. The drawings show minimum features and equipment required for the system. The carbon media polishing systems will be described in Section 44 61 16 - Carbon Adsorber Odor Control System.
- C. The cost of any other changes and modifications to mechanical, structural, electrical, and emergency electrical facilities necessary to adapt alternate equipment to the layout and design shown shall be borne by the Contractor. Clearances shown on the Drawings shall be maintained. Any such proposed changes or modifications are subject to review and acceptance of the Owner. Any costs associated with the engineering review shall be borne by the Contractor.
- D. Coordination:
1. To ensure that all the equipment is properly coordinated and will function in accordance with the requirements of the Contract Documents, the Contractor shall obtain all equipment specified herein from an odor reduction scrubber Manufacturer who shall have vested unit responsibility for the proper function of the complete system. However, The Contractor shall retain ultimate responsibility under this Contract for equipment coordination, installation, operation and guarantee, and the Contractor shall furnish and install all labor, equipment, materials, appurtenances, specialty items and services NOT provided by the supplier but required for a complete and operable system. The equipment covered by this specification is intended to be standard equipment of proven ability as manufactured by reputable concerns having extensive experience in the production of such equipment. The equipment furnished shall be manufactured and installed in accordance with the best practice and methods, and shall operate satisfactorily when installed as shown and as specified in the Contract Documents.

1.4 QUALITY ASSURANCE

- A. Manufacturer:
1. The products furnished under this section shall be of a Manufacturer who has been regularly engaged in the design and manufacture of odor control equipment for a minimum of ten years and biological odor control for eight years. Any costs associated with engineering review of an alternate supplier shall be submitted by a Contractor with all costs of evaluation including site visits be borne by the Contractor.

1.5 SUBMITTALS

- A. Submittals shall be made in accordance with Section 01 33 00 - Submittal Procedures.
- B. In addition, the following specific information shall be provided:
 - 1. The Manufacturer shall submit detailed description of the laminate and the type of reinforcing to be used and a letter from the resin Manufacturer stating:
 - a. That the laminate and reinforcing material used complies with the specifications.
 - b. That the resin will meet the performance requirements stated and is suitable for the service conditions specified herein and the fabrication technique proposed.
 - 2. All material properties used in the calculations shall be derived from actual destructive testing of equivalent laminates.
 - 3. Detailed shop drawings showing weights and dimensions of equipment, all nozzles and manways, wall thicknesses, laminate make-up, fabrication techniques, anchor bolt layout, roof access areas, platforms, ladders, fall prevention systems, pipe attachments and accessories, and construction materials for all equipment. Drawings and description of nozzle and liquid distribution system to include spray pattern, pressure drop, liquid flow rate, support system details and materials of construction.
 - 4. Submit fan data sheets with a description of the proposed fan, fan size, type, arrangement, construction materials, weight, motor horsepower, motor type, power supply, frame size, sheave sizes, belts size, number, and length. Submittal shall include pertinent equipment dimensional data, and a performance curve showing the fan operating point and range. A list of accessories to be furnished shall be included.
 - 5. Design structural calculations for each vessel and their anchorage to supporting construction, signed and sealed by a professional engineer registered in Alabama.
 - a. Provide signed and sealed calculations for the biotrickling filter systems, including vessels, roof access areas, ladders, and safety rails to verify compliance with the design criteria indicated in Section G.2 and all applicable OSHA requirements.
 - 6. Current design does not include wiring restraints. If wiring restraints are required based on calculations, modifications to the biotrickling filter design, including pad size to allow appropriate access space, shall be performed at no additional cost to the Owner. A description of media including but not limited to, pressure drop through media, liquid hold-up data, and media physical characteristics.
 - a. Complete data on the head loss for the air flow through the media at both design air flow rates.
 - b. Details of filter media supports.
 - 7. A description of the proposed quality requirements program that will be used during the manufacturing of the scrubber. Include the resume of the quality requirements manager.
 - 8. A schedule for the scrubber's fabrication along with the location of the fabrication site.
 - 9. Written instructions as to the recommended methods for unloading, storing, and installing the fiberglass scrubbers and recommended lifting and handling procedures.
 - 10. Submit listing of previous installations and references to the Engineer. The proposed vessel fabricator shall demonstrate an experience record of at least 5 years with the Manufacturer of filament wound fiberglass vessels for industrial service.
 - 11. Submit written installation procedures.
 - 12. Submit factory test certifications.
 - 13. Submit Manufacturer recommended support ledge requirements for liquid distributor, packing support, and mist eliminator. Submit recommended influent feed pipe design for liquid distributor.
 - 14. Submit certification indicating the quality requirements, testing, and inspection has been completed and standards specified herein have been met prior to shipment to the jobsite.
 - 15. Submit color chart describing the available colors for the vessel exterior pigment color to be selected by the Engineer and/or Owner.
 - 16. Schematic of the system, showing all components and controls.
 - 17. Electrical data for all equipment.

18. Information and data for all instrumentation and controls and for the control panel, including wiring and interconnection diagram.
19. Control panel layout drawing and fabrication details.
20. Complete listing of physical and chemical process parameters required for proper operation of the system.
21. In addition, the following data for motors shall be provided:
 - a. Motors:
 - 1) Name and Manufacturer
 - 2) Type and model
 - 3) Bearing type and lubrication
 - 4) Horsepower rating and service factor
 - 5) Temperature rating
 - 6) Full load rotative speed
 - 7) Net weight
 - 8) Efficiency at rated load
 - 9) Full load current
 - 10) Overall dimensions

1.6 MANUFACTURER'S SERVICES

- A. The system Manufacturer's representative shall be present at the job site for the following time period; travel time excluded:
 1. One day for each system for inspection and certification of the installation, can be performed concurrently if the schedule allows.
 2. One day to train Owner's staff in operation of both systems to include two hours of classroom and two hours at the site(s)
 3. Two days for initial startup and monitoring for each of the systems can be performed concurrently if the schedule allows.
 4. One follow-up trip for two days, 2 weeks after startup to assess the acclimation process, adjust to steady state operation. Can be performed concurrently if the schedule allows.
 5. One trip for two days 3 – 4 weeks after startup to perform performance testing, can be performed concurrently if the schedule allows.
 6. One trip for two days within one month of warranty expiration to perform performance testing. Tests shall meet performance requirements at design conditions. Refer to Subsection 3.3, PERFORMANCE TESTING for further requirements.
 7. A minimum of four trips is required.

1.7 DELIVERY AND INSTALLATION

- A. Components and accessories shall be shipped in safe packaged containers to prevent damage. Installation of components at the job site shall be in strict compliance of Manufacturer's recommendations and under adequate supervision provided by the system supplier.

1.8 OPERATION AND MAINTENANCE MANUALS

- A. Six (6) copies of a 3-ring bound O&M manual shall be provided.
- B. One copy of a digital pdf O&M manual shall be provided.

1.9 MANUFACTURER'S WARRANTY

- A. The Contractor shall procure and provide copies of all certified Manufacturer's warranty. The complete system, including accessories and components, shall be warranted for two years by the Manufacturer having unit responsibility.

- B. Provide warranty for a period of 2 years 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.
- C. Provide BTF media warranty for a period of 10 years 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.
 1. Media failure includes increase in pressure drop through the media such that the specified airflow rates are not achievable with the installed equipment and/or the failure of the media to meet specified odorant removal levels.

PART 2 - PRODUCTS

2.1 BIOTRICKLING FILTER

- A. General:
 1. Each Biotrickling Filter system shall be vertical, countercurrent flow, and shall consist of an FRP vessel, biological media, spray nozzle, mist eliminator, sump, and all internals. The process support equipment, which includes the nutrient reservoir, auxiliary sump, recirculation pump(s), water control cabinet(s), and electrical cabinet shall be included, as necessary, pre-piped, pre-wired, and factory tested on a integrated single Process Support and Control skid.

2.2 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. Section 44 61 16 - Bio-Trickling Filter and Carbon Adsorber Odor Control System shall be of same Manufacturer.
 1. Daniel Mechanical
 2. BioAir
 3. ECS
 4. Evoqua

2.3 SERVICE CONDITIONS AND PERFORMANCE REQUIREMENTS

- A. BTF Design Specifications and Performance Requirements. BTF shall be sized for minimum empty bed contact time and performance requirements at the higher airflow. Air channeling within BTF at the lower airflow shall not be acceptable.

	10BTF1	
Design Air Changes per Hour	30	15
Design Air Flow Rate, cfm	6,300	3,150
Minimum empty bed contact time, seconds	15	30
Average Inlet H₂S Concentration, ppm(v)¹	200	250
Peak Inlet H₂S Concentration, ppm(v)¹	450	525
Odor Removal % H₂S, % Overall	99%, 90%	99%, 90%
Notes:		

1. Average and Peak Inlet H₂S Concentrations listed are estimated inlet concentrations after the headworks headspace has been diluted at the specified ventilation rates.
2. Average and Peak H₂S Concentrations measured in the headworks headspace are 1,406 ppm and 3,150 ppm, respectively. The concentrations were measured with stagnant air and do not include any dilution from ventilation.

- B. All components of the odor control system shall be compatible with the conditions and constituents to which they will be subjected to during normal operation. Compounds with which the materials of construction must be compatible with include, but are not limited to:
1. Hydrogen sulfide
 2. Carbonyl sulfide
 3. Methyl mercaptan
 4. Dimethyl sulfide
 5. Carbon disulfide
 6. Dimethyl disulfide
- C. Service Conditions for each Odor Control System.
1. Service Conditions:
 - a. Ambient Air Temperature Range: 40–110°F (5–50°C)
 - b. Entering Air Temperature Range: 40–100°F (5–40°C)

2.4 MATERIALS AND CONSTRUCTION

- A. Fiberglass Vessel:

	10BTF1
Air Flow Rate, cfm	6,300
Number of Towers	1
Minimum Number of Media Levels per Tower	1

- B. Materials & Construction:
1. The Biotrickling Filter shall be cylindrical tower in shape with upflow air passage and countercurrent liquid flow. Vessel size and configuration shall be as shown on the drawings. Unit shall be complete with flanges, nozzles, manways, lifting lugs, anchors, and other appurtenances.
 - a. Vessel diameter shall not exceed 10 feet.
 2. The vessel, including its anchorage to supporting construction and all supported attachments, shall be designed to meet all applicable requirements of the governing building code adopted by the jurisdiction. For governing building code, wind speed and exposure, and seismic parameters, see the Structural Notes in the Drawings. Structural analysis shall be performed in accordance with the edition of ASCE 7-"Minimum Design Loads and Associated Criteria for Buildings and Other Structures" adopted by the governing building code.
 3. The vessel shall be filament wound in accordance with ASTM D3299. The vessel shall be designed for positive pressure service conditions as specified for Type II Grade 1 tanks in ASTM D3299. Any fabrication by hand lay-up shall NOT be acceptable. Any vessel made of PVC, polypropylene, or any other material shall NOT be acceptable. A 10:1 safety factor shall be used for internal pressure loadings and a 5:1 safety factor shall be used for external and vacuum loadings. Contact molded components and accessories, including scrubber baffles, shall be fabricated in accordance with ASTM D4097 and PS 15-69. The resin will be exposed continuously to chemical scrubbing liquid and gas as listed in the service conditions above. The resin shall be capable of continuous exposure to H₂SO₄ concentrations up to 5% at temperatures up to 210°F. Without exception the

resin shall be vinyl ester Hetron 922 by Allnex, CoRezyn CORVE 8401 by Interplastic, Derakane 510B-400P by Ashland Chemical, or pre-approved equal. Dual media systems that utilize polyester resin as the structural layer and vinyl ester as the corrosion shall NOT be allowed.

4. The laminate shall consist of a single resin rich layer, with Nexus 111-00010, C-glass veil, or approved equal reinforcement followed by two 1-1/2-ounce layers of random chopped strand glass, fully wetted out with resin. This interior surface shall yield a minimum 100-mil thick corrosion barrier. Filament wind over this to the required thickness. Exterior surface coat shall be paraffinated, complete with ultraviolet screener such as UV-9. No thixotropic or other additives shall be used. The pigment tone shall be selected by the Owner during the submittal.
5. The minimum properties of filament wound laminate shall be as specified in ASTM D3299.
6. The minimum properties of contact molded laminate shall be as follows:
 - a. Minimum glass content 35%
 - b. Tensile strength 17,000 psi
 - c. Tensile modulus 1,400,000 psi
 - d. Flexural strength 27,000 psi
 - e. Flexural modulus 1,000,000 psi
7. Anchorage: Each tank shall be furnished with concrete anchors and hold down lugs, complete with 316 stainless steel plates, bolts, nuts, and washers for proper anchoring of the tank as required by the design calculations.
 - a. Manufacturer shall provide anchor requirements and locations to contractor.
8. Lifting lugs shall be provided for use in transporting and placing the vessel.
9. Visual defects shall be better than Level II on the inside of the vessel and better than Level III on the outside in accordance with ASTM D2563.
10. Tower components shall be preassembled at the point of fabrication. Preassembly will NOT require all joints to be factory assembled, but all joints shall be prepared for filed fabrication and square within plus or minus 3/16 inch. Each matched piece shall then be numbered correspondingly. All FRP work shall be protected from atmospheric or otherwise induced conditions of adverse temperatures, moisture, wind, or blowing dust and sand and other contaminants that would adversely affect the laminate or joint construction. The protective means shall be provided during the construction and curing period.
11. Other than those associated nozzles, couplings, manways, and top and bottom heads, the towers shall be filament wound in one piece with no more than one joint.
12. All metal hardware shall be 316 stainless steel.
13. Sizes of manways shall be as shown on the Drawings, or as required for normal routine maintenance and shall be in accordance with ASTM D3299. As a minimum, manways shall be provided for access to the sump, bottom of EACH media level, nozzle inspection and top of packing, media replacement, and mist eliminator for each tower. Bolted manways shall be provided with 1/8-inch thick full face EPDM gaskets with 316 stainless steel bolts. Provide a transparent blind flange to view operation of the nozzles and allow inspection of the media.
14. Flanged nozzles, double flanged gusseted nozzles, bottom drain nozzle, and threaded full couplings shall be provided as required. Flanged nozzles with 1/8-inch thick EPDM full-face gaskets of 60 durometer shall be provided by the supplier. Press-molded flanges are NOT acceptable. Threaded full couplings shall be PVC.
15. The bottom or reservoir section, as required for system operation, shall include air inlet connection, make-up water connection, recirculation pump suction connection, drain, overflow, and sump low level indicator fabricated of SCH 80 clear PVC pipe.
16. Each bioscrubber sump shall be equipped with a titanium or hastelloy grounding rod. The grounding rod will provide an earth ground for the bioscrubber solution. The Contractor shall install a grounding rod adjacent to the bioscrubber for connection to the lugs.

C. Media Support:

1. Media support plates shall be VINYL ESTER FRP GRID type rated at 150 psi. Free area shall be a minimum of 95% of the cross-sectional area of the tower. Packing support plates and mid span supports shall be suitable to support weight of the packing specified plus entrained recirculation solution. Opening size shall NOT allow passage of packing media in any random orientation. Construction shall be fiberglass constructed of vinyl ester resins. Furnish supplier instructions for placement and removal of the packing support in and out of the tower.
- D. Biological Media:
1. The media material shall be synthetic reticulated polyurethane foam, resistant to the corrosive attack of acids. The media configuration shall promote thorough mixing and good contact between the gas and irrigation solution. Organic material, clay, mineral media, or media containing carbon or impregnated with nutrients or metals shall NOT be allowed.
 2. Media material and configuration shall be suitable for both high airflow and low airflow conditions. Air channeling at low airflow condition shall not be acceptable.
- E. Liquid Distributor:
1. A liquid distribution header shall be provided to uniformly distribute the scrubbing liquid onto the packing material. Internal spray piping shall have flanged connection for easy removal. Without exception the liquid spray distributor system shall be consist of full cone, non-clog spray nozzle attached to the header array. The spray nozzle shall have a minimum free passage diameter of 0.25 inch and shall be specifically designed to be clog resistant. Pressure loss across the nozzle at design capacity shall be no more than 10 psi. The spray nozzles shall be Teflon, polypropylene, PVC or 316 stainless steel. The irrigation piping and nozzle within the vessel shall be readily accessible from the outside of the vessel without any entry into the vessel.
- F. Exhaust Stack:
1. Each tower scrubber shall be furnished with a flanged connection vertical stack fabricated from fiberglass reinforced plastic with flanged connection to the scrubber outlet. Each stack shall be provided with one inch diameter fitting for outlet air sampling.
- G. Lateral Pipe Support:
1. Manufacturer to provide support tabs on side of BTF vessel to attach vertical segment of pipe to vessel for lateral bracing.
 2. Support tabs shall be corrosion resistant.
 3. Vertical support for self weight and/ or uplift of vertical pipe segment shall be the responsibility of pipe supplier.
- H. Identification Tag:
1. Vessel shall be provided with a permanently attached, 16-gauge stainless steel equipment identification plate or label laminated into the final fiberglass coat. The label shall state the following in 1/4-inch die-stamped lettering for the plate or 1-inch lettering for the laminated label.
 2. Equipment identification (tag) number shown on Drawings and vessel name "BIOTRICKLING FILTER".
 3. Resin type, inner surface reinforcement, and resin Manufacturer's name
 4. Date of manufacture
 5. Manufacturer's name and address
 6. Manufacturer serial number
 7. Purchase order number
 8. Allowable temperature range
 9. Design pressure (vacuum)
 10. Vessel dimensions and capacity in cubic feet
 11. Operating Weight

- I. Neoprene Pad:
 - 1. A 1/4" thick, 60 durometer neoprene rubber sheet shall be placed underneath the scrubber vessel.
- J. Ladder and Platform: Size and configuration as indicated on the Drawings and as follows:
 - 1. Ladder: Fabricated from aluminum.
 - 2. Elevated Platform and Structural Members: Fabricated from aluminum for access to the tank top. See Drawings for configuration. Scrubber Manufacturer shall design and supply platform support system. Platform shall be supported from scrubber tower.
 - 3. Ladder Design Live Loads, Deflection, Extension, and Fall Protection System shall all comply with the requirements for Metal Ladders as indicated in Section 05 50 00 - Metal Fabrications and OSHA.
 - 4. Platforms shall be designed to meet OSHA requirements for Walking-Working services. Live load used for design of each platform component shall be a minimum of the greater load effect resulting from a 40 psf distributed load or a 300 pound concentrated load (unfactored).
 - 5. Provide aluminum handrail around platform.
 - 6. Design and fabricate Type 316 stainless steel or FRP support members for anchoring platform to vessel wall.
 - 7. Fasteners:
 - a. Type 316 stainless steel.
 - 8. Secure ladder to the vessel using Type 316 stainless steel or Hastalloy C bolts with polyethylene encapsulated heads.
 - 9. Anchor Bolts:
 - a. Type 316 stainless steel.
 - 10. Ladder shall be equipped with safety rail and fall protection.

2.5 EXHAUST FAN

- A. Exhaust Fan:
 - 1. Fan shall have fiberglass reinforced plastic centrifugal backward inclined impeller. The wheel shall be dynamically balanced. Resin shall be suitable for exposure to the specific service conditions. The shaft shall be carbon steel and shall have a stainless steel sleeve. The shaft seal shall be Teflon or Viton.
 - 2. All fans shall be provided with lugs, brackets, or supplied devices to allow the fan to be firmly bolted to concrete equipment pad.
 - 3. Fan shall be rated for Class 1 Div 2 conditions.
- B. Bearings shall be heavy duty, self aligning grease lubricated ball type with minimum of 100,000-hour B-10 life. OSHA approved belt guard and shaft guard shall be provided. Motor shall be high-efficiency, TEFC, 1800 RPM with a 1.15 service factor and suitable for 3/60/230-460V. Fan shall be belt driven. Fan shall have a constant V-belt drive. Provide access for greasing bearings, tachometer readings of fan and motor speed without removing the cover. Covers shall be properly ventilated to prevent motor overheating.
 - 1. When bearings are not accessible, extended supply and relief fittings shall be supplied. Both supply and relief fittings shall terminate in the same location.
- C. Fan Housing shall be constructed of fiberglass and reinforced with rigid bracing to increase structural integrity. Fan housing shall be ultraviolet and corrosion resistant. Bearing support brackets shall be positioned to directly oppose belt tension forces. Fan housing shall be a curved scroll design with a 1-inch drain connection at the lowest portion of the fan scroll. The fan inlet shall be slip type and the fan outlet shall have a flanged nozzle.
- D. The fan shall be designed for the following specifications:

Fans	10F1, 10F2, 10F3	
Design Air Flow Rate, cfm	6,300	3,150
S.P. up to Filter Inlet, in. WC	4.7	18.5
Approximate Total Pressure Drop, in. WC¹	17.0	30.0
Motor HP	30	30
Notes: 1. Total pressure drop through odor control system to vary by manufacturer. It is the responsibility of the odor control system manufacturer to coordinate final pressure drop with fan manufacturer.		

- E. All fastening and hardware exposed to a corrosive environment shall be Type 316 stainless steel.
- F. Fan base shall be Type 316 stainless steel.
- G. Fan shall be furnished with stainless steel nameplates including information of manufacturer, model number, rated capacity, static pressure, RPM, and any other pertinent data.
- H. Flanged Connections:
 - 1. Connects to expansion joints, dampers, fan, bio-trickling filter, carbon adsorber, or other equipment shall be flanged fiberglass reinforced plastic, unless otherwise noted in the drawings or specifications. Gaskets shall be EPDM.
 - 2. Furnish all bolts, nuts, washers, and other fasteners required. Metallic fasteners shall be Type 316 stainless steel. All flange bolts shall be torqued to values as recommended by manufacturer.
- I. Flexible Connector:
 - 1. Provide flanged expansion joint for inlet and outlet of fan to FRP vessel transition piece. The flange drilling shall be coordinated with fan and transition.
 - 2. Type: W-design configuration with fully molded integral flanges suitable for service with FRP duct.
 - 3. The properties of the flexible connectors shall be as follows: Material shall be EPDM. Material shall be resistant to ultraviolet light degradation and shall be suitable for contact with odorous air as specified herein. The backing rings shall be 1/4-inch thick, 2" wide, type 304 stainless steel. The length from flange-to-flange shall be 6" unless shown otherwise. The extension shall be 1 inch, compression shall be 2 inches, lateral offset shall be 2.5 inches, and the thickness shall be 1/4-inch minimum.
 - 4. Manufacturer shall be:
 - a. Senior Flexonics Pathway
 - b. Or Approved Equal.
- J. Transition Pieces:
 - 1. Provide duct transition pieces between the exhaust fan outlet connection and the bio-trickling filter inlet connection. Transition piece shall be constructed of FRP of the same resin as, and equal or superior in strength to, the adjacent equipment. Dimensions of end connections shall be adjusted to match equipment connection sizes.
 - 2. Manufacturer shall design transition pieces so that they shall be free from buckling, pulsing, warpage, and sagging at design pressures listed above. Thickness of transition pieces shall be designed using a safety factor of 10:1 for pressure and 5:1 for vacuum service.
- K. The fan shall:
 - 1. Be shipped loose from the scrubber system and be anchored to a concrete pad without vibration isolators.

2. Have an AMCA seal.
 3. Manufactured by:
 - a. New York Blower
 - b. Hartzell
 - c. Or Approved Equal.
- L. Motor shall be 480 volt, 3 phase, 60 hz suitable for full voltage starting and continuous operation at 40 degrees C ambient temperature at the specified loads. The motor shall be suitable for Class 1 Div 2 conditions and suitable for use with a VFD.
- M. Motor shall be furnished with stainless steel nameplates including information of manufacturer, serial number, model number, horsepower, speed, voltage, amperes, and any other pertinent data.
- N. The motor shall be manufactured by:
 1. WEG
 2. Siemens
 3. ABB
 4. Or Approved Equal.
- O. Fan shall be located upstream of Bio-Trickling Filter tower and Carbon Adsorber.
- 2.6 DAMPERS
- A. Provide manually operated isolation dampers as indicated on the Drawings. Provide motorized dampers as indicated on the Drawings. See Section 23 33 00 - Air Duct Accessories for more information.
- 2.7 PROCESS CONTROL EQUIPMENT
- A. See Section 40 61 96 Process Control Descriptions - General and 40 61 96.1 Process Control Descriptions - Odor Control for more information.
- B. Without exception all process control equipment shall be provided as a completely integrated system with all components pre-piped and pre-wired by the Manufacturer and shall include:
- C. Fans:
 1. Three fans shall be provided in the odor control package. At low flows of 15 ACH, the fans shall be one duty, two standby. At high flows of 30 ACH, the fans shall be two duty, one standby. System shall be designed such that Operator has the ability to choose low flow or high flow and which fan(s) shall be online.
- D. Flow Control Dampers:
 1. Six motorized flow control dampers shall be provided in the odor control package. Dampers shall be integrated such that the dampers directly upstream and downstream of a fan shall open when the fan is energized and close when the fan is de-energized.
- E. Insertion Mass Flow Meter
 1. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
 - a. FCI
 - b. Kurz
 - c. Or approved equal.

2. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features, and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.
 3. Type:
 - a. Insertion heat elements.
 - b. 316 stainless steel body.
 - c. Provide units with an integral transmitter.
 - d. Flow meters shall be of sufficient length to accommodate shut-off valve as shown in the drawings.
 4. Function/Performance:
 - a. Function: To provide a contact output when air flow is sensed in a pipeline.
 - b. Operating Principle: Two 316 Stainless Steel RTDs, one is heated and the other senses the process temperature. The temperature difference between the two RTDs is proportional to the process flow.
 5. Functional:
 - a. Output: Looped power 4-20mA.
 6. Physical:
 - a. Two 316 stainless steel measuring probes.
 - b. Body: 316 stainless steel with a flanged connection.
 - c. 1-inch minimum NPT mounting or otherwise match the process line connection.
 - d. Instrumentation not mounted in instrument racks or stands shall be provided with sunshields when mounted outdoors.
 7. Manufacturer Start-up and Training Services
 - a. Provide manufacturer's start-up and training services as specified in the start-up and training services paragraph.
- F. Recirculation Pump:
1. As required for system operation, the recirculation pump shall be supplied pre-piped and pre-wired into the process control skid. The recirculation pump shall be seal-less, magnetic, centrifugal type. The pump shall be totally enclosed, manufactured of polypropylene, and shall include Kynar rear housing. The pump motor shall be TEFC, 3500 rpm, 230/460 VAC/3-Ph/60 Hz and shall include a 1.15 service factor.
 2. Provide one shelf spare recirculation pump.
- G. Nutrient Feed System:
1. The nutrient pump shall be housed within an insulated and heated Water Control Cabinet for each tower which is mounted at a location convenient to the operation of the system. The nutrient system stores and delivers biological nutrients to the spray nozzle where the solution is circulated through the packing media. The nutrient reservoir shall provide a minimum of 50 gallons of nutrient for 10BTF1. The nutrient feed system shall include a nutrient pump, reservoir, and all piping and equipment necessary to deliver nutrients from the reservoir to the irrigation water.
- H. Nutrient Storage Tank:
1. A nutrient reservoir shall be constructed of FRP or UV-resistant HDPE and furnished for the containment of biological nutrients with a minimum capacity of 50 gallons for 10BTF1.
 2. Without exception the tank shall be made of vinyl ester fiberglass reinforced plastic or high density polyethylene and be suitable for storage in direct sunlight.
 3. The nutrient storage tank shall be sized to provide a minimum of one month nutrient supply.
 4. The reservoir shall be provided with bulkhead pipe connections for tank drain, outlet, inlet, pressurized water connection, low level indicator, and vent. Flanged connections shall be of the same materials as the tank wall. Threaded connections shall be of standard NPT. The tank details showing the locations of all openings, nozzles, and appurtenances shall be included in shop drawings and submitted for approval before fabrication of the chemical storage tank.

5. The reservoir shall have an electronic low level indicator and a connection to a pressurized water source that is controlled by a ball valve, as required by manufacturer.
 6. Each storage tank shall be insulated and heated to preclude freezing.
- I. Irrigation Piping:
1. The piping on the Process support and Control Skid shall be Sch. 80 PVC and shall include all piping from the Water Control Cabinet to the pump(s), an overflow and water level control device with a clear site tube that allows inspection of the blowdown rate and the level of the vessel sump.
- J. pH probe:
1. Provide each water control cabinet with a prewired pH probe in the BTF sump.
 2. The transmitter shall be remotely mounted on the main control panel.
 3. The probe shall send signals and receive power from the main control panel as shown on the drawings.
 4. pH measurement shall use the potentiometric measurement method utilizing a glass electrode. The pH sensitive glass membrane surface shall react to the acid content of the solution with a specific voltage, which is measured relative to a reference electrode.
 5. Manufacturer: One of the following or equal.
 - a. Sensor: GF 2724 signet pH electrode.
 - b. Transmitter: Signet 8750 with suitable pre-amplifier if required.
 - c. Transmitter performance requirement:
 - 1) Accuracy: within 0.01 pH
 - 2) Repeatability: within 0.01 pH
 - d. Sensor material: glass pH sensor housed in a molded reinforced polypropylene body threaded for insertion, with an in built temperature sensor.
 - e. Transmitter:
 - 1) Should be suitable for panel or field mounting options.
 - 2) Power Supply: 24 VDC with pre-amplifier if required.
 - 3) Output: Isolated 4 to 20 mA DC proportional to pH, Alarm contacts (SPDT) for low pH indication in the main control panel.
 - 4) Display: backlist LCD digital display.
 - 5) Enclosure: NEMA Type 4X.
 - 6) Mounting: panel mounting option.
- K. Instrumentation and Controls:
1. The odor control system consists of three fans, one bio-trickling filter (BTF), one carbon adsorber. The ancillary system to the BTF includes a water panel, recirculation pump, nutrient feed tank, nutrient pump, and one water source for the water panel. Foul air from the headworks flows through the fan(s) to the BTF and then continues through the carbon adsorber before discharging into the atmosphere. The water panel combines flows from the recirculation pump, nutrient pump, and water source to feed the combination to the top of the BTF.
 - a. At low flows with one fan in operation, the motorized dampers on the suction and discharge of that fan will be open. The motorized dampers on the suction and discharge of the other two fans will remain closed.
 - b. At high flows with two fans in operation, the motorized dampers on the suction and discharge of the fans will be open. The motorized dampers on the suction and discharge of the other fan will remain closed.
 - c. The motorized damper after the discharge of the carbon adsorber will only be used to isolate the carbon adsorber in events when the carbon adsorber needs to be taken offline.
 - d. Under normal operating conditions, the system will be controlled based on operator mode selection in SCADA.
 - e. All motorized dampers provided by odor control system will be controlled by vendor-supplied PLC.

2. Automatic Mode:
 - a. There will be two modes that the Owner will select from the SCADA HMI. The first automatic mode is one fan operation. The second automatic mode is two fan operation.
 - b. One Fan Operation Mode:
 - 1) In the One Fan Operation automatic mode, one fan will operate at the flow specified in specification 41 11 29. The odor control system will operate at this setting until another operation mode is selected. The mass flowmeter will operate as the process variable for PID control of the VFD. The VFD will control the fan to a set speed as determined by TAB contractor.
 - 2) Motorized dampers 10CDX and 10CDX on the suction and discharge of the fan will open before the fan ramps up to set speed.
 - 3) Motorized dampers 20FCDX-20FCDX will open to operation set point 1 as determined by TAB contractor.
 - 4) Each motorized damper may have a different control setpoint.
 - c. Two Fan Operation Mode:
 - 1) In the Two Fan Operation automatic mode, two fans will operate at the flow specified in specification 41 11 29. The mass flowmeter will operate the process variable for PID control of the VFDs. The odor control system will operate at this setting until another operation mode is selected.
 - 2) Motorized dampers 10CDX and 10CDX on the suction and discharge of both fans will open.
 - 3) Motorized dampers 20FCDX-20FCDX will open to operation set point 2 as determined by TAB contractor.
 - 4) Each motorized damper may have a different control setpoint
3. Electrical panels shall comply with the requirements of Section 40 67 23 - Control Panels. PLCs shall comply with the requirements of Section 40 63 43 - Programmable Logic Controllers. The electrical control panel shall provide electrical control for the exhaust fan, pumps, and water and nutrient addition systems. The panels that are housed outdoors, shall be provided with sunshields and required air conditioning units.
4. A 480 VAC, 3-phase feed shall be supplied to the panel for use to power the system. The control panel shall include motor starters for fans and pumps. Variable Frequency drives shall comply with the requirements of Section 26 20 23 - Variable Frequency Motor Controllers. Provide fuse protection for all motor circuits. Provide two spare fuses of each size and type.
5. The control panel enclosure shall be of fiberglass construction and rated NEMA 4X 316 SS. The panel shall be mounted at a location outside of hazardous boundaries to system operation and shall be factory tested to full operation with all other components prior to shipment.
 - a. Controls:
 - 1) The Vendor Control Panel (VCP) shall have a Programmable Logic Controller. PLC shall be Allen Bradley ControlLogix or CompactLogix.
 - a) Plant PLC shall receive at a minimum I/O, via fiber connection from the VCP, as shown on the SCADA Architecture, 90-T101.
 - b) Each PLC shall support IEC Standard 61131-3 for all the following programming languages:
 - i. Ladder (LD)
 - ii. Function Block Diagram (FBD)
 - iii. Structured Text (ST)
 - 2) Provide a panel mount 10" Allen-Bradley PanelView Plus 7 Standard OIT for VCP in accordance with Operator Interface Terminal (OIT). Mount to panel face.
 - 3) Provide network components in accordance with Section 40 66 13 - Networking Equipment and Section 40 66 33 - Fiber Optic Communication Systems.
6. The panel shall have the following components or capabilities:

- a. Fan switch (H-O-A)
 - b. Recirculation pump (H-O-A)
 - c. Nutrient pump switch (H-O-A)
 - d. External Interfaces
 - 1) Dry Contact Outputs
 - a) Run Status (SCADA)
 - b) Run Status (Fan Control)
 - c) Run Status (Recirculation Pump Control)
 - d) Run Status (Nutrient Pump Control)
 - e) Common Alarm
 - 7. Each water control cabinet shall be constructed from a NEMA 4X 316 SS cabinet with all internal piping SCH 80 PVC. The panel shall be mounted at a location convenient to system operation. A separate water control cabinet shall be provided for the tower. The cabinet shall contain the following components:
 - a. Recirculation system pressure gauge.
 - b. Make-up water pressure gauge (one per location)
 - c. Heating cable
 - d. pH probe
 - 8. Water rotameter shall be provided for control of water application rates.
 - 9. Both the electrical control panel and water control cabinet shall be installed outside of the classified hazardous area.
- L. Recycle Piping:
- 1. All recycle piping, irrigation water and drain piping, and blowdown piping shall be SCH 80 PVC. All external piping shall be insulated and heat traced by the Contractor as required in specification sections 40 41 13 Heat Tracing and 40 42 00 Process Mechanical Insulation.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. The complete biological odor control system shall be installed in strict accordance with the Manufacturer's recommendations. The system shall be compatible with the basic provisions shown.

3.2 FIELD ENGINEERING/STARTUP

- A. The biological odor control system Manufacturer shall provide field engineering startup assistance to startup, test, and arrive at proper operating conditions. Minimum service time required shall be as listed in Subsection 1.5, MANUFACTURER'S SERVICES. If additional time is required for reasons attributable to the odor control equipment supplier, the costs shall be borne by the supplier. Should the extra time be required because of reasons attributable to the Contractor, these charges will be borne by the Contractor at prevailing rates.

3.3 PERFORMANCE TESTING

- A. General:
 - 1. The Contractor shall be responsible for all costs associated with odor control system testing.
- B. Functional Testing:
 - 1. Using non-odorous ambient air, the entire odor control system shall be operated for NOT less than 24 continuous hours in order to demonstrate the mechanical and electrical integrity of the system. Any mechanical or electrical breakdowns, unusual vibrations, or

control sequencing problems shall be considered sufficient cause to reject the test. Inability to successfully complete the functional testing in five tries shall be considered cause for the construction manager to reject the odor control system. Contractor shall balance all air flows prior to system performance testing.

C. Performance Testing:

1. Performance tests shall be conducted after the Testing and Balancing Report for the entire ductwork system is submitted and approved by Engineer per Section 44 31 83 Adjusting and Balancing Odor Control Systems.
2. The performance tests shall be conducted after sufficient acclimation time and at such time as all anticipated odorous air streams are present in the scrubber inlet. The time of the tests and detailed test procedure shall be submitted for approval prior to the testing period.
3. During testing, scrubber overflow, recirculation and scrubber air flow rates shall be held constant. Changes in scrubber system operating conditions shall NOT be permitted. All fine-tuning of operating conditions shall be performed prior to testing.
4. Design operating conditions shall be maintained for a minimum of 4 hours. During this time, all pertinent operating parameters shall be monitored and recorded, sufficient sampling and analysis shall be conducted to demonstrate that flow rates are at design conditions.
5. Hydrogen sulfide concentration shall be measured in each scrubber inlet and outlet. Inlet and outlet levels shall be measured once every 30 minutes using a portable H₂S analyzer such as Interscan, Jerome or equal.
6. Results:
 - a. A description of the performance tests shall be submitted. The hydrogen sulfide compound removal efficiency shall be as specified in the design and performance requirements. Should scrubber system performance NOT meet any of the above requirements, that system shall have failed the performance tests. The Contractor shall make any additions or modifications to that scrubber system as may be necessary, at no additional cost to the Owner, and the performance tests for that system shall be repeated in its entirety.

3.4 OPERATION AND MAINTENANCE TRAINING

- A. The Contractor shall provide the services of a factory-trained Manufacturer's representative to provide training of the Owner's personnel in the proper operation and maintenance of the equipment. Prior to final acceptance, the Contractor shall furnish the Construction Manager with two copies of the Manufacturer's certifications. Training shall be performed in accordance with Section 01 75 00 - Startup Testing and Training.

3.5 MANUFACTURER'S REPRESENTATIVE

- A. The Contractor shall include in his bid all costs associated with providing the services of the Manufacturer's field representative for checking, aligning, testing, placing in operation, and Owner training.

END OF SECTION

SECTION 44 31 83 – ADJUSTING AND BALANCING ODOR CONTROL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Testing, adjusting, and balancing (TAB) odor control air systems installed on Project.
- B. Section does not include:
 - 1. Testing, adjusting or balancing any building heating, ventilation, air conditioning, refrigeration, hydronic or any other systems.
- C. Performance testing of odor control equipment is specified in the specification sections pertaining to that equipment.
- D. An initial balance shall be made at each design airflow to facilitate odor control startup and a final balance made at each design airflow after all equipment is started and functioning.
 - 1. Project consists of two design airflows, 15 air changes per hour and 30 air changes per hour.

1.2 REFERENCES

- A. NEBB: "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems." (for NEBB Agencies)
- B. AABC "National Standards for Total System Balance" and "Test and Balance Procedures" (for AABC Agencies).
- C. ASHRAE Handbook, Latest Edition

1.3 SYSTEM DESCRIPTION

- A. Refer to Section 44 11 29 Bio-Trickling Filter Odor Control System for the overall odor control system description.

1.4 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Certified TAB reports.

1.5 QUALITY ASSURANCE

- A. Agency Qualifications:
 - 1. The Agency performing the adjusting and balancing shall be regularly engaged in the practice of testing, adjusting and balancing ventilation systems. Experience in adjusting and balancing odor control systems is preferred but is not a requirement.
 - 2. The Agency and personnel performing the adjusting and balancing shall be certified by one of the following:
 - a. National Environmental Balancing Bureau (NEBB);
 - or
 - b. Associated Air Balance Council (AABC)
- B. Comply with the following:

1. NEBB: "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems." (for NEBB Agencies).
2. AABC "National Standards for Total System Balance" and "Test and Balance Procedures" (for AABC Agencies).
3. Recommendations in the latest ASHRAE Handbook.

1.6 SUBMITTALS

- A. Qualification Data:
 1. Submit documentation of the balancing agency showing certification (NEBB or AABC) of agency and personnel.
- B. Submit information describing the personnel and instruments to be used.
- C. Submit a sample report containing, at a minimum:
 1. Name, address and phone number of Agency.
 2. Identify the Owner, Contractor, Engineer and Project on an inside cover sheet.
 3. Site drawing noting locations where measurements will be taken. Copies of the construction drawings may be used for this purpose provided any field changes to duct systems have been incorporated.
 4. Sample forms to include the following at a minimum:
 - a. Duct traverse reporting form (to include final damper position settings)
 - b. Blower data reporting form (to include speeds and differential pressures)
 - c. Forms to report damper positions
 5. Systems readiness checklists.
- D. Reports:
 1. Submit testing, adjusting, and balancing reports after completion of testing. The reports shall document that the systems have been tested, adjusted, and balanced in accordance with the referenced standards; are an accurate representation of how the systems have been installed; are a true representation of how the systems are operating at the completion of the testing, adjusting, and balancing procedures; and are an accurate record of all final quantities measured, to establish normal operating values of the systems.

1.7 PROJECT CONDITIONS

- A. All odor control systems shall be installed and started prior to beginning balancing, including but not limited to blowers, dampers, biotrickling filter, mist eliminator, carbon adsorber, and all media.
- B. Covered basins shall be filled to their normal operating levels and any equipment in the basin shall be operating.
- C. Contractor shall coordinate the requirements of this specification with the startup and testing requirements of the odor control equipment specifications. An initial balance shall be made to facilitate odor control startup and a final balance made after all equipment is started and functioning.

PART 2 - PROCEDURES

2.1 MISCELLANEOUS

- A. Bio-trickling Filter vendor shall supply additional sheaves and belts for all fans as required to make adjustments to blowers. Sheaves shall be new and shall be of the type and material as recommended by the manufacturer of the blower.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements. Notify Engineer of any conditions that might prevent accurately balancing the system.
- B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify systems have been lubricated and greased, that belts are aligned and tight, and that odor control systems are functioning. Mark on the duct the proposed locations for measuring airflows and pressures. Verify that locations of balancing devices are accessible.
- C. Examine the approved submittals for the odor control systems and equipment.
- D. Examine design data including foul air ventilation system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about foul air ventilation system and equipment controls.
- E. Examine equipment performance data including fan curves.
 - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
 - 2. Calculate system-effect factors to reduce performance ratings of foul air ventilation equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems – Duct Design." Compare results with the design data and installed conditions.
 - 3. Do not operate fans "off the curve" or against a closed damper. Examine fan and odor control equipment installation and startup reports.
- F. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- G. Examine test reports specified in individual system and equipment Sections.
- H. Examine operating safety interlocks and controls on odor control equipment.
- I. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from specified values.

3.2 PREPARATION

- A. Prepare a TAB plan that includes strategies and step-by-step procedures.
- B. Prepare system readiness checks and prepare reports. Verify:

1. Permanent electrical-power wiring is complete.
2. Ductwork is complete with all connections made.
3. Equipment and duct access doors are securely closed.
4. Dampers are installed and functioning.
5. Fans are operable, free of vibration and rotating in the correct direction.
6. Access for taking measurements is present.

C. Perform readiness checks before adjusting and balancing the system.

3.3 GENERAL PROCEDURES FOR ADJUSTING AND BALANCING

- A. Perform full duct traverses in at least two directions for each location.
- B. Drill holes in duct to measure pressure and flow at the selected location. Holes shall be no larger than needed to insert tube or probe into the duct and shall be plugged upon completion of testing.
- C. Coordinate modulating damper positions with Control System Specialist. Each modulating damper shall have two balanced positions, one for 15 air changes per hour (single blower operating) and one for 30 air changes per hour (two blowers operating).
 1. Conduct airflow testing of each blower, in addition to damper balancing.
 2. See schedules on Mechanical sheets for modulating dampers at headworks and odor control.
- D. Manual dampers shall be positioned fully-open for balancing and odor control operation.
 1. Manual dampers provide a means of isolation for maintenance.
 2. See schedules on Mechanical sheets for manual dampers at headworks and odor control.
- E. Start odor control blowers until fans are producing the specified airflow. Report inlet and exhaust static pressures. Blower adjustment, if needed, shall be by Contractor and blower manufacturer.
 1. Variable frequency drives controlling the odor control blowers shall be adjusted to provide the two operating points: 15 air changes per hour and 30 air changes per hour.
- F. Adjust balancing dampers until specified airflows are present in the duct drops.
- G. See Mechanical sheets for the airflows at each modulating balancing damper.
- H. After all dampers have been adjusted, repeat airflow measurements at all locations. Adjust damper positions until specified airflow is achieved. Repeat measurements until two consecutive measurements differ by less than 2%. Report final airflows only; preliminary and interim airflows are not to be included in the report.
- I. System shall be balanced to within 10% of the specified airflows.
- J. Mark damper positions at final set points neatly and indelibly for future reference.
- K. Take and report testing and balancing measurements in in-lb units.
 1. Separate reports shall be reported for the two airflows, 15 air changes per hour and 30 air changes per hour.

3.4 RECORD AND REPORT DATA

- A. Record all data obtained during testing, adjusting, and balancing in accordance with, and on the forms recommended by the referenced standards, and as approved on the sample report forms. Emphasis should be given to recording damper positions within 10%, blower speeds, and pressures at blowers and processes.
- B. Prepare report of recommendations for correcting unsatisfactory mechanical performances when system cannot be successfully balanced.

3.5 DEMONSTRATION

- A. Training:
 - 1. Train the Owner's maintenance personnel on troubleshooting procedures and testing, adjusting, and balancing procedures.
 - 2. Schedule training with Owner through the Engineer with at least 5 days prior notice.

END OF SECTION

SECTION 44 61 16 – CARBON ADSORBER ODOR CONTROL SYSTEM

PART 1 - GENERAL

1.1 SCOPE

- A. Furnish all labor, materials, equipment, and incidentals required to install one odor control system for the control of atmospheric H₂S and other noxious odors as shown on drawings and specified herein. The carbon system (10CP1) shall act as a polishing stage in series with the BTF (Biological Trickling Filter) system (10BTF1). The carbon polishing system shall be an activated carbon adsorber system consisting of an adsorber vessel, activated carbon, interconnecting ductwork and other appurtenances for a complete operating system. A demister shall be installed between the BTF units and the carbon polishing units.
- B. The entire system shall consist of the following major components:
 - 1. Demister
 - 2. Adsorber Inlet Transition
 - 3. Adsorber Inlet Flexible Connector
 - 4. Vessel Inlet Isolation Damper
 - 5. Carbon Adsorber Vessel
 - 6. Activated Carbon Media

1.2 SYSTEM DESCRIPTION

- A. The malodorous air shall enter the dual bed carbon adsorber and shall flow through densely packed beds of activated carbon. The activated carbon shall remove hydrogen sulfide and other odor causing constituents. The air shall continue through the vessel and be exhausted through the outlets.
- B. Related Sections:
 - 1. Section 44 11 29 - Bio-Trickling Filter Odor Control System

1.3 QUALITY ASSURANCE

- A. All systems shall be supplied by a single manufacturer fully experienced, reputable, and qualified in the manufacture of the equipment to be furnished.
- B. To ensure unity of responsibility, fan, damper, ducting, vessel, control panel, carbon and other miscellaneous system appurtenances shall be furnished by a single manufacturer.
- C. Each system shall be dual bed bulk carbon adsorption system.

1.4 SUBMITTALS

- A. The Contractor shall submit shop drawings to the Engineer in accordance Section 01 33 00 – Submittal Procedures, and as a minimum, the following items:
 - 1. Certified shop and erection drawings showing the important details of construction, dimensions, and anchor bolt layout.
 - 2. Descriptive literature, bulletins, and catalogs of the equipment.
 - 3. The total weight of the equipment as well as the weight of the single largest items.
 - 4. Calculations showing theoretical anticipated life of carbon media, based on anticipated average hydrogen sulfide (H₂S) concentrations.
 - 5. Test results according to Subsection 2.4.B
 - 6. Carbon media MSDS and specification sheet.

7. Design structural calculations for each vessel and their anchorage to supporting construction, a signed and sealed by a professional engineer registered in Alabama.
 - a. Provide signed and sealed calculations for the Carbon Adsorber systems, including vessels, roof access areas, ladders, and safety rails to verify compliance with the design criteria indicated in Section 2.3 and all applicable OSHA requirements.
 - b. Current design does not include wiring restraints. If wiring restraints are required based on calculations, modifications to the Carbon Adsorber vessel design, including pad size to allow appropriate access space, shall be performed at no additional cost to the Owner.

1.5 OPERATING INSTRUCTIONS

- A. The Contractor shall provide five copies of operation and maintenance manuals for all equipment furnished.
- B. One copy of a digital pdf O&M manual shall be provided.

1.6 EQUIPMENT WARRANTY

- A. The manufacturer shall warrant that the equipment sold here under shall be free from defects in material and workmanship for a period of 1 year from acceptance or 18 months from shipment, whichever occurs first. The warranty does NOT include the carbon media itself.
- B. Provide warranty for a period of 24 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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. See Section 44 11 29 – Bio-Trickling Filter Odor Control system, Subsection 2.2. Bio-Trickling Filter and Carbon Absorber Odor Control system shall be of same manufacturer.

2.2 DESIGN AND PERFORMANCE CRITERIA

- A. Design Criteria: The odor control system shall be designed for the following operating conditions and shall meet the following performance criteria when put in service with fresh carbon media. The carbon adsorber vessel shall be sized for minimum empty bed contact time at the higher airflow. Air channeling within the vessel at the lower airflow shall not be acceptable.

	10CP1	
Design Air Changes Per Hour	30	15
Design Air Flow Rate, cfm	6,300	3,150
Minimum Empty Bed Contact Time, seconds	3	3
Odor Removal % H ₂ S, % Overall	99%, 90%	99%, 90%
Number of units	1	

2.3 CARBON ADSORBER VESSEL

- A. Design Criteria: The carbon adsorber vessel should be designed for the following criteria:

	10CP1
Maximum Vessel Diameter, ft	12.0
Vessel Straight Side Height, ft	As Required
Wall Thickness, ft	Per Design Calc.
Internal Positive Pressure, in.wg	+20
Maximum Operating Temperature, °F	120
Number of Beds	2
Carbon Bed Depth, ft	3

B. Structural Load Criteria:

1. The vessel, including its anchorage to supporting construction and all supported attachments, shall be designed to meet all applicable requirements of the governing building code adopted by the jurisdiction. For governing building code, wind speed and exposure, and seismic parameters, see the Structural Notes in the Drawings. Structural analysis shall be performed in accordance with the edition of ASCE 7-"Minimum Design Loads and Associated Criteria for Buildings and Other Structures" adopted by the governing building code.

C. Material of Construction:

1. The vessel shall be fabricated from premium grade vinyl ester resin FRP construction.
2. Resin used in fabrication shall be a premium vinyl ester resin such as Hetron 922 by Allnex, CoRezyn CORVE 8401 by Interplastic, Derakane 510B-400P by Ashland Chemical, or pre-approved equal. The resin shall be reinforced with an inner veil of a suitable synthetic organic fiber such as Nexus 111-00010, C-glass veil, or approved equal.
3. Reinforcement: Glass fiber reinforcement used shall be commercial grade corrosion resistant borosilicate glass.
4. Fabrication:
 - a. General: Fabrication shall be in accordance with NBS PS 15-69, ASTM D3299 and ASTM D4097. All non-molded surfaces shall be coated with resin incorporating paraffin to facilitate a full cure of the surface. All cut edges, bolt holes, secondary bonds shall be sealed with a resin coat prior to the final paraffinated resin coat.
 - b. Corrosion Liner: The inner surface of all laminates shall be resin rich and reinforced with one NEXUS 111-00010 with a minimum thickness of 10 mils. The interior corrosion layer shall consist of two layers of 1 1/2 oz. per sq. ft. chopped strand mat. The total corrosion liner thickness shall be a minimum of 100 mils.
 - c. Structural Laminate:
 - 1) Option A: Structural laminates shall consist of alternating layers of 1-1/2 oz per sq. ft mat or chopped glass and 24 oz per sq. yard woven roving applied to reach a designed thickness.
 - 2) Option B: Structural laminates shall consist of helical wind roving in accordance with the filament winding process.
 - 3) The exterior shall be surface coated with white gel coat containing ultraviolet light inhibitors.
5. Fittings:
 - a. The vessel shall be fitted with the following fittings:

10CP1 Description	Size (in.)	Type	Qty
Gas Inlet	24	Flanged	1
Gas Outlets	24	Flanged	2
Drain	2	Flanged	1

Pressure Tap	1	NPT	4
Carbon Sample	1	NPT	6

2.4 CARBON ADSORBER VESSEL ACCESSORIES

- A. Differential Pressure Gauge:
 1. Two Series 2000 differential pressure gauge as manufactured by Dwyer Instruments shall be provided to continuously monitor the pressure drop across the carbon beds. The differential pressure gauge shall be isolated with isolation valves and shall be mounted on the vessel.
- B. Carbon Sample Probes:
 1. Each vessel shall have three 1-inch diameter sample probes per bed which shall extend into the bed a minimum of twelve inches. The sample probes shall be blocked off with a ball valve constructed of PVC.
- C. Grounding Rod:
 1. A stainless steel rod shall be provided to adequately ground each carbon bed. Rods shall be grounded via a 10 gauge wire.
- D. Carbon Support Grating and Screen:
 1. Each adsorber vessel shall be furnished to accommodate a two beds of activated carbon having an average depth of three feet per bed. The carbon beds shall be supported on a polypropylene screen through an FRP support grating system. The screen and the support system shall be removable through access manways. The support system shall consist of removable grating. Pall rings or other dumped packing media as a means of carbon support shall NOT be acceptable. The support system shall be designed to withstand a load of at least 150 lbs/ft² with a minimum deflection of 1/4 inch under all conditions.
- E. Access Manway:
 1. The vessel shall have two 24-inch diameter access manways – one for the upper bed and one for the lower bed.
- F. Exhaust Stack:
 1. The adsorber shall be furnished with two flanged connection vertical stacks fabricated from fiberglass reinforced plastic with flanged connection to the tank outlet. Each stack shall be provided with one inch diameter fitting for outlet air sampling.
 2. Stacks and piping shall be configured and installed to prevent rain water from entering into the system.
- G. Anchor Bolts:
 1. Scrubber shall be provided with properly sized epoxy HILTI anchor system. Contractor to coordinate anchorage and foundation design calculations with vessel manufacturer.
- H. Equipment Tags:
 1. The vessel shall be provided with an I.D. Tag with the following minimum information: Carbon Type, Vessel Dimension, Date of Manufacture, Design Conditions, Equipment Tag Number.
- I. Ladder and Platform: Size and configuration as indicated on the Drawings and as follows:
 1. Ladder: Fabricated from aluminum.
 2. Elevated Platform and Structural Members: Fabricated from aluminum for access to the tank top. See Drawings for configuration. Scrubber Manufacturer shall design and supply platform support system. Platform shall be supported from scrubber tower.

3. Ladder Design Live Loads, Deflection, Extension, and Fall Protection System shall all comply with the requirements for Metal Ladders as indicated in Section 05 50 00 - Metal Fabrications and OSHA.
4. Platforms shall be designed to meet OSHA requirements for Walking-Working services. Live load used for design of each platform component shall be a minimum of the greater load effect resulting from a 40 psf distributed load or a 300 pound concentrated load (unfactored).
5. Provide aluminum handrail around platform.
6. Design and fabricate Type 316 stainless steel or FRP support members for anchoring platform to vessel wall.
7. Fasteners: Type 316 stainless steel.
8. Secure ladder to the vessel using Type 316 stainless steel or Hastalloy C bolts with polyethylene encapsulated heads.
9. Anchor Bolts: Type 316 stainless steel.
10. Ladder shall be equipped with safety rail and fall protection.

2.5 ACTIVATED CARBON MEDIA

- A. Type: The activated carbon shall be virgin, pelletized, derived from high grade bituminous coal, vapor phase type, suitable for the control of sewage odors. The carbon shall have the following specifications:
- B. Specifications

Coal Type	Bituminous
MPD,mm	4.0 – 4.25
Apparent Density,g/cc	0.40 - 0.425
Hardness No.	93 min
CTC Activity	60 min
CTC Retentivity, wt %	22 -25
H ₂ S Capacity, gH ₂ S/cc**	0.2 minimum

2.6 MIST ELIMINATOR

- A. Mist Eliminator unit shall consist of a 316SS pad for grease filtration in front of a polypropylene mesh pad with 316SS grids for mist elimination, housed inside an FRP enclosure. The pads shall be removable for cleaning and the housing shall have a drop-out flange to allow removal and replacement of the filter pads. The mist eliminator pads shall be style 7CA/8P by ACS/AMACS Industries. The FRP housing shall be flanged and drilled per PS 15-69, and be ready for installation into the system supply ductwork. A Dwyer Series 2000 Magnehilic gage shall be installed on the housing to indicate pressure drop through the unit.

2.7 INTERCONNECTING DUCTWORK AND DAMPER

- A. The odor control system manufacturer shall provide the necessary ductwork, transitions, and dampers between the BTF, the demister, and the carbon adsorber vessel(s). Construction shall be FRP using the same resin as the adsorber vessels. Each carbon vessel shall be provided with an inlet isolation damper of manufacturer as listed on Drawings, or equal. Design and supply of all supports shall be by the Contractor.

2.8 HARDWARE AND GASKETS

- A. All hardware shall be 316 stainless steel. Gaskets shall be a minimum of 1/8-inch thick, full face, EPDM, **OR** neoprene suitable for the intended service.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Odor control system shall be furnished and installed in accordance with manufacturer's recommendations. The Contractor shall provide all utility connections, inlet ductwork from odor source, concrete pads, fencing and other items shown on the drawings NOT specified. The Contractor shall be responsible for providing a complete and operable system.

3.2 SERVICE OF MANUFACTURER'S REPRESENTATIVE

- A. The Contractor shall provide services of a qualified manufacturer's technical representative as specified under Section 44 11 29 – Bio-Trickling Filter Odor Control System, Subsection 1.5 who shall inspect and certify proper installation of equipment, supervise loading of carbon media, assist in equipment start-up, and provide training of plant operators. The carbon start-up and service shall be performed concurrent with the Bio-Trickling Filter service.

END OF SECTION

DIVISION 46
WATER AND WASTEWATER EQUIPMENT

SECTION 46 23 23.16 – STACKED TRAY VORTEX GRIT REMOVAL EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. The Work for furnishing all labor, equipment, materials, tools, and incidentals required for replacement of the existing (4) grit headcell inlet chutes.
 - 2. The Work that the vortex grit removal equipment manufacturer shall furnish and have overall system responsibility for coordination of all major components of the system.
- B. Equipment Requirements:
 - 1. Like items of equipment provided in later sections shall be the end products of one Manufacturer to achieve standardization of appearance, operation, maintenance, spare parts, and Manufacturer's services.

1.2 SUBMITTALS

- A. Subject to the requirements of Section 01 33 00 – Submittal Procedures.
- B. Action Submittals:
 - 1. Product Data:
 - a. The total weight of the equipment including the weight of the single largest item or component.
 - b. Complete description of surface preparation and shop prime painting.
 - 2. Shop and Erection Drawings:
 - a. Show all important details of construction dimensions and anchor bolt locations.
 - b. Show general arrangement and dimensional drawings of the grit removal system.
- C. Informational Submittals:
 - 1. Manufacturer's Instructions
 - a. Written recommended procedures for job site storage, handling, and installation of the equipment.
 - 2. Manufacturer's Field Report
 - a. A list of manufacturer's recommended spare parts with the manufacturer's current price for each item.
 - b. Bill of materials of all equipment.
 - 3. Certificates:
 - a. Certificate of Compliance:
 - 1) The Manufacturer shall warrant that the Grit Removal System to be supplied shall be manufactured in strict compliance with the Contract Specifications.
- D. See Section 01 77 00 – Closeout Procedures for additional requirements.

1.3 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Comply with Section 01 60 00 – Product Requirements.
- B. Delivery of Materials:
 - 1. Products shall be delivered in original, unbroken packages, containers, or bundles bearing the name of the manufacturer.
- C. Storage:

1. Products shall be carefully stored in a manner that will prevent damage and in an area that is protected from the elements.
- D. Protection of Equipment:
 1. 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 always be kept thoroughly dry. 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.
- E. The equipment, material, spare parts shall be shipped complete except where partial disassembly is required by transportation regulations or for protection of components.
- F. Provide lifting eyes or lugs to allow easy installation of the units to be installed in tanks and in the rooms. Items required to be installed in the rooms shall fit through a standard double door.
- G. Spare parts shall be packed in containers bearing labels clearly designating contents and pieces of equipment for which they are intended.
- H. The Contractor shall inspect equipment prior to unloading and notify the Manufacturer of any damage to equipment to effect proper remedial action. Failure to notify the Manufacturer of damage to equipment prior to unloading shall void all warranties pertaining to subject equipment.
- I. The Contractor shall unload, store and safeguard equipment, materials, and spare parts in accordance with Manufacturer's recommendations.

1.4 QUALITY ASSURANCE

- A. The system shall be furnished by a Manufacturer who is ISO 9001:2008 and 14001 Certified.
- B. Manufacturer shall be successful in the experience of manufacture, operation, and servicing of Grit Removal Systems of type, size, quality, performance, and reliability equal to that specified for a period of not less than 10 years. The Manufacturer shall submit evidence of experience having supplied a minimum of ten installations in North America of similar size to the proposed system.
- C. In the absence of verifiable experience, the Manufacturer shall be required to provide an extended warranty and subsequent Performance Bond for the same number of years that the Manufacturer was found lacking in experience from the specified 10-year period. The performance bond shall commence with acceptance of the equipment and time described in this section and beyond the standard warranty period.
- D. If equipment other than that shown on the Drawings is submitted to the Engineer for consideration as an equal, it shall be the responsibility of the Manufacturer requesting approval to submit with the request a revised design and layout of the mechanical equipment acceptable to the Engineer. Revised drawings shall show the proposed location of the alternate unit, and area required for withdrawal space of replacement or serviceable components. This drawing shall also show clearances of adjacent equipment and service area required by that equipment.

1.5 WARRANTY

- A. Provide warranty for a period of 24 months from the final acceptance 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. See Section 01 78 36 – Warranties and Bonds for additional requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURER

- 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 in this section.
- B. Approved Manufacturers:
 - 1. Hydro International

2.2 MATERIALS AND FINISHES

- A. Materials:
 - 1. Inlet chute shall be 316 stainless steel.
 - 2. Stainless Steel Equipment Fabrication:
 - a. Plate and Sheet:
 - 1) ASTM A167
 - 2) ASTM A240
 - b. Bar:
 - 1) ASTM A276
 - 2) ASTM A479
 - c. Tube:
 - 1) ASTM A312
- B. Exterior Surfaces Finishes:
 - 1. All surfaces shall be free of sharp edges, weld spatter and residue. All welds shall be ground smooth.
 - 2. All stainless steel surfaces shall be acid washed.
 - 3. All non-submerged exterior surfaces shall be Glass Bead Blasted to a uniform finish.

2.3 FABRICATION

- A. Shop Assembly:
 - 1. The system shall be factory assembled and tested.

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 FIELD QUALITY CONTROL

A. Functional Testing:

1. Prior to plant startup, all equipment described in this section shall be inspected for proper alignment, quiet operation, proper connection, and satisfactory performance by means of a functional test. Provide certification of test results. Tests and certification shall be as specified in Section 01 75 00 – Startup Testing and Training.

3.3 STARTUP, TRAINING, AND MANUFACTURER'S SERVICES

- A. A factory trained representative for the equipment specified in this section shall be present at the jobsite and/or classroom designated by the Owner for a maximum of four 8-hour man-days, across two separate visits, for installation inspection, plant startup, functional testing, and operator instructions; travel time excluded. A minimum of 30 days of notice is required to schedule manufacturer's services. Any services with less than 30 days of notice shall result in the Contractor being billed for service time and actual travel costs.
- B. Training of Owner's personnel shall be at times and locations specified by the Owner.

3.4 MANUFACTURER'S CERTIFICATE(S)

- A. Provide as specified in Section 01 75 00 – Startup Testing and Training.

END OF SECTION