6. The ((CxA) will notify testing and balancing Subcontractor 10 days in advance of the date of field verification. Notice will not include data points to be verified.

7. The testing and balancing Subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.

J. HVAC VRF/VRV Systems Equipment Testing Procedures

1. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the (CxA).

2. Scope of HVAC VRF/VRV testing shall include entire HVAC VRF/VRV installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space.

3. Tests will be performed using design conditions whenever possible.

4. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the (CxA) and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

5. The (CxA) may direct that set points be altered when simulating conditions is not practical.

6. If tests cannot be completed because of a deficiency outside the scope of the HVAC system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

7. HVAC VRF/VRV Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in the manufacturer`s installation instructions" Assist the (CxA) with preparation of testing plans.

PART 3 EXECUTION

3.1 GENERAL

A. The Subcontractors shall be responsible for performing procedures presented in specification and contract drawings as detailed in the Functional Performance Tests (FPT). Members of the designated Commissioning Team shall witness various portions of the commissioning process. Responsibilities for these activities are listed in the following paragraphs. Commissioning Team members shall sign-off on appropriate Sections after verifying installation, operation, or documentation. Final sign-off shall be by the Owner and Commissioning Agent.

B. Any test ports, gauges, test equipment, etc., needed to accomplish the functional performance tests shall be provided by Subcontractors.

C. Subcontractors shall provide to the Commissioning Team documentation of calibration of controls. Documentation shall include dates, setpoints, calibration coefficients, control loop verification, and other data required to verify system check-out. Documentation shall be dated and initialed by field engineer or technician performing the Work.

3.2 OPERATION STAFF TRAINING

A. System narrative descriptions will be prepared by the Commission Agent and supported by flow diagrams, one line diagrams, and appropriate Specification Sections for major systems to be commissioned. The Commission Agent will coordinate "system description" meetings with members of facility management and maintenance department groups to review system description documentation. The meetings will provide an overview of major system features, components, and arrangements.

B. The Subcontractor and associated manufacturer's representatives shall provide required training to operational staff after the system description meetings have occurred. The Subcontractor training sessions shall provide a more detailed analogy of systems operation and maintenance.

3.3 INSTRUMENTATION

A. Instrumentation will be provided by the Subcontractor. Instruments used for measurements shall be accurate. Calibration histories for each instrument shall be available for examination. Calibration and maintenance of instruments shall be in accordance with the requirements of NEBB or AABC Standards.

B. Application of instruments and accuracy of measurements shall be in accordance with NEBB or AABC Standards.

3.4 DOCUMENTATION

A. The installing Subcontractor shall be responsible for collection of pertinent data during system start-up and functional performance testing. The Subcontractor shall submit to the Commissioning Agent documentation of tests performed prior to and after system start-up. Documentation shall also include start-up procedures as approved by Commissioning Team.

B. Documentation is to be typewritten on 8.5 by 11 in paper and inserted in a 2-in to 3-in thick three ring binder. Indicate the project name, number, volume number, and volume title on the end panel of each binder.

C. Provide a title sheet for each volume and list the following:

1. Volume Title and Section Name and Number requiring this submittal.
2. Project name, project number, and address.
3. Subcontractor name, address, and phone number.
4. Name, title, signature, and date of person making the submittal.
5. Name of Owner, a blank line for signature, and the date of person accepting the submittal.
6. Name, address, and phone number of Commission Agent; a blank line for signature; and date of person accepting the submittal.

D. Provide a Table of Contents for multiple submittals. List each submittal and page number. Number each page, centered on the bottom in sequential numerical order. Provide tabs for multiple submittals in a single binder.

3.5 STEP ONE – INSTALLATION VERIFICATION

A. General Commissioning responsibilities:

1. Before system start-up begins, the Commission Team shall conduct a final installation verification audit. The Subcontractor shall be responsible for completion of Work including change orders and punch list items to the Owner's satisfaction. The audit shall include, but not be limited to, checking of:

a. Piping specialties including balance, control, and isolation valves.

b. Ductwork specialty items including turning devices, balance, fire, smoke, control dampers, and access doors.

c. Control sensor types and location.

d. Identification of piping, valves, equipment, controls, etc.

e. Major equipment, pumps, valves, starters, gauges, thermometers, etc.

f. Documentation of prestart-up tests performed, including manufacturer's factory tests.

B. If Work is found to be incomplete, incorrect, or non-functional, the Subcontractor shall correct the deficiency before system start-up Work proceeds.

3.6 STEP TWO – SYSTEM START-UP

A. General Commissioning Responsibilities:

1. A start-up plan shall be developed and submitted by the installing Subcontractor. Start-up plan to include the following:

a. Flushing and cleaning of pipe.
b. Filters, strainers, and screens.
c. Valve/damper positions.
d. Electrical tests.
e. Pressure tests.
f. Safeties.
g. Chemical treatment.
h. Manufacturer's tests.

B. The start-up plan will be reviewed and a prestart-up inspection performed by designated members of the Commissioning Team. The installing Subcontractor shall commence with system start-up after approval has been given to start-up plan and the prestart-up inspection is completed. Designated members of the Commissioning Team shall witness system start-up and list system and equipment deficiencies noted during start-up. The Subcontractor shall take corrective action on system deficiencies noted and demonstrate to the Commissioning Team members suitable system operation.

3.7 STEP THREE – FUNCTIONAL PERFORMANCE TESTING

A. General Commissioning Responsibilities:

1. Functional Performance Testing begins after operational testing, adjusting, and balancing of the systems have been completed by the Subcontractors; and the System Description and Hands-on Training sessions have been completed.

2. The objective of the Functional Performance Testing is to advance the building systems from a state of substantial completion to full dynamic operation in accordance with the specified design requirements and design intent.

3. Attaining this object will be accomplished by developing individual systems testing protocols which, when implemented by the Subcontractor, will allow the Commissioning Team to observe, evaluate, identify deficiencies, recommend modifications, tune, and document the systems and systems equipment performance over a range of load and functional levels.

4. Functional Performance tests for the systems to be commissioned are defined in the Commissioning Plan. These tests are intended to be conclusive but may require minor modifications as system operation dictates.

END OF SECTION

SECTION 23 09 01 – INSTRUMENTATION AND CONTROL FOR HVAC (STAND ALONE SYSTEM)

PART 1 GENERAL

1.1 PRODUCTS FURNISHED AND INSTALLED UNDER THIS SECTION

A. Section 23 - Refrigerant Piping - The HVAC Subcontractor shall:

1. Furnish and install all pressure and temperature sensor wells and sockets, which are specified to be supplied by this Section.

B. Section 23 - Ductwork Accessories - The HVAC Subcontractor shall:

1. Furnish and install all duct smoke detectors whether shown on the drawings or required by code. If the project includes an existing fire alarm panel all signals from the duct smoke detectors shall be transmitted to the existing fire alarm panel. If the project does not include an existing fire alarm panel, and a new fire alarm panel is not required for any other reason, signals from the duct smoke detectors shall be transmitted to the HVAC automatic temperature control panel.

2. Furnish and install all automatic dampers and provide necessary blank off plates or transitions required to install dampers that are smaller than duct size.

3. Assemble multiple section dampers with required interconnecting and jackshaft linkage and extend required number of shafts through duct for external mounting of damper motors.

4. Furnish and install all necessary sheet metal baffle plates to eliminate stratification and provide the air volumes specified. Locate baffles by experimentation. Fix and seal permanently in place only after stratification problems have been eliminated.

5. Furnish and install airflow stations specified under this Section.

6. Furnish and install access doors or other approved means of access through ducts for service to control equipment.

C. Section 26 Electrical - The Electrical Subcontractor shall:

1. Furnish and install and connect all power wiring. Power wiring shall be defined as:

a. Wiring of all power feeds through all disconnect starters and variable speed controllers to electric motors.

b. Provide local power disconnects, where required.

c. Provide circuit breakers, starters in motor control centers, and 120-, 208-, 240- and 480-volt power feeders from the starters and circuit breakers to the HVAC equipment, as indicated.

d. Wiring of 208-3ph VAC normal/emergency power feeds to all temperature control panels.

e. Power wiring to 120/277-volt single-phase motors shown on electrical plans and all VAV boxes shown (with or without fan motors).

f. All conduit, wiring and terminations between the ATC Panel and the Facility SCADA System

g. Each ATC panel shall be powered by one 208v-3phase branch circuit by Div 26, and the vendor shall connect their loads to the phases to balance the load to the extent possible.

D. Section 23 Electrical - The HVAC Subcontractor shall:

1. Design and install a complete HVAC controls system as described herein and contract drawings.

2. Provide controls, sensors and control panels relating to the HVAC systems, including starters, thermostats, duct smoke detectors, motorized dampers, louver operators and other equipment as indicated.

3. Provide control wiring of 120-volt and less as indicated in this Section and in conformance the requirements of Division 26 – Electrical and Division 40 – Instrumentation and Control.

E. Starters, whether as an integral or separate part of the equipment, shall be in accordance with the requirements of Section 26 24 19– Motor Control Centers.

F. Enclosures shall be of the same NEMA class as the electrical equipment in the same area.

G. Starters shall be of the same manufacturer as the starters indicated under Section 26 24 19– Motor Control Centers.

H. Low-voltage control wiring shall be in accordance with the National Electric Code.

I. Control wiring for line voltage 120-volt and higher shall be in conformance with the requirements of Division 26.

J. Control Panels shall be in conformance with the requirements of Section 26 27 16 - Electrical Cabinets and Enclosures.

K. Conduit shall be in conformance with the requirements of Section 26 05 33– Raceway and Boxes for Electrical Systems and Section 26 05 43– Underground Ducts and Raceways for Electrical Systems.

1.2 DUCT SMOKE DETECTORS

A. General

1. Furnish and install all duct smoke detectors whether shown on the drawings or required by code. If the project includes an existing fire alarm panel all signals from the duct smoke detectors shall be transmitted to the existing fire alarm panel. If the project does not include an existing fire alarm panel, and a new fire alarm panel is not required for any other reason, signals from the duct smoke detectors shall be transmitted to the HVAC automatic temperature control panel.

2. Air Handling Units and Fans

   a. Provide duct smoke detectors on both the intake and the discharge of air handling units, and fans as required by code.

   b. The detector shall shut off the respective air handling unit or fan upon the detection of smoke.

3. Smoke detectors shall operate on the photoelectric principle and shall respond to a predetermined smoke density regardless of the rate of combustion, the distance between the detector and fire source, the combustible material, the temperature or velocity of the smoke, and whether the fire is in a confined or open area.

4. The detectors shall be designed to ignore invisible airborne particles or smoke densities that are below the factory-set alarm point.

5. The smoke detectors shall be capable of operating at a humidity range of 10 to 90 percent RH.

6. The smoke detectors shall operate from a 24-VDC power source, and shall be Simplex, 4098 Series, ADT; Pyrotronics; or equal.

1.3 RELATED SECTIONS

A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are a part of this Specification and shall be used in conjunction with this Section as a part of the contract documents. Consult them for further instructions pertaining to this Work. The Contractor is bound by the provisions of Division 0 and Division 1.

B. The following Sections constitute related Work:

01 33 00	Submittal Procedures
23 05 00	Common Work Results for HVAC
26 05 20	Low-Voltage Electrical Power and Control Conductors and Cables
26 05 33	Raceway and Boxes for Electrical Systems
26 05 43	Underground Ducts and Raceways for Electrical Systems
26 24 19	Motor Control Centers
26 27 16	Electrical Cabinets and Enclosures
40 67 00	Control Panels

C. Reference Standards

1. All Work, materials, and equipment shall comply with the rules and regulations of all codes and ordinances of the local, state, and federal authorities having jurisdiction.

2. Such codes, when more restrictive, shall take precedence over the Contract Documents.

D. The installation shall comply with the following codes:

American National Standards Institute (ANSI)	
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)	
ASHRAE Standard 135	A Data Communication Protocol for Building Automation and Control Networks
ASHRAE/ANSI	135-2001: Data Communication Protocol for Building Automation and Control Systems (BACNET)
International Building Code (IBC)	
International Mechanical Code (IMC)	
National Electric Code (NEC)	
National Electrical Manufacturers Association (NEMA)	
National Fire Protection Association (NFPA)	
NFPA 72	National Fire Alarm and Signaling Code
Underwriters Laboratories (UL)	

1. All BAS DDC controllers and local user displays shall be UL-listed under Standard UL 916, category PAZX and Standard ULC C100, category UUKL7.

2. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and labeled as such.

1.4 SYSTEM DESCRIPTION

A. Performance Standards

1. The system shall conform to the minimum standards indicated in Tables 1 and 2, below.

2. Information transmission and display times shall be based upon network, rather than modem, connections.

3. Programmable controllers shall be capable of executing DDC PID control loops at a selectable frequency adjustable down to once per second.

4. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.

5. The system shall report all values with end-to-end accuracy as listed or better than those listed in Table 1.

6. Control loops shall maintain measured variable at set point within the tolerances listed in Table 2.

Table 1 - Reporting Accuracy

MEASURED VARIABLE	REPORTED ACCURACY
Space Temperature	plus or minus 1 deg F
Ducted Air	plus or minus 1 deg F
Outside Air	plus or minus 2 deg F
Dew Point	plus or minus 3 deg F

MEASURED VARIABLE	REPORTED ACCURACY
Water Temperature	plus or minus 1 deg F
Delta-T	plus or minus 0.25 deg F
Relative Humidity	plus or minus 5 percent RH
Water Flow	plus or minus 5 percent of full scale
Airflow (terminal)	plus or minus 10 percent of full scale (see Note 1)
Airflow (measuring stations)	plus or minus 5 percent of full scale
Airflow (pressurized spaces)	plus or minus 3 percent of full scale
Air Pressure (ducts)	plus or minus 0.1-in w.g.
Air Pressure (space)	plus or minus 0.01-in w.g.
Water Pressure	plus or minus 2 percent of full scale (see Note 2)
Electrical (A, V, W, Power Factor)	5 percent of reading (see Note 3)
Carbon Monoxide (CO)	plus or minus 5 percent of reading
Carbon Dioxide (CO2)	plus or minus 50 ppm

Note 1: 10 percent to 100 percent of full scale
Note 2: for both absolute and differential pressure
Note 3: not including utility-supplied meters

Table 2 - Control Stability and Accuracy

CONTROLLED VARIABLE	CONTROL ACCURACY	RANGE OF MEDIUM
Airflow	plus or minus 10 percent of full scale	-----
Space Temperature	plus or minus 2 deg F	-----
Duct Temperature	plus or minus 3 deg F	-----
Humidity	plus or minus 5 percent RH	-----

1.5 SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00– Submittal Procedures.

B. No Work may begin on any segment of the Project until submittals have been successfully reviewed for conformity with the design intent.

C. Submittals shall include:

1. Direct Digital Control System Hardware

a. A complete bill of materials of equipment to be used, indicating quantity, manufacturer, model number, and other relevant technical data.

b. Manufacturer's description and technical data, such as performance curves, product specification sheets, and installation and maintenance instructions for the following items and other relevant items not listed:

1) Direct Digital Controller (controller panels)
2) Transducers/Transmitters
3) Sensors (including accuracy data)
4) Actuators
5) Valves

6) Relays/Switches
7) Control Panels
8) Power Supply
9) Batteries
10) Wiring

2. Wiring diagrams and layouts for each control panel, showing all termination numbers.

3. Schematic diagrams for all field sensors and controllers, and floor plans of all sensor locations and control hardware.

4. Diagrams

   a. Submit schematic diagrams for all control, communication, and power wiring.

   b. Submit a schematic drawing of the central system installation. Show all interface wiring to the control system.

   c. Submit riser diagrams of wiring between central control unit and all control panels.

D. Controlled Systems

1. Schematic Diagrams

   a. Submit a schematic diagram of each controlled system.
   b. Indicate all control points labeled, with point names shown or listed.
   c. Graphically show the location of all control elements in the system.

2. Schematic Wiring Diagrams

   a. Submit a schematic wiring diagram for each controlled system.

   b. Label all elements.

   c. Where a control element is the same as that shown on the control system schematic, it shall be labeled with the same name.

   d. Label all terminals.

3. Instrument List

   a. Submit an instrumentation list for each controlled system.

   b. Each element of the controlled system shall be listed in table format.

   c. The table shall show element name, type of device, manufacturer, model number, and product data sheet number.

4. Description

   a. A complete description of the operation of the control system, including sequences of operation.

b. Include and reference a schematic diagram of the controlled system.

5. I/O

a. Submit a points list for each system controller, including both inputs and outputs (I/O), point number, the controlled device associated with the I/O point, and the location of the I/O device.

6. Quantities of items submitted will be reviewed but this shall be the responsibility of the Contractor.

1.6 QUALITY ASSURANCE

A. All products used in this project installation shall be new and currently under manufacture and shall be the version currently being sold by the manufacturer for use in new installations.

B. This installation shall not be used as a test site for any new products unless explicitly approved by the Owner in writing. Spare parts shall be available for at least five years after completion of this contract.

1.7 WARRANTY

A. Labor and materials for the control system specified shall be warranted free from defects for a period of 12 months after final completion and Owner receives beneficial use of the system.

B. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner.

C. The Contractor shall respond to the Owner's request for warranty service within 24 hours during normal business hours.

D. All Work shall have a single warranty date, even when the Owner has received beneficial use due to an early system start-up.

E. If the Work specified is split into multiple contracts or a multi-phase contract, then each contract or phase shall have a separate warranty start date and period.

PART 2 PRODUCTS

2.1 GENERAL

A. Temperature Controls

1. Temperature Control Panels furnished and installed by the HVAC Subcontractor shall be in accordance with Section 26 27 16- Electrical Cabinets and Enclosures. Temperature Control Panels provided by HVAC equipment manufacturers shall be in accordance with Section 40 67 00- Control Panels.

2. The temperature control system shall be as indicated on contract documents and shall consist of DDC controllers.

3. HVAC Subcontractor shall be responsible for the installation, calibration, and operator training as necessary for a complete and full operating temperature control system.

4. The temperature control system shall be a complete stand-alone building automation system, modular in construction and not requiring a central computer for operation or programming.

5. All programming shall be possible from a keypad/display on any field panel or from a remote computer.

6. Systems which do not have a keypad/display capability shall be provided with a portable interface with required cables and software.

B. BAS Components

1. The basic elements of the Building Automation System (BAS) structure shall be built from only standard components kept in inventory by the BAS supplier.

2. The components shall not require customizing other than setting jumpers and switches, and adding firmware modules, software modules or software programming to perform required functions.

3. The BAS shall possess a fully modular architecture, permitting expansion through the addition of more DDCP units, sensors, actuators, and operator terminals.

4. Expansion beyond this must be able to be accomplished in additional panels or expansion modules without abandoning any initial equipment.

C. Direct Digital Control Panel

1. The Direct Digital Control Panel's (DDCP's) software shall include a complete operating system, control algorithm application packages, and a complete custom control, calculation application package to accomplish the indicated sequence of operation.

2. In addition to pre-programmed package software, DDCP controllers shall be provided with field-flexible programming capabilities without the use of external equipment such as EPROM programmers in order to meet the indicated requirements.

3. Each DDCP shall be capable of performing all specified control functions in a completely independent manner.

4. Each DDCP unit shall be capable of sharing point information with other such units, such that control sequences or control loops executed at one control unit may receive input signals from sensors connected to other units within the network.

D. Programming

1. Control software shall utilize “block” programming techniques connecting tested control blocks to form control sequencing.

2. Line-by-line programming requiring complete definition will not be accepted as a programming technique.

3. The programmer shall fill in the control parameters for each block to perform the required control sequence.

2.2 CONTROLLER SOFTWARE

A. Each intelligent field panel shall be completely user programmable, and shall include the indicated programs installed in the base operating system.

B. Alarms

1. The alarm program shall provide for alarm reporting as follows:

a. Pilot light indication at local ATC Panel

b. Remote annunciation of identified alarm to facility SCADA System via hardwired contact closure

C. Analog Input Scaling

1. Analog inputs shall be scaled and labeled to read out in engineering units of the variable being measured (e.g., deg, CFM, etc.).

D. Analog Outputs

1. Each analog output shall be user programmable to be direct or reverse acting and vary the output between 2 and 10 VDC.

2. The panel shall allow the user to program minimum and maximum output levels as well as a manual fixed output level.

3. The analog output shall be assignable to operate based on any physical input or calculated value on the network.

E. System Calendar

1. Each panel other than Application Specific Controllers (such as Terminal Controllers) shall be provided with a 365/366 day battery-backed clock, with an automatic daylight savings time switch-over on the day entered.

F. PID Control

1. In order to provide precise control, each analog output shall be programmable with a proportional plus integral plus derivative (PID) program.

2. Individual constants shall be programmable for the P, I, and D functions.

3. The integral time interval shall be user programmable.

4. The current proportional term, the integral term, and the PID sum shall be dynamically displayed on the screen to provide assistance to start-up and service personnel in tuning the system.

G. The diagnostics program in each panel shall monitor and report system status.

2.3 BUILDING CONTROLLERS

A. General

1. Provide an adequate number of Building Controllers to achieve the indicated performance.

2. Each controller shall meet the following requirements.

   a. The Building Controller shall be provided with sufficient memory to support its operating system, database, and programming requirements.

   b. Controllers that perform scheduling shall be provided with a real-time clock.

B. Communication

1. The Building Controller shall be provided with a service communication port for connection to a portable operator terminal.

C. Environment

1. Building Controller hardware shall be suitable for the anticipated ambient conditions.

2. Controllers used outdoors or in wet ambient conditions shall be mounted within waterproof enclosures, and shall be rated for operation at minus 40 deg F to plus 150 deg F.

3. Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 32 deg F to 120 deg F.

D. Keypad

1. Provide a local keypad and display or a connection for a portable operator terminal for each Building Controller.

2. The keypad shall be provided for interrogating and editing data.

3. An optional system security password shall be available to prevent unauthorized use of the keypad and display.

4. If the manufacturer does not provide this keypad and display, provide a portable operator terminal.

E. Serviceability

1. Provide diagnostic LEDs for power, communication, and processor.

2. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

F. Memory

1. The Building Controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.

2. Applications shall be maintained in flash memory.

G. Immunity to Power and Noise

1. The controller shall operate at 90 percent to 110 percent of its nominal voltage rating, and shall perform an orderly shutdown below 80 percent nominal voltage.

2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 3 ft.

2.4 INPUT/OUTPUT INTERFACE

A. Hardwired inputs and outputs may tie into the system through building controllers, advanced application controllers, or application-specific controllers.

B. Input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground will cause no damage to the controller.

C. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no damage to the controller.

D. Binary Inputs

1. Provide binary inputs to allow the monitoring of ON-OFF signals from remote devices.

2. The binary inputs shall provide a wetting current of at least 12 mA in order to be compatible with commonly available control devices and shall be protected against the effects of contact bounce and noise.

3. Binary inputs shall sense “dry contact” closure without external power (other than that provided by the controller) being applied.

2.5 AUXILIARY CONTROL DEVICES

A. General

1. All materials and equipment used shall be standard components, of regular manufacture for this application.

2. All systems and components shall have been thoroughly tested and proven in actual use.

3. Exceptions to the indicated requirements will not be accepted.

B. Airflow Measurement Devices (AMD) with Temperature and Airflow Alarming Capability

1. Airflow measurement devices shall use the principle of thermal dispersion and provide one self-heated bead-in-glass thermistor and one zero power bead-in-glass thermistor at each sensing node.

a. Thermal dispersion devices that indirectly heat a thermistor are not acceptable.

b. The manufacturer's authorized representative shall review, approve placement and the operating airflow rates for each measurement location indicated on the plans.

c. Provide one AMD for each measurement location provided on the plans, schedules and/or control diagrams to determine the average airflow rate and temperature at each measurement location.

2. Each AMD shall be provided with a microprocessor-based transmitter and one or more sensor probes.

   a. Devices that have electronic signal processing components on or in the sensor probe are not acceptable.

3. Airflow measurement shall be field configurable to determine the average actual or standard mass airflow rate.

   a. Actual airflow rate calculations shall have the capability of being adjusted automatically by the transmitter for altitudes other than sea level.

4. Temperature measurement shall be field configurable to determine the velocity weighted temperate or simple arithmetic average temperature.

5. Sensor Probes

   a. Sensor probes shall be constructed of gold anodized, 6063 aluminum alloy tube insert 316 stainless steel tube in lieu of 6063 aluminum alloy tube, when required.

   b. Sensor probe mounting brackets shall be constructed of 304 stainless steel.

   c. Probe internal wiring between the connecting cable and sensor nodes shall be Kynar coated copper. PVC jacketed internal wiring is not acceptable.

   d. Probe internal wiring connections shall consist of solder joints and spot welds. Connectors of any type within the probe are not acceptable. Printed circuit boards within the probe are not acceptable.

   e. Probe internal wiring connections shall be sealed and protected from the elements and suitable for direct exposure to water.

   f. Each sensor probe shall be provided with an integral, FEP jacket, plenum rated CMP/CL2P, UL/cUL Listed cable rated for exposures from minus 67 deg F to 392 deg F and continuous and direct UV exposure. Plenum rated PVC jacket cables are not acceptable.

   g. Each sensor probe cable shall be provided with a connector plug with gold plated pins for connection to the transmitter.

   h. Each sensor probe shall contain one or more independently wired sensing nodes.

   i. Sensor node airflow and temperature calibration data shall be stored in a serial memory chip in the cable connecting plug and not require matching or adjustments to the transmitter.

j. Each sensor node shall be provided with two bead-in-glass, hermetically sealed thermistors potted in a marine grade waterproof epoxy. Devices that use epoxy or glass encapsulated chip thermistors are not acceptable.

k. Each thermistor shall be individually calibrated at a minimum of 3 temperatures to NIST-traceable temperature standards.

l. Each sensor node shall be individually calibrated to NIST-traceable airflow standards at a minimum of 16 calibration points.

m. The number of independent sensor nodes provided shall be as follows:

Area ft^2	# Sensor Nodes
≤ 0.5	1
> 0.5 & ≤ 1	2
> 1 & ≤ 2	4
> 2 & ≤ 4	6
> 4 & ≤ 8	8
> 8 & ≤ 12	12
> 12 & ≤ 14	14
> 14	16

n. A total of 4 probes shall be required for openings with an aspect ratio ≤ 1.5 and with an area ≥ 25 ft^2.

6. Transmitter

a. A remotely located microprocessor-based transmitter shall be provided for each measurement location.

b. The transmitter shall be comprised of a main circuit board and interchangeable interface card.

c. All printed circuit board interconnects, edge fingers, and test points shall be gold plated.

d. All printed circuit boards shall be electroless nickel immersion gold (ENIG) plated.

e. All receptacle plug pins shall be gold plated.

f. The transmitter shall be capable of determining the average airflow rate and temperature of the sensor nodes.

g. Separate integration buffers shall be provided for display airflow output, airflow signal output (analog and network) and individual sensor output (IR-interface).

h. The transmitter shall be capable of providing a high and/or low airflow alarm.

i. The transmitter shall be capable of identifying an AMD malfunction via the system status alarm and ignore any sensor node that is in a fault condition.

j. The transmitter shall be provided with a 16-character, alpha-numeric, LCD display.

k. The airflow rate, temperature, airflow alarm and system status alarm shall be visible on the display.

l. The transmitter shall be provided with two field selectable (0-5/0-10 VDC or 4-20mA), scalable, isolated and over-current protected analog output signals and one isolated RS-485 (field selectable BACnet MS/TP or Modbus RTU) network connection;

m. Analog output signals shall provide the total airflow rate and be field configurable to output one of the following: temperature, airflow alarm; or system status alarm

n. Network communications shall provide the average airflow rate, temperature, airflow alarm, system status alarm, individual sensor node airflow rates and individual sensor node temperatures.

o. Provide an infra-red I/O card mounted on the transmitter PCB for communication to a handheld retrieval device that can download individual sensor node airflow and temperature data in real time.

p. The transmitter shall be powered by 24 VAC and use a switching power supply that is over-current and over-voltage protected.

q. The transmitter shall use a “watchdog” timer circuit to ensure continuous operation in the event of brown-out and/or power failure.

7. Performance

a. Each sensing node shall have an airflow accuracy of ±2% of reading over an operating range of 0 to 5,000 FPM.

b. Accuracy shall include the combined uncertainty of the sensor nodes and transmitter.

c. Devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter shall demonstrate compliance with this requirement over the entire operating range.

d. Each sensing node shall have a temperature accuracy of plus minus 0.18 deg F over an operating range of minus 20 deg F to 160 deg F.

8. Listings and Certifications

a. The AMD shall be UL873 Listed as an assembly.

b. Devices claiming compliance with the UL Listing based on individual UL component listing are not acceptable.

c. The AMD shall be BTL Listed.

d. The AMD shall carry the CE Mark for European Union Shipments.

9. Installation

    a. Install in accordance with manufacturer's placement guidelines. A written report shall be submitted to the consulting mechanical engineer if any discrepancies are found.

10. Adjusting

    a. The AMD shall not be adjusted to match field measurements without approval from the consulting mechanical engineer when installations meet or exceed manufacturer's suggested placement

11. Acceptable Manufacturers or equal:

    a. EBTRON, inc. model GTX116-P is the basis of design
    b. Sierra
    c. Johnson Controls

C. Damper Actuators

1. Electronic damper actuators shall be of the direct-couple rotary type, suitable for mounting directly on the damper end shaft.

2. Electronic damper actuators shall be properly sized to provide sufficient torque to position the damper throughout its operating range.

3. On dampers with multiple sections, provide one actuator per section.

4. Damper actuators used on economizers and outside air dampers shall be of the spring return type.

D. Control Panels

1. All direct digital controllers mounted on HVAC equipment located indoors shall be installed in NEMA 4X enclosures.

2. All direct digital controllers mounted on HVAC equipment located outdoors shall be installed in NEMA 4X enclosures.

3. Enclosures shall be of suitable size to accommodate power supplies, relays, and accessories as required for the application.

4. Each enclosure shall include a subpanel for direct mounting of the enclosed devices, including matched key locks for all enclosures.

5. Construction

    a. Control panels shall contain all relays, control switches, transformers, pilot lights, timers, time clocks, step controllers, gages, thermostats, and other accessories as necessary for the particular system.

    b. The panels shall be constructed of aluminum with a baked enamel finish, and shall include a hinged front door with locking handle.

c. All manual switches and direct-reading gauges shall be flush-mounted on the front face, and identified by engraved and riveted Bakelite or laminated plastic nameplates with white letters on black background.

d. Manual switches shall be of heavy-duty, oil-tight construction.

6. Wiring

a. Control devices shall be pre-wired internally.

b. Terminate all wires leaving the panel at separate numbered terminal strips.

c. Provide individual connectors for every item of mechanical equipment, all integral and remote pilot lights, and other devices indicated for each panel.

d. Power and control circuit requirements shall be as indicated on the Electrical Drawings.

e. Identify all wires by color coding or numerical tags at both ends.

f. Wire each control device without splices to the terminal strip.

g. Provide integral circuit protection for all panel-mounted control devices.

h. Wire each panel with a one 208v 3-phase, and AC feeder.

7. Panel electrical wiring diagrams shall be secured to the inside of the panel door.

E. Differential Pressure Switches (Air)

1. Provide differential pressure switches across fans and filters for status indication.

2. The differential pressure switches shall be provided with an adjustable setpoint from 0.05-in w.c. to 12-in w.c., with a switch differential that progressively increases from 0.04-in w.c. at minimum to 0.8-in w.c. at maximum.

3. The switch shall be SPDT-rated for 15A (non-inductive) at 125VAC.

F. Float Switches

1. Provide float switches in condensate drain pans as required by code.
2. Float switches shall utilize a magnetically actuated dry reed switch.
3. The float shall be constructed of seamless polypropylene.
4. The switch shall be SPDT-rated for 16A (non-inductive) at 120VAC.

G. Smoke Detectors

1. Division 26 – shall provide area smoke detectors and wire into the fire alarm system in accordance with the requirements of Section 23 05 00– Common Work Results for HVAC.

2. Division 23 – shall provide HVAC duct detectors interlock wiring between duct smoke detectors and starter safety circuits.

H. Differential Pressure Transducers (Air)

1. Provide differential pressure transducers for monitoring air system and airflow measuring station differential pressures.

2. Differential pressure transducers shall be 100 percent solid-state, and shall include glass-on-silicon, ultra-stable capacitance sensors.

3. Each differential pressure transducer shall incorporate short circuit and reverse polarity protection.

4. Transducer output shall be either 0-10 VDC or 4-20 mA.

5. Provide the differential pressure transducers in an enclosure that is suitable for duct mounting.

6. The desired set point shall be within the top 50 percent of the transducer's operating range.

I. Current Sensing Relays

1. Provide current switches for indication of equipment status.

2. Amperage ratings shall be adjustable, with the desired set point being within the top 50 percent of the current relay's operating range.

3. Current sensing relays shall incorporate trip indication LEDs and shall be sized for proper operation with the equipment served.

J. Thermostats - Line Voltage

1. Materials: cold-rolled steel; beige thermoplastic; liquid sensing element

2. Contact Rating

   a. 6 amps running; 36 amps locked rotor; 120 VAC
   b. 3.5 amps running; 21 amps locked rotor; 208 VAC
   c. 3.0 amps running; 8 amps locked rotor; 240 VAC

3. Switch Action: single-pole, double-throw; open on rising temperature

4. Sensing Element: coiled bulb and capillary

5. Range: 0 to 130 deg F

6. Manufacturer, or Equal

   a. Dry Locations (no hose valves or open water processes in room): **Johnson Controls Model A19BAC-1** in NEMA 1 enclosure

   b. Wet (hose valves or open water processes in room) or Outdoor Locations: **Johnson Controls Model A19PRC-1** in NEMA 4X enclosure.

K. Occupancy Sensors

1. Occupancy sensors shall be provided with occupancy-sensing sensitivity adjustment, and an adjustable off-delay timer with a range encompassing 30 seconds to 15 minutes.

2. Occupancy sensors shall be rated for operation in ambient air temperatures from 50 deg F 10 deg C to 110 deg F 43 deg C.

3. Occupancy sensors shall be of the passive infrared type, and shall be provided with a multi-level, multi-segmented viewing lens and a conical field of view with a viewing angle of 180 degrees and a detection of at least 20 ft 6.1 m.

4. Passive infrared occupancy sensors shall provide field-adjustable background light-level adjustment with an adjustment range suitable to the light level in the sensed area.

5. Passive infrared sensors shall be immune to false triggering from radio frequency interference and other electromagnetic interference.

L. Selector Switches

1. Selector switches shall be of the 2- or 3-position, knob or key type as required by the sequence of operation.

2. Selector switches shall be of oil-tight construction and fitted with snap-fit contact blocks rated for 10A, 600 Vac/dc operation.

3. Provide labels indicating switch position.

M. Pilot Lights

1. Provide pilot lights as required by the sequence of operation.
2. Pilot lights shall utilize multi-colored dome lenses and replaceable LED lamps.
3. Provide labels indicating light function.

2.6 WIRING AND RACEWAYS

A. Provide copper wiring, plenum cable, and raceways as indicated in the applicable Sections of Division 26 – Electrical.

B. All insulated wire shall be copper conductor, and UL-labeled for 194 deg F minimum service.

2.7 CONTROL SYSTEM MANUFACTURERS, OR EQUAL

A. Schneider Electric

B. Johnson Controls

C. Siemens

D. Honeywell

E. Trane

F. The above list of manufacturers applies to controller software, custom application programming language, building controllers, custom application controllers; and application specific controllers; all other indicated products (e.g., sensors, valves, dampers and actuators) need not necessarily be manufactured by the above manufacturers.

PART 3 EXECUTION

3.1 EXAMINATION

A. The Drawings shall be thoroughly examined for control device and equipment locations, and any discrepancies, conflicts, or omissions shall be reported to the Engineer for resolution before rough-in work is started.

B. Inspect the Project Site to verify that the equipment may be installed as indicated, and report any discrepancies, conflicts, or omissions to the Engineer for resolution before rough-in work is started.

C. Examine the Contract Documents for other parts of the Work, and if head room or space conditions appear inadequate, report these discrepancies to the Engineer and obtain written instructions for any changes that may be necessary to accommodate the Work with the work of others.

D. Changes in the Work made necessary by the failure or neglect of the Contractor to report such discrepancies shall be considered to be part of the Contract.

3.2 COORDINATION

A. Site

1. Where the Work will be installed in close proximity to, or will interfere with, the work of other trades, the Contractor shall assist in accommodating space conditions to make a satisfactory adjustment.

2. If the Contractor installs the Work before coordinating with other trades, so as to cause any interference with the work of other trades, the Contractor shall make the necessary changes in the Work in order to correct the condition as part of the Contract.

3. Coordinate and schedule the Work with all other work in the same area, or with work that is dependent upon other work, in order to facilitate mutual progress.

B. Coordination with Other Controls

1. Other controls and control devices that are to be part of or integrated into the control system specified in this Section. These controls shall be integrated into the system and coordinated by the Contractor as follows:

2. All communication media and equipment shall be provided as specified in Part 2, “Communication” of this Specification.

3. Each supplier of a control product is responsible for the configuration, programming, startup, and testing of that product to meet the sequences of operation described in this Section.

4. The HVAC Subcontractor shall coordinate and resolve any incompatibility issues that arise between the control products provided under this Section and those provided under other Sections or divisions of this Specification.

5. The HVAC Subcontractor is responsible for the integration of control products provided by multiple suppliers regardless of where this integration is described within the contract documents.

C. Coordination with Facility SCADA System

1. Each Automatic Temperature Control System Panel (ATC) shall annunciate critical alarms with Pilot Light (Red) illumination.

2. All critical alarms will also be annunciated to the Facility SCADA system via hard wired contact closure of each respective alarm.

3. All other local Pilot Light indication (Green – System On) (Yellow – System Caution) (Blue – System Off) are considered non-critical and not required to be annunciated to the Facility SCADA System

4. Division 23 - shall provide necessary relays and termination strip for wiring to the Facility SCADA System. Conduit and wiring between the ATC Panel and the SCADA system shall be by Electrical Subcontractor

5. See general sheets for ATC panel and Pilot Light layout.

3.3 GENERAL WORKMANSHIP

A. Install equipment, piping, wiring, and raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.

B. Provide sufficient slack and flexible connections to allow for vibration isolation of piping and equipment.

C. Install all equipment in readily accessible locations as defined by the National Electrical Code (NEC)

D. Verify the integrity of all wiring to ensure continuity and freedom from shorts and grounds.

E. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and shall be executed in strict adherence to local codes and standard practices.

3.4 WIRING FOR CONTROL SYSTEMS

A. Furnish and install all wire, conduit, raceways, and cable systems as required for the complete operation of the Building Management and Control System in accordance with the

requirements of Section 26 05 20, Low-Voltage Electrical Power and Control Conductors and Cables.

3.5 SENSOR INSTALLATION

A. Install sensors in accordance with the manufacturer's recommendations.

B. Mount sensors rigidly and adequately for the environment within which the sensor operates.

C. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.

D. All wires attached to sensors shall be air-sealed in their raceways or in the wall in order to stop air transmitted from other areas from affecting sensor readings.

E. Averaging Sensors

1. Sensors used in mixing plenums and hot and cold decks shall be of the averaging type.
2. Averaging sensors shall be installed in a serpentine manner vertically across the duct.
3. Support each bend with a capillary clip.

F. Temperature Sensors

1. All pipe-mounted temperature sensors shall be installed in wells.
2. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.

3.6 ACTUATORS

A. Mount and link control damper actuators according to manufacturer's instructions.

B. To compress seals when spring-return actuators are used on normally closed dampers, the actuator shall be powered to an approximately 5 degree open position, the damper closed manually, and then the linkage tightened.

C. Check the operation of damper/actuator combination in order to confirm that the actuator modulates damper smoothly throughout the stroke to both OPEN and CLOSED positions.

D. Provide all mounting hardware and linkages for the actuator installation.

E. Electric and Electronic Actuators

1. Dampers

a. Actuators shall be direct-mounted on the damper shaft or jackshaft unless indicated as a linkage installation.

b. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5 degrees available for tightening the damper seals.

c. Actuators shall be mounted in accordance with the manufacturer's recommendations.

3.7 CONTROLLERS

A. General

1. Provide a separate controller for each AHU or other HVAC system.

2. A DDC controller may control more than one system provided that all points associated with the system are assigned to the same DDC controller.

3. Control of an AHU or other mechanical equipment item shall not be split between multiple controllers; points used for control loop reset, such as outside air or space temperature, are exempt from this requirement.

B. Building Controllers and Custom Application Controllers

1. Building controllers and custom application controllers shall be selected to provide a minimum of 15 percent spare I/O point capacity for each point type found at each location.

2. If input points are not universal, 15 percent of each type shall be required, and if outputs are not universal, 15 percent of each type is required.

3. A minimum of one spare is required for each type of point used.

4. The future use of spare capacity shall require providing the field device, field wiring, point database definition, and custom software.

5. No additional controller boards or point modules shall be required to implement use of such spare points.

3.8 PROGRAMMING

A. Provide sufficient internal memory for the specified sequences of operation and trend logging.

B. Provide a minimum of 25 percent of available memory free for future use.

C. BACnet Points

1. Provide a detailed BACnet points list.

2. In addition to standard I/O information, the BACnet points list shall contain the proposed I/O names and BACnet object description.

3. The proposed I/O names and object descriptions are subject to change as directed by the Engineer.

4. Deliver an as-built list of the BACnet points with actual names and BACnet object addresses to the Owner at Project completion.

D. Software Programming

1. Provide programming for the system and adhere to the indicated sequences of operation.

2. Provide all other system programming necessary for the operation of the system but not indicated in this Section.

3. Embed into the control program sufficient comment statements to clearly describe each section of the program, reflecting the language used in the sequences of operation.

3.9 CONTROL SYSTEM CHECKOUT AND TESTING

A. Start-up Testing

1. All testing listed in this article shall be performed by the Contractor and shall make up part of the necessary verification of an operating control system.

2. This testing shall be completed before the Engineer is notified of the system demonstration.

B. Furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this Section.

C. Verify that all control wiring is properly connected, free of shorts and ground faults, and that terminations are tight.

D. Enable the control systems and verify calibration of all input devices individually.

E. Perform calibration procedures according to manufacturers' recommendations.

F. Verify that all binary output devices (e.g., relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.

G. Verify that all analog output devices (e.g., I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct.

H. Control Valves

1. Check all control valves and automatic dampers in order to ensure proper action and closure.

2. Make any necessary adjustments to valve stem and damper blade travel.

I. Verify that the system operation adheres to the sequences of operation.

J. Simulate and observe all modes of operation by overriding and varying inputs and schedules.

K. Tune all PID loops and optimize START/STOP routines.

L. Alarms and Interlocks

1. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.

2. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.

3. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

3.10 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Demonstration

1. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this Section.

2. These tests shall occur after the Contractor has completed the installation, started up the system, and performed tests.

3.11 TRAINING

A. Provide a minimum of 2 on-site or classroom training sessions of 1 day each, throughout the Contract period for personnel designated by the Owner.

B. Additional Training

1. Provide 2 additional training sessions at 6 and 12 months following the facility's turnover.
2. Each session to be 4 hours in length and shall be coordinated with the Owner.

C. Train the designated Owner's staff to perform the following items:

1. Day-to-day Operations:

a. Operate the system proficiently

b. Understand the control system architecture and configuration

c. Understand the DDC system components

d. Understand system operation, including DDC system control and optimizing routines (algorithms)

e. Operate the workstation and peripherals

f. Log on and off the system

g. Access graphics, point reports, and logs

h. Adjust and change system set points, time schedules, and holiday schedules

i. Recognize malfunctions of the system by observation of the system graphics, trend logs, and other system tools

j. Understand system drawings and the operation and maintenance manual

k. Understand the job layout and location of control components

l. Access data from the DDC controllers and ASCs

m. Operate portable operator terminals

2. Advanced Operations:

    a. Create, delete, and modify alarms, including annunciation and routing of these items

    b. Create, delete, and modify trend and graph or print these both on ad-hoc basis and at user-definable time intervals

    c. Create, delete, and modify reports

    d. Add, remove, and modify the system's physical points

    e. Create, modify, and delete programming

    f. Add panels when required

    g. Add operator interface stations

    h. Create, delete, and modify system displays, both graphical and others

    i. Perform DDC system field checkout procedures

    j. Perform DDC controller unit operation and maintenance procedures

    k. Configure hardware including controllers and I/O points

    l. Maintain, calibrate, and replace system components

3. System Management and Administration:

    a. Maintain software and prepare backups
    b. Interface with job-specific, third-party operator software
    c. Add new users and understand password security procedures

D. Groupings

1. Split the above objectives into 3 logical groupings, as follows and based on the above descriptions.

2. Participants may attend one or more of these, depending on their level of knowledge required.

    a. Day-to-day operators
    b. Advanced operators
    c. System managers and administrators

E. Provide a course outline and materials in accordance with the “Submittals” article in Part 1 of this Section.

F. The instructor shall provide one copy of training material per student

G. The instructor shall be factory-trained and experienced in presenting this material.

H. Classroom training shall be performed using a network of working controllers representative of the installed hardware.

END OF SECTION

SECTION 23 23 00 – REFRIGERANT PIPING

PART 1 GENERAL

1.1 SUMMARY

A. The Contractor shall provide copper tube for refrigeration service, complete and in place, as indicated in accordance with the Contract Documents

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 17	Structural Design, Support, and Anchorage
07 92 13	Elastomeric Joint Sealants

B. Reference Standards

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)	
AHRI 710 (2009)	Performance Rating of Liquid-Line Driers
AHRI 711 (2009)	Performance Rating of Liquid-Line Driers
AHRI 720 (2002)	Refrigerant Access Valves and Hose Connectors
ANSI/AHRI 750 (2007)	Thermostatic Refrigerant Expansion Valves
ANSI/AHRI 760 (2007)	Performance Rating of Solenoid Valves for Use With Volatile Refrigerants
AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)	
ANSI/ASHRAE 15 & 34	
ASHRAE 17 (2008)	Method of Testing Capacity of Thermostatic Refrigerant Expansion Valves
AMERICAN WELDING SOCIETY AWS A5.8/A5.8M (2011)	Specification for Filler Metals for Brazing and Braze Welding, AWS BRH (2007; 5th Ed) Brazing Handbook, AWS D1.1/D1.1M (2010) Structural Welding Code – Steel, AWS Z49.1 (2005) Safety in Welding and Cutting and Allied Processes
ASME INTERNATIONAL (ASME)	
ASME B1.20.1 (1983; R 2006)	Pipe Threads, General Purpose
ASME B16.11 (2009)	Forged Fittings, Socket-Welding and Threaded
ASME B16.21 (2011)	Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.22 (2001; R 2010)	Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26 (2011)	Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.3 (2011)	Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5 (2009)	Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Inch Standard
ASME B16.9 (2007)	Standard for Factory-Made Wrought Steel Buttwelding Fittings
ASME B31.1 (2010)	Power Piping
ASME B31.5 (2010)	Refrigeration Piping and Heat Transfer Components
ASME B31.9 (2011)	Building Services Piping
ASME B40.100 (2005; R 2010)	Pressure Gauges and Gauge Attachments

ASME BPVC SEC IX (2010)	BPVC Section IX-Welding and Brazing Qualifications
ASTM INTERNATIONAL (ASTM)	
ASTM A193/A193M (2011)	Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A334/A334M (2004a; R 2010)	Standard Specification for Seamless and Welded Carbon and Alloy-Steel Tubes for Low-Temperature Service
ASTM A53/A53M (2010)	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A653/A653M (2011)	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B117 (2011)	Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B280 (2008)	Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM B32 (2008)	Standard Specification for Solder Metal
ASTM B62 (2009)	Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B75 (2002; R 2010)	Standard Specification for Seamless Copper Tube
ASTM B813 (2010)	Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
ASTM D3308 (2006)	PTFE Resin Skived Tape
ASTM D520 (2000; R 2011)	Zinc Dust Pigment
ASTM E84 (2011b)	Standard Test Method for Surface Burning Characteristics of Building Materials

1.3 QUALITY ASSURANCE

A. Submit 4 copies of qualified procedures, and list of names and identification symbols of qualified welders and welding operators, prior to non-factory welding operations. Piping shall be welded in accordance with the qualified procedures using performance qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. Notify the Contracting Officer 24 hours in advance of tests to be performed at the work site, if practical. The welder or welding operator shall apply the personally assigned symbol near each weld made, as a permanent record.

B. Contract Drawings: Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. Carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Protect stored items from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation is the Contractor's responsibility. Replace any materials found to be damaged at the Contractor's expense. During installation, cap piping and similar openings to keep out dirt and other foreign matter.

PART 2 PRODUCTS

2.1 REFRIGERANT PIPING SYSTEM

A. Refrigerant piping, valves, fittings, and accessories shall be in accordance with ANSI/ASHRAE 15 & 34 and ASME B31.5, except as specified herein. Refrigerant piping, valves, fittings, and accessories shall be compatible with the fluids used and capable of withstanding the pressures and temperatures of the service. Refrigerant piping, valves, and accessories used for refrigerant service shall be cleaned, dehydrated, and sealed (capped or plugged) prior to shipment from the manufacturer's plant. Submit drawings, at least 2 weeks prior to beginning construction, provided in adequate detail to demonstrate compliance with contract requirements. Drawings shall consist of:

1. Piping layouts which identify all valves and fittings.
2. Plans and elevations which identify clearances required for maintenance and operation.

2.2 PIPE, FITTINGS AND END CONNECTIONS (JOINTS)

A. Copper Tubing

1. Copper tubing shall conform to ASTM B280 annealed or hard drawn as required.

2. Copper tubing shall be soft annealed where bending is required and hard drawn where no bending is required.

3. Soft annealed copper tubing shall not be used in sizes larger than 1 3/8-in. Joints shall be brazed except that joints on lines 7/8-in and smaller may be flared. Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 and ASTM B62.

4. Wrought copper and bronze solder-joint pressure fittings shall conform to ASME B16.22 and ASTM B75M ASTM B75. Joints and fittings for brazed joint shall be wrought-copper or forged-brass sweat fittings.

5. Cast sweat-type joints and fittings shall not be allowed for brazed joints. Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment.

B. Solder

1. Solder shall conform to ASTM B32, grade Sb5, tin-antimony alloy for service pressures up to 150 psig. Solder flux shall be liquid or paste form, non-corrosive and conform to ASTM B813.

C. Brazing Filler Metal

1. Filler metal shall conform to AWS A5.8/A5.8M, Type BAg-5 with AWS Type 3 flux, except Type BCuP-5 or BCuP-6 may be used for brazing copper-to-copper joints.

2.3 VALVES

A. Valves, General

1. Valves shall be designed, manufactured, and tested specifically for refrigerant service. Valve bodies shall be of brass, bronze, steel, or ductile iron construction. Valves 1-in and smaller shall have brazed or socket welded connections. Valves larger than 1-in shall have butt welded end connections.

2. Threaded end connections shall not be used, except in pilot pressure or gauge lines where maintenance disassembly is required and welded flanges cannot be used. Internal parts shall be removable for inspection or replacement without applying heat or breaking pipe connections.

3. Valve stems exposed to the atmosphere shall be stainless steel or corrosion resistant metal plated carbon steel. Direction of flow shall be legibly and permanently indicated on the valve body.

4. Control valve inlets shall be fitted with integral or adapted strainer or filter where recommended or required by the manufacturer. Purge, charge and receiver valves shall be of manufacturer's standard configuration.

B. Refrigerant Stop Valves

1. Valve shall be the globe or full-port ball type with a back-seating stem especially packed for refrigerant service. Valve packing shall be replaceable under line pressure. Valve shall be provided with a handwheel operator and a seal cap. Valve shall be the straight or angle pattern design as indicated.

C. Check Valves

1. Valve shall be the swing or lift type as required to provide positive shutoff at the differential pressure indicated. Valve shall be provided with resilient seal.

D. Liquid Solenoid Valves

1. Valves shall comply with ANSI/AHRI 760 and be suitable for continuous duty with applied voltages 15 percent under and 5 percent over nominal rated voltage at maximum and minimum encountered pressure and temperature service conditions.

2. Valves shall be direct-acting or pilot-operating type, packless, except that packed stem, seal capped, manual lifting provisions shall be furnished. Solenoid coils shall be moisture-proof, UL approved, totally encapsulated or encapsulated and metal jacketed as required.

3. Valves shall have safe working pressure of 400 psi and a maximum operating pressure differential of at least 200 psi at 85 percent rated voltage. Valves shall have an operating pressure differential suitable for the refrigerant used.

E. Expansion Valves

1. Valve shall conform to ANSI/AHRI 750 and ASHRAE 17. Valve shall be the diaphragm and spring-loaded type with internal or external equalizers, and bulb and capillary tubing.

2. Valve shall be provided with an external superheat adjustment along with a seal cap. Internal equalizers may be utilized where flowing refrigerant pressure drop between outlet of the valve and inlet to the evaporator coil is negligible and pressure drop across the evaporator is less than the pressure difference corresponding to 2 deg F of saturated suction temperature at evaporator conditions. Bulb charge shall be determined by the manufacturer for the application and such that liquid will remain in the bulb at all operating conditions. Gas limited liquid charged valves and other valve devices for limiting evaporator pressure shall not be used without a distributor or discharge tube or effective means to prevent loss of control when bulb becomes warmer than valve body.

3. Pilot-operated valves shall have a characterized plug to provide required modulating control. A de-energized solenoid valve may be used in the pilot line to close the main valve in lieu of a solenoid valve in the main liquid line. An isolatable pressure gauge shall be provided in the pilot line, at the main valve.

4. Automatic pressure reducing or constant pressure regulating expansion valves may be used only where indicted or for constant evaporator loads.

F. Safety Relief Valves

1. Valve shall be the two-way type, unless indicated otherwise.

2. Valve shall bear the ASME code symbol. Valve capacity shall be certified by the National Board of Boiler and Pressure Vessel Inspectors. Valve shall be of an automatically reseating design after activation.

G. Evaporator Pressure Regulators, Direct-Acting

1. Valve shall include a diaphragm/spring assembly, external pressure adjustment with seal cap, and pressure gauge port. Valve shall maintain a constant inlet pressure by balancing inlet pressure on diaphragm against an adjustable spring load. Pressure drop at system design load shall not exceed the pressure difference corresponding to a 2 deg F change in saturated refrigerant temperature at evaporator operating suction temperature. Spring shall be selected for indicated maximum allowable suction pressure range.

H. Refrigerant Access Valves

1. Refrigerant access valves and hose connections shall be in accordance with AHRI 720.

2.4 PIPING ACCESSORIES

A. Filter Driers

1. Driers shall conform to AHRI 711AHRI 710. Sizes 5/8-in and larger shall be the full flow, replaceable core type. Sizes ½-in and smaller shall be the sealed type. Cores shall be of

suitable desiccant that will not plug, cake, dust, channel, or break down, and shall remove water, acid, and foreign material from the refrigerant.

2. Filter driers shall be constructed so that none of the desiccant will pass into the refrigerant lines. Minimum bursting pressure shall be 1,500 psi.

B. Sight Glass and Liquid Level Indicator

1. Assembly and Components: Assembly shall be pressure- and temperature-rated and constructed of materials suitable for the service. Glass shall be borosilicate type.

2. Ferrous components subject to condensation shall be electro-galvanized.

C. Gauge Glass

1. Gauge glass shall include top and bottom isolation valves fitted with automatic checks, and packing followers; red-line or green-line gauge glass; elastomer or polymer packing to suit the service; and gauge glass guard.

D. Bull's-Eye and Inline Sight Glass Reflex Lens

1. Bull's-eye and inline sight glass reflex lens shall be provided for dead-end liquid service. For pipe line mounting, two plain lenses in one body suitable for backlighted viewing shall be provided.

E. Moisture Indicator

1. Indicator shall be a self-reversible action, moisture reactive, color changing media. Indicator shall be furnished with full-color-printing tag containing color, moisture and temperature criteria. Unless otherwise indicated, the moisture indicator shall be an integral part of each corresponding sight glass.

F. Vibration Dampeners

1. Dampeners shall be of the all-metallic bellows and woven-wire type.

G. Flexible Pipe Connectors

1. Connector shall be a composite of interior corrugated phosphor bronze or Type 300 Series stainless steel, as required for fluid service, with exterior reinforcement of bronze, stainless steel or monel wire braid. Assembly shall be constructed with a safety factor of not less than 4 at 300 deg F. Unless otherwise indicated, the length of a flexible connector shall be as recommended by the manufacturer for the service intended.

H. Strainers

1. Strainers used in refrigerant service shall have brass or cast iron body, Y-or angle-pattern, cleanable, not less than 60-mesh noncorroding screen of an area to provide net free area not less than ten times the pipe diameter with pressure rating compatible with the refrigerant service. Screens shall be stainless steel or monel and reinforced spring-loaded where necessary for bypass-proof construction.

I. Pressure and Vacuum Gauges

1. Gauges shall conform to ASME B40.100 and shall be provided with throttling type needle valve or a pulsation dampener and shut-off valve. Gauge shall be a minimum of 3 ½-in in diameter with a range from 0 psig to approximately 1.5 times the maximum system working pressure. Each gauge range shall be selected so that at normal operating pressure, the needle is within the middle-third of the range

J. Temperature Gauges

1. Temperature gauges shall be the industrial duty type and be provided for the required temperature range. Gauges shall have Fahrenheit scale in 2 degrees graduations scale (black numbers) on a white face. The pointer shall be adjustable. Rigid stem type temperature gauges shall be provided in thermal wells located within 5 ft of the finished floor. Universal adjustable angle type or remote element type temperature gauges shall be provided in thermal wells located 5 ft to 7 ft above the finished floor. Remote element type temperature gauges shall be provided in thermal wells located 7 ft above the finished floor.

K. Stem Cased-Glass

1. Stem cased-glass case shall be polished stainless steel or cast aluminum, 9-in long, with clear acrylic lens, and non-mercury filled glass tube with indicating-fluid column.

L. Bimetallic Dial

1. Bimetallic dial type case shall be not less than 3 ½-in, stainless steel, and shall be hermetically sealed with clear acrylic lens.

2. Bimetallic element shall be silicone dampened and unit fitted with external calibrator adjustment. Accuracy shall be one percent of dial range.

M. Liquid-, Solid-, and Vapor-Filled Dial

1. Liquid-, solid-, and vapor-filled dial type cases shall be not less than 3 ½-in, stainless steel or cast aluminum with clear acrylic lens.

2. Fill shall be nonmercury, suitable for encountered cross-ambients, and connecting capillary tubing shall be double-braided bronze.

N. Thermal Well

1. Thermal well shall be identical size, ½-in or ¾-in NPT connection, brass or stainless steel. Where test wells are indicated, provide captive plug-fitted type ½-in NPT connection suitable for use with either engraved stem or standard separable socket thermometer or thermostat. Mercury shall not be used in thermometers. Extended neck thermal wells shall be of sufficient length to clear insulation thickness by 1-in.

O. Pipe Hangers, Inserts, and Supports

1. Pipe hangers, inserts, guides, and supports shall conform to MSS SP-58 and MSS SP-69.

P. Escutcheons

1. Escutcheons shall be chromium-plated iron or chromium-plated brass, either one piece or split pattern, held in place by internal spring tension or set screws.

2.5 FABRICATION

A. Factory Coating

1. Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish, except that items located outside of buildings shall have weather resistant finishes that will withstand 500 hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 1/8-in on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used shall be coated with a zinc-rich coating conforming to ASTM D520, Type I.

B. Refrigernant Pipe Insulation

1. Insulation shall be a flexible, closed-cell elastomeric pipe insulation, AP Armaflex, AC Accoflex.

2. Adhesive shall be Armaflex 520, 520 Black or 520 BLV Adhesive. The insulation must conform to ASTM C534 Grade 1, Type I.

3. Insulation materials shall have a closed cell structure to prevent moisture from wicking which makes it an efficient insulation.

4. Insulation materials shall be manufactured without the use of CFC's, HFC's or HCFC's. It is also formaldehyde free, low VOCs, fiber free, dust free and resists mold and mildew.

5. Insulation materials shall have a flame-spread index of less than 25 and a smoke-developed index of less than 50 as tested in accordance with ASTM E 84. In addition, the products, when tested, shall not melt or drip flaming particles, and the flame shall not be progressive.

6. Insulation materials shall have a maximum thermal conductivity of 0.27 Btu-in./h-ft^2-deg F at a 75 deg F mean temperature as tested in accordance with ASTM C 177 or ASTM C 518.

7. Insulation materials shall have a maximum water vapor transmission of 0.08 per m-in when tested in accordance with ASTM E 96, Procedure A.

8. As a minimum, insulated items installed indoors shall have a flame spread index no higher than 75 and a smoke developed index no higher than 150.

9. Insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50.

10. Flame spread and smoke developed indexes shall be determined by ASTM E84.

11. Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket shall be tested as a composite material.

12. Jackets, facings, and adhesives shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E84.

13. All liquid and suction lines shall be insulated continuously from a point 6-in inside the display case to the suction service valve at the compressor.

14. All low temperature lines (plus 10 deg F and below) shall be insulated with a minimum of 1-in wall thickness.

15. All medium and high temperature lines (above plus 10 deg F) shall be insulated with a minimum of ¾-in wall thickness.

16. Heat reclaim lines shall be insulated from the condensing unit to the heat reclaim units with ¾-in thickness.

17. All refrigerant copper lines must be free of extraneous chemicals such as corrosive cleaners or building materials' dust prior to the installation of the insulation. The insulation must be clean and dry prior to installation.

18. Refrigerant pipe shall be sealed while slipping on insulation to prevent foreign matter from entering the tube.

19. Insulation is to be slid onto pipe; longitudinal slitting of the insulation is not allowed except on mitered sections. Insulation shall be pushed onto pipe, not pulled.

20. Insulation shall be mitered, preadhered and longitudinally slit inside throat to fit over all Ptraps, tees and elbows or bends over 90 degrees.

21. All butt joints and mitered seams shall be adhered with full coverage of adhesive on both surfaces. Insulation shall not be stretched when adhering.

22. Insulation must be installed in an adequately ventilated area. It may be necessary to increase insulation thickness if adequate ventilation is not present, Do not crowd the insulation, allow for adequate air movement.

23. At the beginning, at every 12 ft to 18 ft, and at the ends of piping runs, the insulation shall be adhered directly to the copper using a 2-in strip of adhesive. Insulation should not be adhered to the pipe at the extreme low points in any piping run.

24. Saddles shall be installed under all insulated lines at unistrut clamps, clevis hangers, or locations where insulation may be compressed.

25. Armafix IPH or NPH insulation pipe hangers can be installed at the compression locations and the seams shall be sealed with Armaflex 520, 520 Black or 520 BLV contact adhesive.

26. To minimize the movement of Armafix, a pair of non-skid pads be adhered to the clamps. In addition, to prevent loosening of the clamps, use of an anti-vibratory fastener, such as a nylon-locking nut.

27. Wood dowels or blocks, of a thickness equal to the insulation, shall be inserted and must be completely sealed into the insulation at the saddle locations. All seams shall be sealed with Armaflex 520, 520 Black or 520 BLV contact adhesive.

28. Hangers clamped directly to the pipe shall be insulated over the hanger; insulation shall be fully adhered to the hanger. In addition, hangers with double rods shall be insulated between the rods. All seams of the insulation shall be sealed with adhesive.

29. All insulation exposed to sunlight or installed outdoors shall be protected with two coats of WB Armaflex Finish or weather resistant coating.

PART 3 EXECUTION

3.1 EXAMINATION

A. After becoming familiar with all details of the work, perform a verification of dimensions in the field. Submit a letter, at least 2 weeks prior to beginning construction, including the date the site was visited, conformation of existing conditions, and any discrepancies found before performing any work.

3.2 INSTALLATION

A. Pipe and fitting installation shall conform to the requirements of ASME B31.1. Pipe shall be cut accurately to measurements established at the jobsite, and worked into place without springing or forcing, completely clearing all windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted without written approval. Pipe or tubing shall be cut square, shall have burrs removed by reaming, and shall permit free expansion and contraction without causing damage to the building structure, pipe, joints, or hangers.

1. Directional Changes: Changes in direction shall be made with fittings, except that bending of pipe 4-in and smaller will be permitted, provided a pipe bender is used and wide weep bends are formed. Mitering or notching pipe or other similar construction to form elbows or tees will not be permitted. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted.

2. Functional Requirements: Piping shall be installed ½-in/10 ft of pipe in the direction of flow to ensure adequate oil drainage. Open ends of refrigerant lines or equipment shall be properly capped or plugged during installation to keep moisture, dirt, or other foreign material out of the system. Piping shall remain capped until installation. Equipment piping shall be in accordance with the equipment manufacturer's recommendations and the contract drawings. Equipment and piping arrangements shall fit into space allotted and allow adequate acceptable clearances for installation, replacement, entry, servicing, and maintenance.

B. Fittings and End Connections

1. Threaded Connections: Threaded connections shall be made with tapered threads and made tight with PTFE tape complying with ASTM D3308 or equivalent thread-joint

compound applied to the male threads only. Not more than three threads shall show after the joint is made.

C. Brazed Connections

1. Brazing shall be performed in accordance with AWS BRH, except as modified herein. During brazing, the pipe and fittings shall be filled with a pressure regulated inert gas, such as nitrogen, to prevent the formation of scale. Before brazing copper joints, both the outside of the tube and the inside of the fitting shall be cleaned with a wire fitting brush until the entire joint surface is bright and clean. Brazing flux shall not be used. Surplus brazing material shall be removed at all joints. Steel tubing joints shall be made in accordance with the manufacturer's recommendations. Joints in steel tubing shall be painted with the same material as the baked-on coating within 8 hours after joints are made. Tubing shall be protected against oxidation during brazing by continuous purging of the inside of the piping using nitrogen. Piping shall be supported prior to brazing and not be sprung or forced.

D. Welded Connections

1. Welded joints in steel refrigerant piping shall be fusion-welded. Branch connections shall be made with welding tees or forged welding branch outlets. Pipe shall be thoroughly cleaned of all scale and foreign matter before the piping is assembled. During welding the pipe and fittings shall be filled with an inert gas, such as nitrogen, to prevent the formation of scale. Beveling, alignment, heat treatment, and inspection of weld shall conform to ASME B31.1. Weld defects shall be removed and rewelded at no additional cost to the Government. Electrodes shall be stored and dried in accordance with AWS D1.1/D1.1M or as recommended by the manufacturer. Electrodes that have been wetted or that have lost any of their coating shall not be used.

E. Flared Connections

1. When flared connections are used, a suitable lubricant shall be used between the back of the flare and the nut in order to avoid tearing the flare while tightening the nut.

F. Flanged Connections

1. When steel refrigerant piping is used, union or flange joints shall be provided in each line immediately preceding the connection to each piece of equipment requiring maintenance, such as compressors, coils, chillers, control valves, and other similar items. Flanged joints shall be assembled square end tight with matched flanges, gaskets, and bolts. Gaskets shall be suitable for use with the refrigerants to be handled.

G. Valves General

1. Refrigerant stop valves shall be installed on each side of each piece of equipment such as compressors condensers, evaporators, receivers, and other similar items in multiple-unit installation, to provide partial system isolation as required for maintenance or repair. Stop valves shall be installed with stems horizontal unless otherwise indicated. Ball valves shall be installed with stems positioned to facilitate operation and maintenance. Isolating valves for pressure gauges and switches shall be external to thermal insulation. Safety switches shall not be fitted with isolation valves. Filter dryers having access ports may be considered

a point of isolation. Purge valves shall be provided at all points of systems where accumulated non-condensable gases would prevent proper system operation. Valves shall be furnished to match line size, unless otherwise indicated or approved.

H. Expansion Valves

1. Expansion valves shall be installed with the thermostatic expansion valve bulb located on top of the suction line when the suction line is less than 2 1/8-in in diameter and at the 4 o'clock or 8 o'clock position on lines larger than 2 1/8-in. The bulb shall be securely fastened with two clamps. The bulb shall be insulated. The bulb shall installed in a horizontal portion of the suction line, if possible, with the pigtail on the bottom. If the bulb must be installed in a vertical line, the bulb tubing shall be facing up.

I. Valve Identification

1. Each system valve, including those which are part of a factory assembly, shall be tagged. Tags shall be in alphanumeric sequence, progressing in direction of fluid flow. Tags shall be embossed, engraved, or stamped plastic or nonferrous metal of various shapes, sized approximately 1 3/8-in diameter, or equivalent dimension, substantially attached to a component or immediately adjacent thereto. Tags shall be attached with nonferrous, heavy duty, bead or link chain, 14-gauge annealed wire, nylon cable bands or as approved. Tag numbers shall be referenced in Operation and Maintenance Manuals and system diagrams.

J. Vibration Dampers

1. Vibration damper shall be provided in the suction and discharge lines on spring mounted compressors. Vibration dampers shall be installed parallel with the shaft of the compressor and shall be anchored firmly at the upstream end on the suction line and the downstream end in the discharge line.

K. Strainers

1. Strainers shall be provided immediately ahead of solenoid valves and expansion devices. Strainers may be an integral part of an expansion valve.

L. Filter Dryer

1. A liquid line filter dryer shall be provided on each refrigerant circuit located such that all liquid refrigerant passes through a filter dryer.

2. Dryers shall be sized in accordance with the manufacturer's recommendations for the system in which it is installed.

3. Dryers shall be installed such that it can be isolated from the system, the isolated portion of the system evacuated, and the filter dryer replaced. Dryers shall be installed in the horizontal position except replaceable core filter dryers may be installed in the vertical position with the access flange on the bottom.

M. Sight Glass

1. A moisture indicating sight glass shall be installed in all refrigerant circuits down stream of all filter dryers and where indicated. Site glasses shall be full line size.

N. Discharge Line Oil Separator

1. Discharge line oil separator shall be provided in the discharge line from each compressor. Oil return line shall be connected to the compressor as recommended by the compressor manufacturer.

O. Accumulator

1. Accumulators shall be provided in the suction line to each compressor.

P. Flexible Pipe Connectors

1. Connectors shall be installed perpendicular to line of motion being isolated. Piping for equipment with bidirectional motion shall be fitted with two flexible connectors, in perpendicular planes. Reinforced elastomer flexible connectors shall be installed in accordance with manufacturer's instructions. Piping guides and restraints related to flexible connectors shall be provided as required.

Q. Temperature Gauges

1. Temperature gauges shall be located specifically on, but not limited to the following: the liquid line leaving a receiver and the suction line at each evaporator or liquid cooler. Thermal wells for insertion thermometers and thermostats shall extend beyond thermal insulation surface not less than 1-in.

R. Pipe Hangers, Inserts, and Supports

1. Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69, except as modified herein. Pipe hanger types 5, 12, and 26 shall not be used. Hangers used to support piping 2-in and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Piping subjected to vertical movement, when operating temperatures exceed ambient temperatures, shall be supported by variable spring hangers and supports or by constant support hangers.

S. Hangers

1. Type 3 shall not be used on insulated piping. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

T. Inserts

1. Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustments may be used if they otherwise meet the requirements for Type 18 inserts.

U. C-Clamps

1. Type 19 and 23 C-clamps shall be torqued in accordance with MSS SP-69 and have both locknuts and retaining devices, furnished by the manufacturer.

2. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

V. Angle Attachments

1. Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

W. Saddles and Shields

1. Where Type 39 saddle or Type 40 shield are permitted for a particular pipe attachment application, the Type 39 saddle, connected to the pipe, shall be used on all pipe 4-in and larger when the temperature of the medium is 60 deg F or higher. Type 40 shields shall be used on all piping less than 4-in and all piping 4-in and larger carrying medium less than 60 deg F. A high density insulation insert of cellular glass shall be used under the Type 40 shield for piping 2-in and larger.

X. Horizontal Pipe Supports

1. Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 1 ft from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 5 ft apart at valves. Pipe hanger loads suspended from steel joist with hanger loads between panel points in excess of 50 pounds shall have the excess hanger loads suspended from panel points.

Y. Vertical Pipe Supports

1. Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 15 ft not more than 28 ft from end of risers, and at vent terminations.

Z. Pipe Guides

1. Type 35 guides using, steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

AA. Steel Slides

1. Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 4-in and larger, a Type 39 saddle shall be used. On piping under 4-in, a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate.

BB. High Temperature Guides with Cradles

1. Where there are high system temperatures and welding to piping is not desirable, then the Type 35 guide shall include a pipe cradle, welded to the guide structure and strapped

securely to the pipe. The pipe shall be separated from the slide material by at least 4-in, or by an amount adequate for the insulation, whichever is greater.

CC. Multiple Pipe Runs

1. In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member.

2. Spacing of the base support members shall not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run.

DD. Structural Attachments

1. Attachment to building structure concrete and masonry shall be by cast-in concrete inserts, built-in anchors, or masonry anchor devices. Inserts and anchors shall be applied with a safety factor not less than 5. Supports shall not be attached to metal decking.

2. Masonry anchors for overhead applications shall be constructed of ferrous materials only.

3. Structural steel brackets required to support piping, headers, and equipment, but not shown, shall be provided under this section.

EE. Seismic Requirements

1. Piping and attached valves shall be supported and braced to resist seismic loads as specified under 01 33 17, Structural Design, Support, and Anchorage.

2. Comply with spec Section 01 33 17, Structural Design, Support, and Anchorage

FF. Pipe Alignment Guides

1. Pipe alignment guides shall be provided where indicated for expansion loops, offsets, and bends and as recommended by the manufacturer for expansion joints, not to exceed 5 ft on each side of each expansion joint, and in lines 4-in or smaller not more than 2 ft on each side of the joint.

GG. Pipe Anchors

1. Anchors shall be provided wherever necessary or indicated to localize expansion or to prevent undue strain on piping. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results using turnbuckles where required. Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline. Where pipe and conduit penetrations of vapor barrier sealed surfaces occur, these items shall be anchored immediately adjacent to each penetrated surface, to provide essentially zero movement within penetration seal. Detailed drawings of pipe anchors shall be submitted for approval before installation.

HH. Building Surface Penetrations

1. Sleeves shall not be installed in structural members except where indicated or approved. Sleeves in nonload bearing surfaces shall be galvanized sheet metal, conforming to ASTM A653/A653M, Coating Class G-90, 20 gauge. Sleeves in load bearing surfaces shall be uncoated carbon steel pipe, conforming to ASTM A53/A53M, Schedule 30. Sealants shall be applied to moisture and oil-free surfaces and elastomers to not less than ½-in depth. Sleeves shall not be installed in structural members.

II. Refrigerated Space

1. Refrigerated space building surface penetrations shall be fitted with sleeves fabricated from hand-lay-up or helically wound, fibrous glass reinforced polyester or epoxy resin with a minimum thickness equal to equivalent size Schedule 40 steel pipe. Sleeves shall be constructed with integral collar or cold side shall be fitted with a bonded slip-on flange or extended collar. In the case of masonry penetrations where sleeve is not cast-in, voids shall be filled with latex mixed mortar cast to shape of sleeve and flange/external collar type sleeve shall be assembled with butyl elastomer vapor barrier sealant through penetration to cold side surface vapor barrier overlap and fastened to surface with masonry anchors. Integral cast-in collar type sleeve shall be flashed with not less than 4-in of cold side vapor barrier overlap of sleeve surface. Normally noninsulated penetrating round surfaces shall be sealed to sleeve bore with mechanically expandable seals in vapor tight manner and remaining warm and cold side sleeve depth shall be insulated with not less than 4-in of foamed-in-place rigid polyurethane or foamed-in-place silicone elastomer. Vapor barrier sealant shall be applied to finish warm side insulation surface. Warm side of penetrating surface shall be insulated beyond vapor barrier sealed sleeve insulation for a distance which prevents condensation. Wires in refrigerated space surface penetrating conduit shall be sealed with vapor barrier plugs or compound to prevent moisture migration through conduit and condensation therein.

JJ. General Service Areas

1. Each sleeve shall extend through its respective wall, floor, or roof, and shall be cut flush with each surface. Pipes passing through concrete or masonry wall or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. Sleeves shall be of such size as to provide a minimum of ¼-in all-around clearance between bare pipe and sleeves or between jacketed-insulation and sleeves.

2. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over-insulation and sleeve shall be sealed in accordance with Section 07 92 13 - Elastomeric Joint Sealants.

KK. Waterproof Penetrations

1. Pipes passing through roof or floor waterproofing membrane shall be installed through a 17 oz copper sleeve, or a 0.032-in thick aluminum sleeve, each within an integral skirt or flange.

2. Flashing sleeve shall be suitably formed, and skirt or flange shall extend not less than 8-in from the pipe and be set over the roof of floor membrane in a troweled coating of

bituminous cement. The flashing sleeve shall extend up the pipe a minimum of 2-in above the roof or floor penetration. The annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation shall be sealed as indicated. Penetrations shall be sealed by either one of the following methods.

3. Waterproofing Clamping Flange: Pipes up to and including 10-in in diameter passing through roof or floor waterproofing membrane may be installed through a cast iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess.

4. Modular Mechanical Type Sealing Assembly: In lieu of a waterproofing clamping flange and caulking and sealing of annular space between pipe and sleeve or conduit and sleeve, a modular mechanical type sealing assembly may be installed. Seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion protected carbon steel bolts, nuts, and pressure plates. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal rubber sealing elements to expand and provide a watertight seal between the pipe/conduit seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. The Contractor electing to use the modular mechanical type seals shall provide sleeves of the proper diameters.

LL. Escutcheons

1. Finished surfaces where exposed piping, bare or insulated, pass through floors, walls, or ceilings, except in boiler, utility, or equipment rooms, shall be provided with escutcheons. Where sleeves project slightly from floors, special deep-type escutcheons shall be used. Escutcheon shall be secured to pipe or pipe covering.

MM. Access Panels

1. Access panels shall be provided for all concealed valves, vents, controls, and items requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced.

NN. Identification Tags

1. Provide identification tags made of brass, engraved laminated plastic or engraved anodized aluminum indicating service and item number on all valves and dampers. Tags shall be 1 3/8-in minimum diameter and marking shall be stamped or engraved. Indentations shall be black for reading clarity. Tags shall be attached to valves with No. 12 AWG copper wire, chrome-plated beaded chain or plastic straps designed for that purpose.

3.3 CLEANING AND ADJUSTING

A. Clean uncontaminated system(s) by evacuation and purging procedures currently recommended by refrigerant and refrigerant equipment manufacturers, and as specified herein, to remove small amounts of air and moisture. Systems containing moderate amounts of air, moisture contaminated refrigerant, or any foreign matter shall be considered contaminated systems. Restoring contaminated systems to clean condition including disassembly, component replacement, evacuation, flushing, purging, and re-charging, shall be performed using currently approved refrigerant and refrigeration manufacturer's procedures. Restoring contaminated systems shall be at no additional cost to the Government as determined by the Contracting Officer. Water shall not be used in any procedure or test.

3.4 REFRIGERANT PIPING TESTS

A. General

1. After all components of the refrigerant system have been installed and connected, subject the entire refrigeration system to pneumatic, evacuation, and startup tests as described herein. Submit a schedule, at least 2 weeks prior to the start of related testing, for each test. Identify the proposed date, time, and location for each test. Conduct tests in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Provide all material, equipment, instruments, and personnel required for the test. Provide the services of a qualified technician, as required, to perform all tests and procedures indicated herein.

2. SYSTEMS. Submit 6 copies of the tests report in bound 8 1/2 by 11-in booklets documenting all phases of the tests performed. The report shall include initial test summaries, all repairs/adjustments made, and the final test results.

B. Preliminary Procedures

1. Prior to pneumatic testing, equipment which has been factory tested and refrigerant charged as well as equipment which could be damaged or cause personnel injury by imposed test pressure, positive or negative, shall be isolated from the test pressure or removed from the system. Safety relief valves and rupture discs, where not part of factory sealed systems, shall be removed and openings capped or plugged.

C. Pneumatic Test

1. Pressure control and excess pressure protection shall be provided at the source of test pressure. Valves shall be wide open, except those leading to the atmosphere. Test gas shall be dry nitrogen, with minus minus 70 deg F dewpoint and less than 5 ppm oil. Test pressure shall be applied in two stages before any refrigerant pipe is insulated or covered. First stage test shall be at 10 psi with every joint being tested with a thick soap or color indicating solution. Second stage tests shall raise the system to the minimum refrigerant leakage test pressure specified in ANSI/ASHRAE 15 & 34 with a maximum test pressure 25 percent greater. Pressure above 100 psig shall be raised in 10 percent increments with a pressure acclimatizing period between increments. The initial test pressure shall be recorded along with the ambient temperature to which the system is exposed. Final test pressures of the second stage shall be maintained on the system for a minimum of 24 hours. At the end of

the 24 hour period, the system pressure will be recorded along with the ambient temperature to which the system is exposed. A correction factor of 0.3 psi will be allowed for each degree F change between test space initial and final ambient temperature, plus for increase and minus for a decrease. If the corrected system pressure is not exactly equal to the initial system test pressure, then the system shall be investigated for leaking joints. To repair leaks, the joint shall be taken apart, thoroughly cleaned, and reconstructed as a new joint. Joints repaired by caulking, remelting, or back-welding/brazing shall not be acceptable. Following repair, the entire system shall be retested using the pneumatic tests described above. The entire system shall be reassembled once the pneumatic tests are satisfactorily completed.

D. Evacuation Test

1. Following satisfactory completion of the pneumatic tests, the pressure shall be relieved and the entire system shall be evacuated to an absolute pressure of 300 micrometers. During evacuation of the system, the ambient temperature shall be higher than 35 deg F. No more than one system shall be evacuated at one time by one vacuum pump. Once the desired vacuum has been reached, the vacuum line shall be closed and the system shall stand for 1 hour. If the pressure rises over 500 micrometers after the 1 hour period, then the system shall be evacuated again down to 300 micrometers and let set for another 1 hour period. The system shall not be charged until a vacuum of at least 500 micrometers is maintained for a period of 1 hour without the assistance of a vacuum line. If during the testing the pressure continues to rise, check the system for leaks, repair as required, and repeat the evacuation procedure. During evacuation, pressures shall be recorded by a thermocouple-type, electronic-type, or a calibrated-micrometer type gauge.

E. System Charging and Startup Test

1. Following satisfactory completion of the evacuation tests, the system shall be charged with the required amount of refrigerant by raising pressure to normal operating pressure and in accordance with manufacturer's procedures. Following charging, the system shall operate with high-side and low-side pressures and corresponding refrigerant temperatures, at design or improved values. The entire system shall be tested for leaks. Fluorocarbon systems shall be tested with halide torch or electronic leak detectors.

F. Refrigerant Leakage

1. If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system shall immediately be isolated from the remainder of the system and the refrigerant pumped into the system receiver or other suitable container. Under no circumstances shall the refrigerant be discharged into the atmosphere.

G. Contractor's Responsibility

1. At all times during the installation and testing of the refrigeration system, take steps to prevent the release of refrigerants into the atmosphere. The steps shall include, but not be limited to, procedures which will minimize the release of refrigerants to the atmosphere and the use of refrigerant recovery devices to remove refrigerant from the system and store the refrigerant for reuse or reclaim. At no time shall more than 3 ounces of refrigerant be released to the atmosphere in any one occurrence. Any system leaks within

the first year shall be repaired in accordance with the requirements herein at no cost to the Government including material, labor, and refrigerant if the leak is the result of defective equipment, material, or installation.

END OF SECTION

SECTION 23 31 13 – METAL DUCTS

PART 1 GENERAL

1.1 THE SUMMARY

A. Provide ductwork, complete and operable, as indicated in accordance with the Contract Documents.

B. Furnish design calculations used to determine duct wall thickness and reinforcements.

C. American Iron and Steel (AIS) Compliance: Materials provided under work of this Section shall comply with the AIS requirements of the Water Infrastructure Finance and Innovation Act (WIFIA). All materials provided and incorporated into this Project shall meet the AIS requirements of P.L. 113-76, Consolidated Appropriations Act, 2014.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
01 33 17	Structural Design, Support and Anchorage

B. Reference Standards

Associated Air Balance Council (AABC)	
Air Movement and Control Association International, Inc. (AMCA)	
AMCA 500	Test Methods for Louvers, Dampers, and Shutters
American Society of Civil Engineers (ASCE)	
ASCE 7-10	Minimum Design Loads for Buildings and Other Structures
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)	
ASTM International (ASTM)	
ASTM D638	Standard Test Method for Tensile Properties of Plastics
ASTM D790	Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM D2240	Standard Test Method for Rubber Property - Durometer Hardness
ASTM D2310	Standard Classification for Machine-Made “Fiberglass” (Reinforced Thermosetting Resin) Pipe
ASTM D2563	Standard Practice for Classifying Visual Defects in Glass-Reinforced Plastic Laminate Parts
ASTM D2992	Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for “Fiberglass” (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings
ASTM D2996	Filament-Wound “Fiberglass” (Glass-Fiber-Reinforced Thermosetting Resin) Pipe
ASTM E84	Standard Test Method for Surface Burning Characteristics of Building Materials
National Fire Protection Association (NFPA)	
NFPA 90A	Standard for the Installation of Air Conditioning and Ventilating Systems
NFPA 90B	Standard for the Installation of Warm Air Heating and Air Conditioning Systems

NFPA 91	Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists and Noncombustible Particulate Solids
Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)	
SMACNA	Thermoset FRP Duct Construction Manual

C. Codes and Standards, General

1. Anchorage and bracing for all suspended ductwork and other distribution systems needs to be provided per 2016 CBC Section 1613/ASCE 7-10 Chapter 13

2. Perform and provide the Work in full accordance with the latest rules and regulations or publications of the State Energy Resources Conservation and Development Commission, the State Fire Marshall, the Industrial Safety Orders, the Health and Safety Rules (Air Conditioning systems), the local Plumbing Code, the local Building Code, and other local codes.

3. In the absence of applicable codes, follow the installation and workmanship standards set by the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).

4. Provide the ductwork systems in accordance with the latest edition of the ASHRAE Handbook, SMACNA Manual, and the International Mechanical Code.

5. Where conflict between these standards arises, the most stringent criterion shall control. Ducts shall be listed for use without the necessity for internal fire protection sprinklers or any devices relied on to cut off air flow in the event of fire by Factory Mutual Research Standard 4922.

6. ASHRAE Standards: Comply with AS~E handbook, Equipment Volume, Chapter "Duct Construction," for fabrication and installation of metal duct.

7. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilation Systems," NFPA 90B "Standard for the Installation of Warm Air Heating and Air Conditioning Systems," and NFPA 91 "Standard for the Installation of Blower and Exhaust Systems."

8. Field Reference Manual: Have available for reference at Project field office a copy of SMACNA "Round Industrial Duct Construction Standards."

9. Comply with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible" for fabrication and installation of metal duct, and SMACNA's "Round Industrial Duct Construction Standards" intended for use by designers of industrial ventilation systems.

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Submittal Procedures.

B. Shop Drawings:

1. The HVAC design drawings define the general layout, configuration, routing, size, and the general intent of the design and are not fabrication drawings. Contractors shall be

responsibility to develop the shop drawings required for the construction of the HVAC system(s).

2. Submit detailed fabrication drawings with layouts and all necessary dimensions and details on equipment, and ductwork. Show all fittings, and supports necessary to accommodate the equipment provided in a complete and functional system. Show main and branch runs, fittings, offsets, takeoffs, accessories, supports, anchorage, point loads and seismic restraints, and dimensions of sub-assemblies to be shipped.

3. The ductwork dimensions provided on the design drawings represent a free area and they are clear inside dimensions. The contractor shall be responsible to account for the loss of free area due acoustical lining, or any internal obstructions, and oversize the ductwork to provide the same free area as the one shown on the design drawings.

1.4 QUALITY ASSURANCE

A. Qualifications, General

1. Ductwork shall be fabricated and installed by experienced workers who have experience with fabrication, and installation of ductwork.

2. Work and materials shall be in full accordance with the latest rules and regulations or publications of the State Energy Resources Conservation and Development Commission, the State Fire Marshall, the Industrial Safety Orders, the Health and Safety Rules (Air Conditioning systems), the local Plumbing Code, the local Building Code, and other local codes.

3. Nothing in the Contract Documents shall be construed to permit work in violation of the above codes, rules and regulations.

4. In the absence of applicable codes, the installation and workmanship shall follow the standards set by the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).Use firms regularly engaged in the manufacture of ETFE coated stainless steel duct products of types, materials, and sizes required.

5. The manufacturer shall perform their own sheet metal fabrication and coating processes.

6. Use manufacturers whose ETFE-coated stainless steel duct shall have been in satisfactory use for not less than 5 years.

7. The Owner shall have the right to tour the manufacturer's plant any time that fabrication is being performed on duct intended for the Project.

8. Installer Qualifications: The installation contractor shall have at least 3 years of successful experience on duct projects, specifically industrial exhaust systems.

B. Inspection and Testing

1. All ductwork shall be inspected and approved by a qualified QC person in order to ensure proper welding and dimensional tolerances. The Inspector shall provide a written approval

to the resident engineer or owner, stating that the ductwork has been inspect and is free of any defects.

1.5 DELIVERY, STORAGE, AND HANDLING

A. General

1. Duct, fittings, and dampers shall be protected from damage and shall be supported by minimum 4-in wide strapping to avoid damage due to flex strains and point loading during shipping and installation.

2. Debris and other extraneous material shall not be allowed to enter the duct.

3. Duct, fittings, and dampers shall not be thrown or dropped.

B. Material Protection

1. Protect coated duct from damage due to normal handling during shipment and storage.

2. Protection shall be applied to ends of the duct in order to prevent dirt and moisture from entering ducts and fittings.

3. Protection must be of suitable strength and material to withstand tearing and puncture.

4. Multiple pieces may be bolted together at the factory to provide protection and limit the number of open ends requiring protection.

C. Consignee must inspect shipment upon delivery and note any and all damages and discrepancies on bill of lading and notify manufacturer within 24 hours.

D. Coated duct

1. Coated duct shall not be stored in an area where it will have a chance to be damaged from traffic or debris.

2. All coated duct shall be stored on cardboard, Styrofoam, or similar material.

3. Where possible, store coated duct inside and protect from dirt and debris.

4. Where necessary to store outside, store coated duct above grade and enclose with waterproof wrapping in order to protect from dirt and debris.

5. If the coating is scratched during shipping or himd1ing it must be inspected using the methods described in Part 2 - Products.

6. Contact the manufacturer for approved repair procedures.

1.6 WARRANTY

A. Provide the ductwork manufacturer’s standard warranty.

B. Furnish the warranty to the Engineer upon final acceptance of the completed systems by the Owner.

PART 2 PRODUCTS

2.1 HANGERS AND SUPPORTS

A. Anchorage and bracing for all suspended ductwork and other distribution systems needs to be provided per 2016 CBC Section 1613/ASCE 7-10 Chapter 13

B. Ductwork shall be firmly anchored or connected to supporting members.

C. Provide necessary hangers, supports, concrete inserts, and anchors for material and equipment to be installed.

D. No perforated strap hangers nor wire supports will be accepted.

E. Construct the anchors and inserts of 304 stainless steel.

F. Locate hangers and supports not greater than 10 ft from each expansion loop or joint.

G. Provide hangers and supports for ductwork and equipment in accordance with SMACNA standards.

2.2 GALVANIZED AND ALUMINUM DUCTWORK (ALL DUCTWORK SHALL BE ALUMINUM UNLESS OTHERWISE NOTED)

A. General

1. Provide air-tight and well-braced ductwork.

2. Carefully support the ductwork in horizontal runs, with rod and angle supports at no greater than 8 ft intervals.

3. Run ductwork as close as possible to the indicated layouts.

B. Construction

1. Construct sheet metal ducts and plenums with air-tight joints and seams in accordance with ASHRAE standards and the SMACNA Duct Construction Manual.

2. Tape the joints on concealed ducts with pressure-less tape and adhesive, except for welded and soldered joints.

3. Ductwork materials shall be aluminum, unless otherwise indicated.

4. Provide the following duct gauges, as a minimum:

Maximum Dimension of Duct inches	Galvanized Steel U.S. Standard Gauge	Aluminum B and S Gauge
12 and less	26	24
13 through 30	24	22
31 through 54	20	20
55 through 84	20	18

5. All low pressure ductwork shall be designed for 3-in vacuum and pressure and be constructed of sheet metal of not less than the gauge designated in table above, and gauge designations provided by Brown and Sharpe Standards.

6. Radius of bends shall be not less than 1.5 duct diameters, unless otherwise indicated.

7. Provide turning vanes on all mitered elbows and extractors, as required and indicated.

8. Except where accepted by the Engineer, provide fan discharge connections and ductwork reductions with duct side slopes not exceeding 30 degrees.

9. Properly insulate aluminum duct and supports from concrete or dissimilar metals by an applied bituminous coating or by rubber gaskets at contact points.

10. Construct interior partitions from aluminum, in accordance with the latest ASHRAE guide recommendations for construction for high-pressure rectangular duct work.

11. Construct the units in accordance with the ASHRAE guide recommendations for high-pressure ductwork.

12. Seams shall be lock-formed and mastic-filled.

13. Provide rectangular casing seams in the corners of the silencer shell in order to provide maximum unit strength and rigidity.

14. Provide interior partitions with die-formed entrance and exit shapes in order to provide the maximum aerodynamic efficiency and minimum self-noise characteristics in the sound attenuator.

15. Blunt noses or squared off partitions will not be accepted.

16. Use solid galvanized steel to attach the interior partitions to the casing, welded to the outer casing.

17. Attachment of the interior partitions to the tracks shall be such that a minimum of 4 thicknesses of metal exist at this location.

18. The track assembly shall stiffen the exterior casing, provide a reinforced attachment detail for the interior partitions, and shall maintain a uniform airspace width along the length of the silencer for consistent aerodynamic and acoustic performance.

19. In addition to the above attachments, secure the interior partitions to the outer casing with welded nose clips at both ends of the sound attenuator.

20. Achieve airtight construction by the use of a duct-sealing compound applied at the Site.

21. Sound traps shall not fail structurally when subjected to a differential air pressure of 8-in w.g. inside-to-outside of casing.

C. Seams

1. Provide double-locked seams.

2. Provide rectangular ducts with longer than a 12-in dimension with full-perimeter standing seams not less than 1-in high.

3. Provide reinforcements at intervals not greater than 30-in along the duct.

4. No "S" seams will be accepted.

D. Low-Pressure Ductwork

1. Design all low-pressure ductwork for 3-in vacuum and pressure.
2. Gauge designations refer to Brown and Sharpe Standards.

E. Access Doors

1. Provide access doors in the ductwork at all fire dampers, motorized and back draft dampers, filters, and as indicated.

2. Provide doors with the following features:

   a. continuously hinged;

   b. double-skinned;

   c. constructed of either 22-gauge galvanized steel or 20-gauge aluminum to match the ductwork material;

   d. one cam lock for sizes up to 16-in square or 2 cam locks for sizes over 16-in square;

   e. match insulation thickness in door with ductwork insulation; and,

   f. foam sealing gaskets on all four sides.

3. Access Doors Manufacturer, or Equal

   a. Ruskin, SMACNA Standard Duct Access Doors

F. Flexible Connections

1. Attach the equipment to the ducts through using flexible connections in order to facilitate removal of the units and for sound isolation.

2. Provide flexible connectors consisting of heavy duct canvas or woven glass fabric, silicon-coated.

3. Canvas connectors shall be composed of a heavy cotton that is impregnated for waterproofing and fire retardance.

4. Use glass fabric where temperatures exceed 200 deg F.

5. The weight of the canvas shall be 20 ounces per sq yd.

6. The weight of the glass fabric shall be approximately 12 ounces per sq yd.

7. Flexible duct shall be insulated.

8. The maximum length of flexible duct shall not exceed 10 ft.

9. Flexible duct connections shall be composed of banded or flanged 8 oz canvas, reinforced plastic, or equal, at each point where a blower unit is connected to a duct.

10. Maintain a minimum clearance of 3-in between the duct and the source of vibration.

11. Provide materials that join and support the flexible duct in accordance with the latest edition of SMACNA.

G. Supports

1. Provide aluminum angles with 304 stainless steel threaded hanger rods as supports for horizontal ducts and plenums.

2. Supports for vertical ducts shall be aluminum of the angle bracket type.

3. Sufficiently brace inlet ducts to withstand the maximum negative pressure.

H. Seismic Restraints

1. Design the duct supports and restraints for static, dynamic, and seismic loads in Zone 4 in accordance with the International Building Code.

2. Seismic restraints shall not induce stresses in the ductwork caused by thermal expansion and contraction.

3. Comply with Section 01 33 17, Structural Design Support and Anchorage

I. Duct Dimensions

1. Increase sheet metal duct dimensions by 2-in for internally lined ducts.

J. Corrosion-Resistant Ducts

1. Provide exhaust hoods as indicated, constructed of Type 316 stainless steel.
2. Fabricate the stainless steel ducts of the same gauge as the galvanized steel ducts.

K. Balancing Dampers

1. Provide butterfly or multi-blade dampers as indicated and required in order to balance the air quantities to their indicated values.

2. Provide a locking quadrant on each manual damper, with easy access for operation.

L. Inspection Doors

1. Provide duct inspection doors consisting of a 12-in by 16-in steel frame with gasketing around its periphery, and either a hinged glass or a removable visual panel.

2. Doors shall be constructed of **Plexiglas**, **Lucite**, or equal.

3. On smaller ducts, provide separate 6-in by 8-in doors with 6-in by 6-in visual panels.

4. Provide duct inspection doors at each duct-mounted fire damper and electric duct heater.

M. Bird Screens

1. Provide removable bird screens on outside air intakes and exhaust air discharges to outside air.

2. Secure the screens in frames constructed of the same metal as the screens.

3. The bird screens shall be ½-in mesh by 14-gauge and shall be of same material and finish as duct, hood, louver, or equipment to which the screens are attached.

N. Turning Vanes

1. Square-turn elbows shall be fitted with shop-fabricated double-blade turning vanes mounted inside the rails.

2. Construction shall be of the same material as the ductwork and shall be rigid enough to prevent vibration at high air flow.

O. Air Extractors

1. Provide an air extractor on each take-off from the main supply duct adjacent to a diffuser, register, or grille, where a splitter is not used.

2. Provide extractors with synchronized steel curved blades, heavy side rails, and a screw operator.

3. Air Extractors Manufacturer, or Equal

a. Carnes
b. Tuttle and Bailey

2.3 STAINLESS STEEL DUCTWORK

A. General

1. Provide ductwork that is approved to carry the FM label for exhaust duct suitable for installation without sprinklers or fire protection.

2. Provide ducts with a flame spread rating of not more than 25, and a smoke development rating of less than 50, when tested by FM.

3. Provide ductwork with companion angle-ring bolted flange ("Van Stone") connections, constructed of Type 304 stainless steel.

4. Provide elbows and fittings in conformance with SMACNA standards.

5. Provide straight pieces of duct in nominal 47-in lengths.

6. Supplier

    a. Provide ductwork from a manufacturer regularly engaged in the manufacturing and fabrication of ECTFE fluoropolymer-coated stainless-steel duct for a minimum of 5 years.

    b. The ductwork supplier shall have the facilities to fabricate the stainless steel ductwork and shall be FM certified to apply the ECTFE fluoropolymer coating.

    c. Subcontracted services for metal work and coating will not be accepted.

B. Fabrication

1. Provide ductwork fabricated of Type 316L stainless steel and coated with an ECTFE fluoropolymer resin suitable to provide corrosion resistance for its intended service.

2. Fabricate stainless steel duct in conformance with the indicated SMACNA standards, using construction tables for desired S. P. service.

3. Machine fusion-weld all longitudinal seams.

4. Hand welds and mig welds will not be accepted.

5. Traverse seams shall be continuously TIG welded.

6. Machine-turn all companion flange ends in order to provide uniformity.

C. Coating

1. Preparation

    a. Completely "sandblast" the interior coated surface of all ductwork prior to coating, in order to achieve a profile that provides an adequate bonding surface.

    b. Properly mask the exterior of the duct during preparation in order to provide protection against exterior surface abrasion.

    c. Knurling or solvent etching of the interior surface in lieu of "sandblasting" will not be accepted.

2. Completely mask the exterior of the duct with a heat-resistant material prior to coating in order to protect against over-spraying.

3. Apply the electrostatically applied ECTFE fluoropolymer coating in 2 steps, as follows:

    a. apply a primer coat of 3-4 mils; and
    b. apply a top coat of 8-9 mils for an average coating thickness of 12 mils.

4. Provide a complete and uniform coating.

D. Assembly

1. The ductwork fabricator shall supply all nuts, bolts, and gaskets as necessary to assemble the duct pieces.

2. Stainless steel nuts and bolts shall be constructed of Type 304 stainless steel.

3. Fabricate gaskets material from minimum ¼-in thick PTFE.

E. Ductwork Fabricator / Coater, or Equal

1. Viron International Corporation

PART 3 EXECUTION

3.1 GENERAL

A. Floor, Wall and Roof Openings for New Construction

1. Provide necessary openings in walls, floors and roofs for the passage of heating and ventilating equipment in buildings.

2. The openings shall be as indicated, or as required to provide passage for the heating and ventilating Work.

3. Provide hanger and support inserts into masonry or structural steel as required for proper completion of the Work.

B. Floor, Wall and Roof Openings for Existing Construction

1. Provide openings for piping and equipment as required in the existing construction, whether or not they are specifically indicated.

2. Cut the openings in a neat and orderly manner without damaging existing structures. Do not overcut corners.

3. Patch openings to match the existing construction.

4. Provide and assume responsibility for hangers and supporting members in the existing masonry or structural steel as required for proper completion of the Work.

C. Interior and Exterior Wall Penetrations

1. Where ducts pass through exterior walls, interior partitions or pass through walls dividing two separate controlled areas, conceal the space between construction openings and the duct with sheet metal flanges of the same gauge as the duct.

2. Overlap the opening on 4 sides by at least 1 ½-in.

3.2 INSTALLATION

A. General

1. Field Measurements

    a. Duct lengths shall be determined from measurements taken at the Site.
    b. The indicated dimensions are approximate and shall not be used for fabrication.

2. Install ducts as indicated.

3. Necessary provisions shall be taken into consideration during fabrication and installation of ductwork to provide for expansion and contraction.

4. Ductwork shall be free from vibration when in operation.

5. Provide necessary vibration isolation devices.

6. Apply antiseize compound to bolt threads.

7. Provide smooth bends or internal turning vanes at elbows, tees, and other points where the air flow changes direction.

8. The inside of duct, specials, and fittings shall be smooth, clean, and free from blisters, sand and dirt.

9. Ductwork shall be airtight.

10. Joints shall be carefully and neatly constructed, as indicated and as recommended by the manufacturer.

11. Flanges

    a. Tighten flange bolts sufficiently to slightly compress the gasket and make a seal, but not so tightly as to distort the flanges.

    b. Provide a flat washer under each nut and bolt head.

12. Dampers

    a. Position the dampers to fit into the connecting ductwork at the indicated locations.

    b. Install axles in the horizontal position unless otherwise necessary for proper operation of the damper.

13. Supports and Hangers

    a. Support the ductwork in accordance with the manufacturer's recommendations and as indicated.

    b. Duct supports shall comply with SMACNA Standards and applicable code requirements.

c. Supports and hangers shall transmit loads into the building structural frame through a system of intermediate beams and struts as necessary to comply with the indicated requirements.

d. Supports or hangers employing clip angles or similar devices for attachment to the duct will not be accepted.

e. Design the supports to resist IBC seismic forces.

14. Alignment and Elevation

a. Provide ductwork to the indicated lines and elevations, and slope as indicated to facilitate water drainage.

b. Use laser beam equipment or surveying instruments to maintain alignment and elevation.

c. If laser beam equipment is used, perform periodic elevation measurements with surveying instruments in order to verify accuracy.

B. Control Dampers

1. General

a. Coordinate damper submittals for type, quantity, and size in order to ensure compatibility with sheet metal design.

b. Follow the manufacturer's instructions for field installation of control dampers.

c. Unless specifically designed for vertical blade application, mount the dampers with the blade axis horizontal.

2. Duct Openings

a. Duct openings shall be free of obstructions and irregularities that might interfere with blade or linkage rotation or actuator mounting.

b. Duct openings shall measure ¾-in larger than damper dimensions, and shall be square, straight, and level.

3. Damper Sections

a. Individual damper sections, as well as entire multiple section assemblies, shall be completely square and free of racking, twisting, and bending.

b. Measuring the damper sections diagonally from upper corners to opposite lower corners of each damper section, both dimensions shall be within 1/8-in of each other.

4. Shafts

a. Install an extended shaft or jackshaft in accordance with the manufacturer's instructions.

b. If a sticker on the damper face shows recommended extended shaft location, attach the shaft on the labeled side of damper to that blade.

5. Operation

a. Damper blades, axels, and linkage shall operate without binding.

b. After installation but before system operation, cycle the damper in order to ensure proper operation.

c. On multiple section assemblies, sections shall open and close simultaneously.

6. Provide a visible and accessible indication of damper position on the drive shaft end.

7. Support ductwork or damper actuator in areas of damper when required in order to prevent sagging due to damper or damper actuator weight.

8. After installing low-leakage dampers with seals, caulk between the frame and the duct or opening in order to prevent leakage around the perimeter of damper.

C. Smoke Dampers

1. Coordinate smoke damper and smoke/fire damper installations, wiring, and checkout in order to ensure that the dampers function properly and that they respond to the proper fire alarm system general, zone, and detector trips.

2. Immediately report discrepancies to the Engineer not less than 14 Days prior to inspection by the code authority having jurisdiction.

3.3 DUCT CLEANING

A. The ducts shall be blown clean of dust and debris using compressed air.
B. Do not use system fans for duct cleaning.

3.4 FIELD TESTING

A. Leak-test the ductwork after installation, in accordance with the National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems, a publication of the Associated Air Balance Council (AABC).

B. The maximum allowable leakage criteria shall be in conformance with ASHRAE standards.

END OF SECTION

SECTION 23 34 00 – HVAC FANS

PART 1 GENERAL

1.1 SUMMARY

A. Provide fans, blowers, ventilators, and appurtenances, complete and operable, as indicated in accordance with the Contract Documents.

B. Where 2 or more fans, blowers, ventilators or appurtenances of the same type or size are required, they shall be furnished by the same manufacturer.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00, Submittal Procedures.

B. Shop Drawings

1. Submit certified fan curves for each fan.

C. O&M Data

1. Submittals shall include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.

1.3 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts:

1. Drive Belts: Provide one for each fan

1.4 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
03 30 00	Cast-in-Place Concrete
09 96 00	High Performance Coatings
26 05 10	Low-Voltage Electric Motors

B. Reference Standards

Air Moving and Conditioning Association (AMCA)	
AMCA 300-14	Reverberant Room Method for Sound Testing of Fans
Standard 99	Standards Handbook, Reverberant Room Method for Sound Testing of Fans.
Standard 210	Laboratory Methods of Testing Fans for Rating

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)	
	HVAC Applications chapter in "Seismic Restraint Design"
	Spec 01 33 17 – Seismic and Wind Design Criteria
Institute of Electrical and Electronics Engineers, Inc. (IEEE)	
112	Standard Test Procedure for Polyphase Induction Motors and Generators
National Electrical Manufacturers Association (NEMA)	
MG 112.53a	Motors and Generators
National Fire Protection Association (NFPA)	
70	National Electric Code (NEC)
90A	Standard for the Installation of Air Conditioning and Ventilating Systems
Occupational Safety and Health Act (OSHA)	
Underwriters Laboratories Inc. (UL)	
	Product Directories

1.5 MOTORS

A. All motors shall conform to the latest IEEE and NEMA requirements for mechanical and electrical characteristics, including service factors.

B. Motors shall be in accordance with the requirements of Section 26 05 10, Low-Voltage Electric Motors.

C. Each motor shall bear the manufacturer's nameplate with complete motor data.

D. Each motor shall be of ample size and construction to carry continuously all loads which might be imposed by the piece of equipment it drives throughout the full range of operation of the equipment, and the maximum motor loading shall in all cases be less than or equal to the nameplate horsepower rating, exclusive of the service factor.

E. All 2-speed motors shall be 2-winding motors.

PART 2 PRODUCTS

2.1 UPBLAST ROOF EXHAUST FANS (EF-04 FOR MECHANICAL ROOM)

A. Provide upblast centrifugal direct-drive roof-mounted exhausters as indicated.

B. Upblast roof exhaust fans shall be of all-aluminum construction.

C. Centrifugal ventilators shall be constructed of heliarc-welded extruded aluminum and shall be provided with a cast aluminum power assembly.

D. Units shall be provided with V-belt drives, vibration eliminators, and motor as indicated.

E. Fans

1. Provide fan motors with externally mounted disconnect switches and shall be of the open drip-proof type.

2. Fans shall be completely coated outside and on all surfaces in contact with the exhausted air stream with hi-pro polyester coating, or equal, except where otherwise indicated.

3. The fans shall be complete with motor-operated dampers, roof curb, and bird screen.

4. Fans shall meet the requirements and performance in the Contract drawings.

F. Manufacturer, or Equal

1. Greenheck, Model CUBE, CUE

a. Cook

2.2 INLINE EXHAUST FANS (EF-01 TO 03 FOR CHEMICAL ROOM AND SF-01 TO 03 FOR MEETING ROOM, KITCHEN, AND STORAGE)

A. Provide inline exhaust fans as indicated.

B. Provide fans of the centrifugal, direct-drive, inline type.

C. Fan housing shall be of square design construction of heavy-gauge galvanized steel and shall include square duct mounting collars and removable access panels.

D. The fan wheel shall be of the centrifugal backward inclined type, of aluminum construction, and shall include a wheel cone matched to the inlet cone.

E. The fan motor shall be of the heavy-duty ball bearing type, mounted out of the air stream, and provided with belt guards.

F. Fans shall be completely coated outside and on surfaces in contact with the air stream with hi-polyester coating, or equal, except where otherwise indicated.

G. Fans shall meet the requirements and performance in the Contract drawings.

H. Manufacturer, or Equal

1. Greenheck, Model BSQ, SQ
2. Cook

2.3 CEILING TOILET EXHAUST FANS, DIRECT-DRIVE (EF-05)

A. Provide toilet ceiling exhaust fans as indicated.

B. Fans shall be of the forward-curved, direct-drive type.

C. The fan housing and scroll shall be constructed of corrosion-resistant galvanized steel.

D. Grilles shall be constructed of white high-impact polystyrene (non-yellowing) with 2 attachment screws and shall provide an 85-percent free area.

E. Provide the fan with a round-curved outlet connection.

F. Fan Wheels

1. Fan wheels shall be of the forward-curved type and shall be constructed of calcium carbonate-filled polypropylene.

2. Wheels shall be dynamically balanced for vibration-free operation.

G. The integral backdraft damper shall be chatter proof.

H. The entire fan, motor, and wheel assemblies shall be removable without disturbing the housing.

I. Fan Motors

1. Provide motors with thermal overload protection sized to match fan loads.
2. Nominal fan motor speeds shall not exceed 1550 RPM.
3. Fan motors shall be suitably grounded and mounted on vibration isolators.
4. Fan motor housing shall be complete with mounting angles.

J. Fans shall be completely coated outside and on surfaces in contact with the air stream with hi-pro polyester, or equal, except where otherwise indicated.

K. Fans shall meet the requirements and performance in the Contract drawings.

L. Manufacturer, or Equal

1. Greenheck, Model SP

2. Cook

PART 3 EXECUTION

3.1 INSTALLATION

A. Fans, blowers, ventilators, and hoods shall be installed in strict accordance with the manufacturer's recommendations.

B. Pipe the housing drains to the nearest utility drain

END OF SECTION

SECTION 23 70 00 – CENTRAL HVAC EQUIPMENT

PART 1 GENERAL

1.1 THE SUMMARY

A. Provide the air handling units and appurtenances, complete and operable, as indicated in accordance with the Contract Documents.

B. Single Manufacturer: Where 2 or more air handling units or appurtenances of the same type or size are to be provided, they shall be furnished by the same manufacturer.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	**Submittal Procedures**
23 05 00	Common Work Results for HVAC
26 05 10	Low-Voltage Electric Motors

B. Reference Standards

Air-Conditioning, Heating and Refrigeration Institute (AHRI)	
AHRI 410	Forced-Circulation Air Cooling and Air Heating Coils
AHRI 430	Standard for Application of Central-Station Air Handling Units
AHRI 260	Sound Rating of Ducted Air Moving and Conditioning Equipment
Air Movement and Control Association International, Inc. (AMCA)	
AMCA 99	Standard Handbook
AMCA 210	Laboratory Methods of Testing Fans for Rating Purposes
AMCA 300	Test Code for Sound Rating Air Moving Devices
AMCA 301	Method of Publishing Sound Ratings for Air Moving Devices
AMCA 500	Test Methods for Louvers, Dampers, and Shutters
AMCA 611-95	Methods of Testing Airflow Measurement Stations for Rating
American Bearing Manufacturers Association (ABMA)	
ABMA STD 9	Load Ratings and Fatigue Life for Ball Bearings
American National Standards Institute (ANSI)	
ANSI Z223.1	Natural Fuel Gas Code Handbook
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)	
ASHRAE 52.1/52.2	Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size
ASHRAE 62	Ventilation for Acceptable Indoor Air Quality
ASHRAE 90.1	Energy Standard for Buildings Except Low-Rise Residential Buildings

Canadian Electric Code (CEC)	
Canadian Gas Association (CGA)	
CGA B149.1	Natural Gas Installation Code
American Society of Mechanical Engineers (ASME)	
ASTM International (ASTM)	
ASTM A653	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A924	Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ETL Testing Laboratories (ETL)	
International Organization for Standardization (ISO)	
ISO-9002	Quality Standard
National Electrical Manufacturers Association (NEMA)	
National Fire Protection Association (NFPA)	
NFPA 54	National Fuel Gas Code
NFPA 90A	Installation of Air Conditioning and Ventilation Systems
Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)	
SMACNA	Low Pressure Duct Construction Standards
Underwriters Laboratories (UL)	
UL 181	UL Standard for Safety Factory-Made Air Ducts and Air Connectors
ANSI/UL 900	Test Performance of Air Filter Units

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00, Submittal Procedures.

B. The submittals shall include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.

C. Furnish a certified fan curve for each fan.

1.4 CODE REQUIREMENTS

A. Perform the Work in strict accordance with 2022 Oregon Mechanical Specialty Code, and other authorities having jurisdiction.

B. Obtain the required certifications and become thoroughly familiar with the local codes.

C. Obtain and pay for all necessary permits.

PART 2 PRODUCTS

2.1 MAKE-UP AIR HANDLING UNITS – NATURAL GAS HEATING INDIRECT-FIRED (MAU-01 FOR CHEMICAL ROOM)

A. Air Handling Unit

1. The manufacturer shall have a fully implemented and auditable quality assurance program, equal to ISO-9002 Quality Standard.

2. The air handling units and major components shall be products of manufacturers regularly engaged in the production of such equipment and with a minimum of 10 continuous years of proven production experience.

3. Unless stated otherwise, the units shall be shipped to the jobsite in one piece, factory assembled.

B. Unit shall be fully assembled at the factory and consist of an insulated metal cabinet, hot gas reheat coil, indirect gas-fired furnace, motorized dampers, filter assembly intake air, supply air blower assembly, and an electrical control center. All specified components and internal accessories factory installed are tested and prepared for single-point high voltage connection except with electric post heat and exhaust fan only power which have dual point power.

C. Cabinet

1. Materials: Formed, double wall insulated metal cabinet, fabricated to permit access to internal components for maintenance.

a. Unit's exterior shall be supplied from the manufacturer using G60 galvaneal steel with proprietary pre-painted material in the following finish color; Concrete Gray-RAL 7023. This has been subjected to a salt spray test per ASTM-B117 and evaluated using ASTM-D714 and ASTM-D610 showing no observable signs of rust or blistering until reaching 2,500 hours. This is Greenheck's Permatector™ option. Uncoated galvanized steel exterior is not acceptable.

b. Internal assemblies: 24 gauge, galvanized (G90) steel except for motor supports which shall be minimum 14 gauge galvanized (G90) steel.

2. Cabinet Insulation: Comply with NFPA 90A and NFPA 90B and erosion requirements of UL 181.

3. Materials: Rigid urethane injected foam. Foam board not acceptable.

a. Thickness: 2 inch (50.8 mm)

b. Thermal Resistance R16

c. Thermally broken

d. Meets UL94HF-1 flame requirements.

e. Location and application: Full coverage of entire cabinet exterior to include walls, roof of unit, unit base, and doors.

4. Materials: Fiberglass insulation. If insulation other than fiberglass is used, it must also meet the Fire Hazard Classification shown below.

    a. Thickness: 2 inch (50.8 mm)

    b. Thermal Resistance R8

    c. Fire Hazard Classification: Maximum flame spread of 25 and smoke developed of 50, when tested in accordance with ASTM C 411.

    d. Location and application: Divider panels between outdoor air and return air/exhaust air streams.

5. Roof Insulation: 2 inch (50.8 mm) fiberglass located above the 1 inch (25.4 mm) foam panel.

6. Access panels / doors: Unit shall be equipped with insulated, hinged doors or removable access panels to provide easy access to all major components. Doors and access panels shall be fabricated of 18 gauge galvanized G90 steel or painted galvannealed steel.

7. Supply Air blower assemblies: Blower assembly shall consist of an electric motor and direct-drive fans. Assembly shall be mounted on heavy gauge galvanized steel rails and further mounted on 1.125 inch thick neoprene vibration isolators. Blower motors shall be capable of continuous speed modulation and controlled by a VFD.

8. Control panel / connections: Units shall have an electrical control center where all high and low voltage connections are made. Control center shall be constructed to permit single-point high voltage power supply connections. RTU shall be equipped with a Unit Disconnect Switch.

9. Reheat coil with factory installed modulating hot gas reheat valve.

10. Indirect gas furnace

    a. Shall be ETL Certified as a component of the unit.

    b. Shall have an integral combustion gas blower.

    c. Shall have fault sensors to provide fault conditions to optional digital controller or building controls.

    d. Shall have 4-pass tubular heat exchangers, constructed of type 409 stainless steel. Heat exchanger tubes shall be installed on the vest plate by means of swaged assembly, welded connections are not acceptable. Heat exchanger tubes shall be supported by a minimum of two fabricated assemblies that support the tubes and also permit expansion and contraction of the tubes.

    e. Heat exchanger shall have a 25 year extended warranty.

    f. Furnace control shall be High Turndown 12:1 .

g. Shall be encased in a weather-tight metal housing with intake air vents. Large, metal lift-off door shall provide easy access to the enclosed vest plate, control circuitry, gas train, burner assembly and exhaust blower.

h. Shall have solid state controls permitting stand-alone operation or control by building controllers.

11. Motorized dampers / Intake Air, Motorized dampers of low leakage type shall be factory installed.

D. Blower

1. Blower section construction, Supply Air: direct drive motor and blower shall be assembled on a 14-gauge galvanized steel platform and shall be equipped with 1.125 inch thick neoprene vibration isolation devices.

2. Blower assemblies: Shall be statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and horsepower.

3. Fan: Direct drive, airfoil plenum fan with steel wheel statically and dynamically balanced. Prop or belt-drive fan not acceptable due to low static capabilities.

4. Blades: Painted steel blades only.

5. Blower section motor source quality control: Blower performance shall be factory tested for flow rate, pressure, power, air density, rotation speed and efficiency. Ratings are to be established in accordance with AMCA 210, "Laboratory Methods of Testing Fans for Rating".

E. Motors

1. General: Blower motors greater than 1/2 horsepower shall be "NEMA Premium" unless otherwise indicated. Compliance with EPAct minimum energy-efficiency standards for single speed ODP and TE enclosures is not acceptable. Motors shall be heavy-duty, permanently lubricated type to match the fan load and furnished at the specified voltage, phase and enclosure.

2. Motors shall be 60 cycle, 3 phase 460 volts.

F. Unit Controls

1. The unit shall be constructed so that it can function as a stand-alone heating system controlled by factory-supplied controllers, thermostats and sensors. This unit shall be controlled by a factory-installed microprocessor programmable controller (DDC) that is connected to various optional sensors.

2. Unit shall incorporate a DDC controller with integral LCD screen that provides text readouts of status. DDC controller shall have a built-in keypad to permit operator to access read-out screens without the use of ancillary equipment, devices or software. DDC controllers that require the use of equipment or software that is not factory-installed in the unit are not

acceptable. Alarm readouts consisting of flashing light codes are not acceptable. Owner-specified ventilating conditions can be input by means of push buttons.

3. Unit supply fan shall be configured for Constant Volume (ON/OFF).

4. Unit exhaust fan shall be configured for

5. Outside Air / Return Air damper control shall be

6. Operating protocol: The DDC shall be factory-programmed for BACnet MSTP.

7. Variable Frequency Drive (VFD): unit shall have factory installed variable frequency drive for modulation of the exhaust air blower assembly. The VFD shall be factory-programmed for unit-specific requirements and shall not require additional field programming to operate.

8. Unit shall be provided with a space thermostat measuring temperature and relative humidity. 2 temperature sensors shall be provided for temperature averaging.

G. Filters

1. Unit shall have permanent 2-inch (50.8 mm) aluminum filters located in the outdoor air intake and shall be accessible from the exterior of the unit. MERV 8 disposable pleated filters shall be provided in the air stream supply. MERV 8 disposable pleated filters shall be provided in the supply final air stream.

PART 3 EXECUTION

3.1 INSTALLATION

A. All air handling equipment shall be installed by a qualified Contractor in strict accordance with the manufacturer's recommendations.

END OF SECTION

SECTION 23 82 10 – ELECTRIC HEATING EQUIPMENT

PART 1 GENERAL

1.1 SUMMARY

A. The Contractor shall provide the electric heaters, and appurtenances, complete and operable, as indicated in accordance with the Contract Documents.

B. Where 2 or more heaters or appurtenances of the same type or size are required, they shall be furnished by the same manufacturer.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
23 05 00	Common Work Results for HVAC
26 05 10	Low-Voltage Electric Motors

B. Reference Standards

Underwriters Laboratories (UL)
National Electrical Manufacturers Association (NEMA)
American Society of Mechanical Engineers (ASME)

1.3 CONTRACTOR SUBMITTALS

A. Submittals shall be furnished in accordance with the requirements of Section 01 33 000, Submittal Procedures.

B. The submittals shall include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.

C. Product Data: Submit manufacturer's product data for heaters showing an electrical connection diagram, dimensions, capacities, ratings, performance characteristics, control type, and accessories

D. Record Documents: Manufacturers wiring diagrams detailing electrical connections to duct heater for power, signal, and control systems wiring, differentiating clearly between manufacturer-installed wiring and field-installed wiring.

1.4 QUALITY

A. Codes and Permits

1. The Work shall be in strict accordance with the State Mechanical Code, the State of Illinois, Village of Machesney Park, and any other authorities having jurisdiction.

2. The Contractor shall have the required certification and be thoroughly familiar with the local codes.

3. The Contractor shall obtain and pay for necessary permits.

B. Diligent Care

1. Care shall be taken at all times to protect floors, stairways, and walls during the make-up, erection of piping and placing of equipment.

2. The Contractor shall remove all stains and repair all damage before final acceptance of the Work.

C. Materials

1. The materials used in connection with the electric heating system work shall:

a. be new;
b. be free from flaws and defects;
c. be fully equal to the quality specified; and,
d. conform to the requirements of applicable specifications and standards.

2. If during the construction of the Project the Engineer finds materials that have identifying marks removed, or lacking such marks completely, such items may be rejected until the Contractor has shown proof that said items conform to the indicated requirements, where the adequacy and extent of such proof shall be determined by the Engineer.

PART 2 PRODUCTS

2.1 GENERAL

A. Motors shall be in conformance with the requirements of Section 26 05 10, Low-Voltage Electric Motors.

B. The electrical system and components for electric heating systems shall be in conformance with the requirements of Section 23 05 00, Common Work Results for HVAC.

2.2 ELECTRIC UNIT HEATERS (EUH-01)

A. General

1. Electric unit heaters shall be of the horizontal or vertical type as indicated, and shall be provided complete with motor, fan, wire guard, heating element, casing, vibration isolators and support brackets.

2. The units shall be UL-listed and shall meet the requirements of the National Electric Code.

3. The units shall be provided with their own wall or ceiling mounting brackets.

B. Casings

1. The fan casings shall be steel reinforced in order to provide a suitable support for the heating element and for attachment of the support brackets.

2. Casings shall be finished with factory finish.

C. Fans and Motors

1. Fans shall be of the multi-blade propeller type and shall be directly connected to the motor shaft or centrifugal fan.

2. Motor units shall be statically and dynamically balanced.

3. Motors shall be especially designed for unit operation.

4. Fan shafts shall be equipped with self-aligning ball or roller bearings and shall extend a sufficient length to receive the fan hub.

5. The fan shall be keyed and locked to the fan shaft.

6. The fan and motor unit shall be mounted on vibration isolators in order to prevent noise.

D. Electrical

1. The electric heating bank shall consist of metal sheath aluminum-finned heating elements.

2. Provide automatic reset thermal over-heat protection of the linear capillary type and wired for instantaneous de-energizing.'

3. The heating bank shall be provided with protective air inlet louvers.

4. Provide low-voltage control transformers.

5. The heaters shall be provided with power disconnect switches (field installed kits), and a built-in thermostat unless otherwise indicated.

6. The heaters shall be rated as indicated in the Contract drawings.

E. Accessory Thermostat

1. Provide an accessory thermostat with each heater for remote wall mounting.
2. The thermostat shall be UL-listed and provided with a NEMA 4X enclosure.

F. Electric Unit Heaters Manufacturer, or Equal

1. Chromalox, HD3D-300
2. Reznor

2.3 ELECTRIC DUCT HEATERS (DH-01)

A. Provide horizontal duct heaters with heating and air delivery capacities as indicated.

B. Heaters shall be rated as indicated in the Contract drawings.

C. Mounting:

1. Heaters installed in vertical ducts are tested and approved for up and down airflow.
2. Heaters installed in the vertical sides of horizontal or vertical ducts are tested and approved.
3. Heaters are approved for airflow in both directions when installed in horizontal duct.

D. Element housing: Element housing shall be constructed of heavy gauge G60, minimum, galvanized steel and configured for Slip-in or Flanged mounting.

E. Testing Agency Listing and Labeling: Assembly shall be listed to UL standard 1996 and approved for installation with zero clearance to combustibles. Heater shall bear UL and CSA labels.

F. Heating elements: All heating elements shall be made of N60 or 80/20 nickel/chromium resistance wire with ends terminated by means of staking and Heliarc welding to machine screws. Heating element support structure shall consist of galvanized steel wire formed around ceramic insulators that fully encircle and support the heating element.

G. Control Panel:

1. Construction:

    a. Unit mounted control panel and cover shall be constructed of heavy gauge minimum G60 galvanized steel with multiple knockouts for field wiring.

    b. Unit mounted control panel and cover shall be constructed to comply with NEMA 4 or 4x standards. Finish on panel shall be powder coating on NEMA 4 or stainless steel on NEMA 4x.

2. Control cabinet cover shall be held in place with hinges and tool-release latches or door-interlocking type disconnect switch handle when provided. Two latches shall be employed when cover is 48 inches wide or greater. Control panel shall provide means of safety disconnect and overcurrent protection. Include the following controls:

    a. Door interlocking disconnect switch
    b. Fan interlock circuit or an (adjustable), airflow proving switch
    c. Staged (4 stages) or Vernier SCR control
    d. Transformer, (fused), 24VAC
    e. Thermostat, (duct)

H. Over-temperature protection: Duct heater shall be supplied with primary automatically resetting and secondary manually reset thermal cut-out devices. These devices must function independently to prohibit the heater's operation if either one is activated. A disconnecting magnetic contactor circuit is required. All safety components must be serviceable through the control cabinet access panel without the need to remove the heater from the duct.

I. Over-current protection: Duct heaters rated at more than 48 amps shall be supplied with factory-installed fusing. Heating elements shall be subdivided and fused accordingly.

J. All wiring component sizing, component spacing and protective devices within the control cabinet shall be factory installed and comply with NEC and UL standards. All heaters shall function properly with a 50 or 60 Hz power supply.

K. Power and control conductors shall be terminated in factory installed and labeled terminal blocks.

L. A wiring diagram depicting the layout and connection points of all electrical components shall be affixed to the inside of the control cabinet cover.

M. A rating label stating model number, serial number, volts, amps, phase, frequency, control volts, volt-amps and minimum airflow requirements shall be affixed to the interior and exterior of the control cabinet cover.

N. Electric Duct Heaters Manufacturers, or Equal

1. Indeeco Co., Type TFQU
2. Brasch
3. Greenheck, IDHE

PART 3 EXECUTION

3.1 INSTALLATION

A. The electric heating equipment shall be installed by a qualified installer in strict accordance with the manufacturer's recommendations.

B. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

C. All installation shall be in accordance with manufacturer’s published recommendations.

D. Inspect areas and conditions under which terminal units are to be installed. Do not proceed with Work until unsatisfactory conditions have been corrected in manner acceptable to installer.

E. Do not operate electric heaters for any purpose until ductwork is clean of any possible debris.

F. Maintain minimum working clearances around the heater electrical panel in accordance with NEC Article 110.

G. Install duct heaters in metal ducts and casings constructed according to SMACNA “HVAC Duct Construction Standards.”

H. If applicable, anchor duct heaters in position using suitable supports.

I. Connect duct heaters and components to wiring systems and to ground as indicated by manufacturer wiring diagram and NEC. Tighten connectors and terminals to torques specified in UL 486A.

J. After construction is completed, including painting, clean unit’s exposed surfaces and vacuum clean electric duct heaters and inside of cabinets.

END OF SECTION

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SECTION 23 81 29 – VARIABLE REFRIGERANT FLOW HVAC SYSTEMS

PART 1 GENERAL

1.1 THE SUMMARY

A. Provide air conditioning units and appurtenances, complete and operable, in accordance with the Contract Documents.

B. Where two or more air conditioning units or appurtenances of the same type or size are required, they shall be furnished by the same Manufacturer.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures

B. Reference Standards

Air-Conditioning, Heating and Refrigeration Institute (AHRI)	
AHRI 410	Forced-Circulation Air Cooling and Air Heating Coils
AHRI 430	Standard for Application of Central-Station Air Handling Units
AHRI 260	Sound Rating of Ducted Air Moving and Conditioning Equipment
AHRI Std. 1230 I-P	Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment
Air Movement and Control Association International, Inc. (AMCA)	
AMCA 99	Standard Handbook
AMCA 210	Laboratory Methods of Testing Fans for Rating Purposes
AMCA 300	Test Code for Sound Rating Air Moving Devices
AMCA 301	Method of Publishing Sound Ratings for Air Moving Devices
AMCA 500	Test Methods for Louvers, Dampers, and Shutters
AMCA 611-95	Methods of Testing Airflow Measurement Stations for Rating
American Bearing Manufacturers Association (ABMA)	
ABMA STD 9	Load Ratings and Fatigue Life for Ball Bearings
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)	
ASHRAE 52.1/52.2	Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size
ASHRAE 62	Ventilation for Acceptable Indoor Air Quality
ASHRAE 90.1	Energy Standard for Buildings Except Low-Rise Residential Buildings
American Society of Mechanical Engineers (ASME)	
ETL Testing Laboratories (ETL)	
ASTM International (ASTM)	
ASTM B117	Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM G85	Standard Practice for Modified Salt Spray (Fog) Testing

Building Automation Solutions (BAS)	
Department of Energy (DOE)	
International Organization for Standardization (ISO)	
ISO 9001	Quality management systems — Requirements
ISO 14001	Environmental management systems — Requirements with guidance for use
National Electric Code (NEC)	
National Fire Protection Association (NFPA)	
NFPA 90A	Installation of Air Conditioning and Ventilation Systems
Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)	
SMACNA	Low Pressure Duct Construction Standards
Underwriters Laboratories (UL)	
ANSI/UL 900	Test Performance of Air Filter Units
ANSI/UL 1995	Heating and Cooling Equipment
American Society of Civil Engineers (ASCE)	
ASCE Standard 7	Minimum Design Loads and Associated Criteria for Building and Other Structures
Canadian Standards Association (CSA)	
CAN/CSA-C22.2	Safety of Information Technology Equipment

1.3 CODE REQUIREMENTS

A. The Work shall be in strict accordance with 2022 Oregon Mechanical Specialty Code and other authorities having jurisdiction.

B. Obtain the required certifications and become thoroughly familiar with the local codes.

C. Obtain and pay for all necessary permits.

1.4 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00, Submittal Procedures.

B. The submittals shall include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.

C. Furnish a certified fan curve for each fan.

PART 2 PRODUCTS

2.1 VARIABLE REFRIGERANT VOLUME/FLOW (VRV/VRF) AIR CONDITIONING – HEAT PUMP (CU-01 TO 02)

A. Acceptable Manufacturers or equal:

1. Daikin VRV Technology
2. Mitrsubishi VRF Technology
3. LG VRF

B. System Description

1. The Heat Pump Air Conditioning system shall be a Variable Refrigerant Volume or Variable Refrigerant Flow Series (heat or cool model) split system as specified. The system shall consist of multiple evaporators, REFNET™ joints and headers, a two-pipe refrigeration distribution system using PID control and VRV or VRF condensing unit. The condensing unit shall be a direct expansion (DX), air-cooled heat pump, multi-zone air-conditioning system with variable speed inverter driven compressors using R-32 refrigerant. The condensing unit may connect an indoor evaporator capacity up to 200 percent of the condensing unit capacity. All zones are each capable of operating separately with individual temperature control.

2. The condensing unit shall be interconnected to indoor unit models and shall range in capacity from 7,500 Btu/hr to 96,000 Btu/hr in accordance with manufacturers engineering data book detailing each available indoor unit. The indoor units shall be connected to the condensing unit utilizing REFNET™ specified piping joints and headers to ensure correct refrigerant flow and balancing. T style joints are not acceptable.

3. Operation of the system shall permit either cooling or heating of all of the indoor units simultaneously. Each indoor unit or group of indoor units shall be able to provide set temperature independently via a local remote controller, an Intelligent Controller, an Intelligent Manager or a BMS interface.

C. Controls

1. The control system shall consist of a low voltage communication network of unitary built-in controllers with on-board communications and a web-based operator interface. A web controller with a network interface card shall gather data from this system and generate web pages accessible through a conventional web browser on each PC connected to the network. Operators shall be able to perform all normal operator functions through the web browser interface.

2. System controls and control components shall be installed in accordance with the manufacturer's written installation instructions.

3. Furnish energy conservation features such as optimal start, night setback, request-based logic, and demand level adjustment of overall system capacity as specified in the sequence.

4. System shall provide direct and reverse-acting on and off algorithms based on an input condition or group conditions to cycle a binary output or multiple binary outputs.

5. Provide capability for future system expansion to include monitoring and use of occupant card access, lighting control and general equipment control.

6. System shall be capable of email generation for remote alarm annunciation.

7. Control system start-up shall be a required service to be completed by the manufacturer or a duly authorized, competent representative that has been factory trained in controls system configuration and operation. The representative shall provide proof of certification for CMCN Essentials Training and/or CMCN Hands-On Training indicating successful completion of no more than 2 years prior to system installation. This certification shall be

included as part of the equipment and/or controls submittals. This service shall be equipment and system count dependent and shall be a minimum of one 8 hour period to be completed during normal working hours.

D. Features

1. Voltage Platform – Heat pump condensing units shall be available with a 460V/3/60 power supply.

2. Advanced Zoning – A single system shall provide for up to 62 zones.

3. Autocharging – Each system shall have a refrigerant auto-charging function.

4. Oil Return Heating – Each system shall maintain continuous heating during oil return operation. Reverse cycle (cooling mode) oil return during heating operation shall not be permitted due to the potential reduction in space temperature.

5. Independent Control – Each indoor unit shall use a dedicated electronic expansion valve for independent control.

6. VFD Inverter Control – Each condensing unit shall use a high efficiency, variable speed "inverter" compressor coupled with inverter fan motors for superior part load performance.

7. Compressor capacity shall be modulated automatically to maintain constant suction and condensing pressures while varying the refrigerant volume for the needs of the cooling or heating loads.

8. Indoor units shall use PID to control superheat to deliver a comfortable room temperature condition and optimize efficiency.

9. Systems shall be capable of up to 540 ft (640 ft equivalent) of linear piping between the condensing unit and furthest located indoor unit.

10. Systems shall be capable of up to 3,280 ft total "one-way" piping in the piping network.

11. Systems shall have a vertical (height) separation of up to 295 ft between the condensing unit and the indoor units.

12. Systems shall be capable of up to 295 ft from the first REFNET™ branch point.

13. The condensing unit shall have the ability to connect an indoor unit evaporator capacity of up to 200 percent of the condensing unit capacity.

14. Systems shall be capable of 49ft between indoor units.

15. Condensing units shall be supported with a fan motor ESP up to 0.32-in w.g. as standard to allow connection of discharge ductwork and to prevent discharge air short circuiting.

16. Simple Wiring – Systems shall use 16/18 AWG, 2 wire, multi-stranded, non-shielded and non-polarized daisy chain control wiring.

17. Energy Efficiency – System shall have equivalent or better performance than high efficiency air cooled or water cooled chiller systems.

18. Outside Air – Systems shall provide outside air capability.

19. Space Saving – Each system shall have a condensing unit module footprint as small as 3 ft 5/8-in x 2 ft 6/18-in (7.66 sq ft).

20. Advanced Diagnostics – Systems shall include a self diagnostic, auto-check function to detect a malfunction and display the type and location.

21. Each condensing unit shall incorporate contacts for electrical demand shedding.

22. Advanced Controls – Each system shall have at least one remote controller capable of controlling up to 16 indoor units.

23. Each system shall be capable of integrating with open protocol BACnet and LonWorks building management systems.

24. Low Sound Levels – Each system shall use indoor and condensing units with quiet operation as low as 27 dB(A).

E. Warranty

1. The units shall have a manufacturer's warranty for a period of 1 year from date of installation. The units shall have a labor warranty for a period of 1 year from date of installation. The compressors shall have a warranty of 7 years from date of installation. During the stated period, should any part fail due to defects in material and workmanship, it shall be repaired or replaced by the manufacturer. All warranty service work shall be performed by a the manufacturer factory trained service professional.

F. Quality Assurance

1. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL), in accordance with ANSI/UL 1995 – Heating and Cooling Equipment and bear the Listed Mark.

2. All wiring shall be in accordance with the National Electric Code (NEC).

3. The system will be produced in an ISO 9001 and ISO 14001 facility, which are standards set by the International Standard Organization (ISO). The system shall be factory tested for safety and function.

4. Mechanical equipment for wind-born debris regions shall be designed in accordance with ASCE 7-2010 and installed to resist the wind pressures on the equipment and the supports.

5. The condensing unit will be factory charged with R32.

G. Delivery, Storage and Handling

1. Unit shall be stored and handled according to the manufacturer's recommendations.

H. Installation Requirements

1. The system must be installed by a factory trained contractor/dealer. The bidders shall be required to submit training certification proof with bid documents. The mechanical contractor's installation price shall be based on the systems installation requirements. The mechanical contractor bids with complete knowledge of the HVAC system requirements. Untrained contractors who wish to bid this project may contact the equipment manufacturer to arrange training prior to bid day.

I. The VRV/VRF system shall perform as indicated below:

Capacity MBH	System IEER* (part load - ducted)	System IEER* (part load – non-ducted)	System IEER* (part load - mixed)
72	21.5	25.8	23.7
96	18.8	23.0	20.9
120	17.2	20.4	18.8
144	22.1	21.5	21.8
168	20.2	22.0	21.1
192	19.1	19.9	19.5
216	19.5	19.2	19.4
240	16.1	18.2	17.2
264	19.1	20.8	20.0
288	18.8	19.6	19.2
312	17.0	18.2	17.6
336	16.1	15.9	16.0
360	15.3	15.1	15.2

Capacity MBH	System EER* (full load - ducted)	System EER* (full load – non-ducted)	System EER* (full load - mixed)
72	12.8	14.1	13.4
96	12.5	13.5	13.0
120	11.9	12.5	12.2
144	12.7	14.0	13.4
168	12.1	12.4	12.3
192	11.8	11.7	11.8
216	11.7	11.6	11.7
240	11.6	11.5	11.6
264	11.7	11.3	11.5
288	10.5	11.5	11.0
312	11.5	10.7	11.1
336	10.7	10.8	10.8
360	10.8	9.8	10.3

Capacity MBH	System COP@47F* (full load - ducted)	System COP@47F* (full load – non-ducted)	System COP@47F* (full load - mixed)
72	3.71	4.00	3.86
96	3.65	4.20	3.93
120	3.63	3.80	3.72
144	3.70	3.90	3.80
168	3.70	3.95	3.83
192	3.55	3.70	3.63
216	3.60	3.80	3.70
240	3.50	3.60	3.55
264	3.50	3.50	3.50
288	3.45	3.50	3.48
312	3.30	3.30	3.30
336	3.45	3.45	3.45
360	3.20	3.45	3.33

Capacity MBH	System COP@17F* (full load - ducted)	System COP@17F* (full load – non-ducted)	System COP@17F* (full load - mixed)
72	2.40	2.65	2.53
96	2.50	2.85	2.68
120	2.50	2.65	2.58
144	2.45	2.55	2.50
168	2.45	2.65	2.55
192	2.45	2.55	2.50
216	2.45	2.60	2.53
240	2.35	2.55	2.45
264	2.30	2.45	2.38
288	2.45	2.45	2.45
312	2.35	2.35	2.35
336	2.35	2.35	2.35
360	2.30	2.40	2.35

J. Performance Conditions:

1. Cooling: indoor temp. of 78 deg F DB, 65 deg F WB and outdoor temp. of 95 deg F DB.

2. Heating: indoor temp. of 70 deg F DB and outdoor temp. of 34 deg F DB, 33 deg F WB.

3. The system IEER, EER and COP values for systems sized 300 MBH and smaller shall be certified to AHRI Std. 1230 I-P. Systems sized larger than 300 MBH shall be rated to AHRI Std. 1230 I-P.

K. Operating Range

1. The operating range in cooling will be 23 deg F DB ~ 122 deg F DB.

2. The operating range in heating will be 0 deg F DB – 77 deg F DB / -4 deg F WB – 60 deg F WB.

3. Cooling mode indoor room temperature range will be 57 deg F -77 deg F WB.

4. Heating mode indoor room temperature range will be 59 deg F -80 deg F DB.

L. Low ambient operation

1. The outdoor unit shall be capable of operating in cooling mode down to -10 deg F with optional manufacturer supplied low ambient kit.

2. Manufacturer supplied low ambient kit shall be provided with predesigned control box rated for outdoor installation and capable of controlling kit operation automatically in all outdoor unit operation modes.

3. Manufacturer supplied low ambient kit shall be listed by Electrical Laboratories (ETL) and bear the ETL label.

4. Manufacturer supplied low ambient kit shall be factory tested in low ambient temperature chamber to ensure operation. Factory performance testing data shall be available when requested.

M. Snow/Hail Gard

1. The outdoor unit shall be provided with a manufacturer supplied 20 gauge hot dipped galvanized snow /hail guard. The snow/hail guard protects the outdoor coil surfaces from hail damage and snow build-up in severe climates.

N. Unit Defrost

1. Unit must defrost all circuits simultaneously in order to resume full heating more quickly. Partial defrost which may extend “no or reduced heating” periods shall not be allowed.

O. Refrigerant Piping

1. The system shall be capable of refrigerant piping up to 540 actual feet or 620 equivalent feet from the condensing unit to the furthest indoor unit, a total combined liquid line length of 3,280 ft of piping between the condensing and indoor units with 295 ft maximum vertical difference, without any oil traps.

2. REFNET™ piping joints and headers shall be used to ensure proper refrigerant balance and flow for optimum system capacity and performance. T style joints shall not be acceptable as this will negatively impact proper refrigerant balance and flow for optimum system capacity and performance.

3. Refrigerant piping between indoor and outdoor units shall be sized and installed by manufacturer factory trained service professional.

4. Both refrigerant lines from the outdoor unit to the BC (Branch Circuit) Controller (Single or Main) shall be insulated.

P. Refrigerant

1. R32 refrigerant shall be required.

Q. Refrigerant valves:

1. The unit shall be furnished with multiple branch circuits which can individually accommodate up to 54,000 Btu/hr and up to three indoor units. Branches may be twinned to allow more than 54,000 Btu/hr.

2. Each branch shall have multiple two-position valves to control refrigerant flow.

3. Service shut-off valves shall be field-provided/installed for each branch to allow service to any indoor unit without field interruption to overall system operation.

4. Linear electronic expansion valves shall be used to control the variable refrigerant flow.

R. Safety Shutoff Valve

1. Codes and Standards:

   a. The safety shut-off valve shall be designed and manufactured to comply with ASHRAE 15, UL 60335-2-40 or UL 60335-2-59, and shall be listed and evaluated by a Nationally Recognized Testing Laboratory.

2. Refrigerant compatibility and configuration:

   a. The shut-off valve shall be specifically designed for use with R-32 refrigerant (A2L classification) and shall not be used with other refrigerants.

   b. The shut-off valve shall be single-port type.

   c. The safety shut-off valve shall be compatible with refrigerant leak detection and mitigation system, including enclosure ventilation.

3. Performance Requirement

   a. Upon receipt of a refrigerant leak signal from a refrigerant detection sensor, the safety shut-off valve shall automatically close to isolate refrigerant flow with accordance with ASHRAE 15 A2L safety requirement and manufacturer's installation manual.

   b. The valve shall also automatically close upon loss of power to provide fail-safe isolation of refrigerant charge.

4. Electrical Requirements

   a. The safety shut-off valve shall be suitable for operation on 208/230 V, single-phase, 60 Hz power supply.

b. Electrical installation shall comply with national electrical codes and the manufacturer's installation manual.

S. Safety Shutoff Valve Enclosure

1. The safety shutoff valve enclosure shall be designed and manufactured to comply with ASHRAE 15, UL 60335-2-40 or UL 60335-2-59 and shall be listed and evaluated by a Nationally Recognized Testing Laboratory.

2. The enclosure shall be compatibility with the manufacturer's safety shut-off valve and valve control box.

3. Enclosure shall be of factory-fabricated sheet metal panels with gasketing.

4. Enclosure shall include top, bottom, side, front control-box extension, and sensor extension panels.

T. Future Use

1. Each VRV/VRF system shall include at least 1 unused branches or branch devices for future use. Branches shall be fully installed & wired in central location with capped service shutoff valve & service port.

U. Condensing Unit General

1. The condensing unit shall be designed specifically for use with VRV/VRF series components.

2. The condensing unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports and refrigerant regulator.

3. Liquid and suction lines must be individually insulated between the condensing and indoor units.

4. The condensing unit can be wired and piped with access from the left, right, rear or bottom.

5. The connection ratio of indoor units to condensing unit shall be permitted up to 200 percent.

6. Each condensing system shall be able to support the connection of up to 59 indoor units dependent on the model of the condensing unit.

7. The sound pressure level standard shall be that value as listed in the manufacturers engineering manual for the specified models at 3 ft from the front of the unit. The condensing unit shall be capable of operating automatically at further reduced noise during night time.

8. The system will automatically restart operation after a power failure and will not cause any settings to be lost, thus eliminating the need for reprogramming.

9. The unit shall incorporate an auto-charging feature.

10. The condensing unit shall be modular in design and should allow for side-by-side installation with minimum spacing.

11. The following safety devices shall be included on the condensing unit; high pressure sensor and switch, low pressure switch, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.

12. To ensure the liquid refrigerant does not flash when supplying to the various indoor units, the circuit shall be provided with a sub-cooling feature.

13. Oil recovery cycle shall be automatic occurring 2 hours after start of operation and then every 8 hours of operation. Each system shall maintain continuous heating during oil return operation. Reverse cycle (cooling mode) oil return during heating operation shall not be permitted due to the potential reduction in space temperature.

14. The condensing unit shall be capable of heating operation at 0 deg F dry bulb ambient temperature without additional low ambient controls or an auxiliary heat source.

V. Condensing Unit Cabinet

1. The condensing unit shall be completely weatherproof and corrosion resistant. The unit shall be constructed from rust-proofed mild steel panels coated with a baked enamel finish.

W. Condensing Unit Fan

1. The condensing unit shall consist of one or more propeller type, direct-drive 350 or 750 W fan motors that have multiple speed operation via a DC (digitally commutating) inverter.

Capacity MBH	Fan Motor Output (W) & Quantity
72	750 x 1
96	350 x 2
120	350 x 2
144	750 x 2
168	(350 x 2) + (750 x 1)
192	(350 x 2) + (750 x 1)
216	(350 x 2) + (350 x 2)
240	(350 x 2) + (350 x 2)
264	(350 x 2) + (350 x 2) + (750 x 1)
288	(350 x 2) + (350 x 2) + (750 x 1)
312	(350 x 2) + (350 x 2) + (750 x 1)
336	(350 x 2) + (350 x 2) + (350 x 2)
360	(350 x 2) + (350 x 2) + (350 x 2)

2. The condensing unit fan motor shall have multiple speed operation of the DC (digitally commutating) inverter type, and be of high external static pressure and shall be factory set

as standard at 0.12-in w.g. A field setting switch to a maximum 0.32-in w.g. pressure is available to accommodate field applied duct for indoor mounting of condensing units.

3. The fan shall be a vertical discharge configuration with a nominal airflow maximum range of 6,350 CFM to 24,690 CFM dependent on model specified.

4. Nominal sound pressure levels shall be as shown below.

Capacity MBH	Sound Pressure Level dB(A)
72	57
96	60
120	60
144	60
168	62
192	62
216	63
240	63
264	64
288	64
312	64
336	65
360	65

5. The fan motor shall have inherent protection and permanently lubricated bearings and be mounted.

6. The fan motor shall be provided with a fan guard to prevent contact with moving parts.

7. Night setback control of the fan motor for low noise operation by way of automatically limiting the maximum speed shall be a standard feature. Operation sound level shall be selectable from 3 steps as shown below.

Operation Sound (dB)	Night Mode Sound Pressure Level (dB)
Step 1 max.	55
Step 2 max.	50
Step 3 max.	45

X. Condenser Coil

1. The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond.

2. The heat exchanger coil shall be of a waffle louver fin and rifled bore tube design to ensure high efficiency performance.

3. The heat exchanger on the condensing units shall be manufactured from Hi-X seamless copper tube with N-shape internal grooves mechanically bonded on to aluminum fins to an e-Pass Design.

4. The fins are to be covered with an anti-corrosion acrylic resin and hydrophilic film type E1.

5. The pipe plates shall be treated with powdered polyester resin for corrosion prevention. The thickness of the coating must be between 2.0 to 3.0 microns.

Y. Compressor

1. The inverter scroll compressors shall be variable speed (PVM inverter) controlled which is capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit. In addition, samplings of evaporator and condenser temperatures shall be made so that the high/low pressures detected are read every 20 seconds and calculated. With each reading, the compressor capacity (INV frequency or STD ON/OFF) shall be controlled to eliminate deviation from target value.

2. Non inverter-driven compressors, which cause inrush current (demand charges) and require larger wire sizing, shall not be allowed.

3. The inverter driven compressor in each condensing unit shall be of highly efficient reluctance DC (digitally commutating), hermetically sealed scroll "G2-type" with a maximum speed of 7,980 rpm.

4. Neodymium magnets shall be adopted in the rotor construction to yield a higher torque and efficiency in the compressor instead of the normal ferrite magnet type. At complete stop of the compressor, the neodymium magnets will position the rotor into the optimum position for a low torque start.

5. The capacity control range shall be as low as 4 percent to 100 percent.

6. Each non-inverter compressor shall also be of the hermetically sealed scroll type.

7. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.

8. Oil separators shall be standard with the equipment together with an intelligent oil management system.

9. The compressor shall be spring mounted to avoid the transmission of vibration.

10. Units sized 6 tons shall contain a minimum of 1 compressor. 8-12 ton units shall contain a minimum of 2 compressors. 14-16 ton units shall contain a minimum of 3 compressors. 18-20 ton units shall contain a minimum of 4 compressors. 22-26 ton units shall contain a minimum of 5 compressors. 28-30 ton units shall contain a minimum of 6 compressors. In the event of compressor failure the remaining compressors shall continue to operate and provide heating or cooling as required at a proportionally reduced capacity. The microprocessor and associated controls shall be designed to specifically address this condition.

Tonnage	Number of Compressors	Compressor Types
6	1	1 inverter
8	2	1 inverter + 1 fixed

Tonnage	Number of Compressors	Compressor Types
9	2	1 inverter + 1 fixed
12	4	(1 inverter) x 2
14	4	(1 inverter + 1 fixed) + 1 inverter
16	4	(1 inverter + 1 fixed) + 1 inverter
18	4	(1 inverter + 1 fixed) x 2
20	4	(1 inverter + 1 fixed) x 2
22	5	(1 inverter + 1 fixed) x 2 + 1 inverter
24	5	(1 inverter + 1 fixed) x 2 + 1 inverter
26	5	(1 inverter + 1 fixed) x 2 + 1 inverter
28	6	(1 inverter + 1 fixed) x 3
30	6	(1 inverter + 1 fixed) x 3

11. In the case of multiple condenser modules, conjoined operation hours of the compressors shall be balanced by means of the Duty Cycling Function, ensuring sequential starting of each module at each start/stop cycle, completion of oil return, completion of defrost or every 8 hours.

Z. Electrical:

1. The power supply to the condensing unit shall be 460 volts, 3 phase, 60 hertz +/- 10 percent.

2. The control voltage between the indoor and condensing unit shall be 16VDC non-shielded, stranded 2 conductor cable.

3. The control wiring shall be a two-wire multiplex transmission system, making it possible to connect multiple indoor units to one condensing unit with one 2-cable wire, thus simplifying the wiring installation.

4. The control wiring lengths shall be as shown below.

	Condenser to Indoor Unit	Condenser to Central Controller	Indoor Unit to Remote Control
Control Wiring Length	6,665 ft	3,330 ft	1,665 ft
Wire Type	16/18 AWG, 2 wire, non-polarity, non-shielded, stranded		

AA. Protection Coating:

1. The outdoor unit shall be coated with the a protection coating which adheres to the following specifications:

			Coating Thickness	
Component	**Base Material**	**Surface Treatment**	**External Surface**	**Internal Surface**
External Panel Base	Alloyed Galvanized Steel Sheet	Thermoset Polyester-Resin Powder Coating	≥ 70 µm	≥ 70 µm

			Coating Thickness	
Component	Base Material	Surface Treatment	External Surface	Internal Surface
External Front Panel	Alloyed Galvanized Steel Sheet	Thermoset Polyester-Resin Powder Coating	≥ 85 µm	≥ 85 µm
Pillar	Alloyed Galvanized Steel Sheet	Thermoset Polyester-Resin Powder Coating	≥ 70 µm	≥ 70 µm
Compressor Cover	Galvanized Steel Sheet	Thermoset Polyester-Resin Powder Coating	≥ 70 µm	≥ 70 µm
Fin Guard	Steel wires	Weather Resistant Polypropylene-resin coating	≥ 300 µm	≥ 300 µm
Fan Guard and Drum	Weather Resistant Polypropylene Plastic	No Treatment		
Fan	Weather Resistant Acrylic Nitrile Styrene plastic	No Treatment		
Fan Motor Frame	Galvanized Steel Sheet	No Treatment		
Fan Motor Shaft	High Carbon S35C Steel	Rust Prevention Coating		
Fan Motor Support	Galvanized Steel Sheet	Thermoset Polyester-Resin Powder Coating	≥ 70 µm	≥ 70 µm
Heat Exchanger (Fin Only)	Aluminum Plate	Cellulose and Polyurethane-resin coating	≥ 1.5 µm	
Electrical Parts Box	Galvanized Aluminum Sheet	Thermoset Polyester-Resin Powder Coating	≥ 70 µm	
Printed Circuit Board	Epoxy Resin	Polyurethane Coating	≥ 10 µm	
Screws	Steel	Zinc-nickel Alloy Plating with a Chromate film	≥ 5 µm	

2.2 VARIABLE REFRIGERANT VOLUME/FLOW (VRV/VRF) AIR CONDITIONING INDOOR UNITS

A. Quality Assurance

1. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL), in accordance with ANSI/UL 1995/CAN/CSA-C22.2 No. 236-05 (R2009) – Heating and Cooling Equipment and bear the Listed Mark.

2. All wiring shall be in accordance with the National Electric Code (NEC)/Canadian Electrical Code (CEC).

3. The system will be produced in an ISO 9001 and ISO 14001 facility, which are standards set by the International Standard Organization (ISO). The system shall be factory tested for safety and function.

4. The outdoor unit will be factory charged with R-32.

B. Warranty

1. The units shall have a manufacturer's warranty for a period of 1 year from date of installation. The units shall have labor warranty for a period of 1 year from date of installation. During the stated period, should any part fail due to defects in material and workmanship, it shall be repaired or replaced by the manufacturer. All warranty service work shall be performed by a the manufacturer factory trained service professional.

C. Installation requirements

1. The system must be installed by a factory trained contractor/dealer. The bidders shall be required to submit training certification proof with bid documents. The mechanical contractor's installation price shall be based on the systems installation requirements. The mechanical contractor bids with complete knowledge of the HVAC system requirements.

D. VRF/VRV SYSTEM PRODUCTS

1. VRF/VRV SYSTEM ROUND FLOW CEILING CASSETTE UNIT (3 ft x3 ft) (AC-01 TO 05 FOR ELECTRICAL ROOM)

a. General:

1) Unit shall be a round flow ceiling cassette fan coil unit, operable with R-32 refrigerant, equipped with an electronic expansion valve, for installation into the ceiling cavity equipped with an air panel grill. It shall be available in capacities from 9,500 Btu/hr to 48,000 Btu/hr. It shall be a round flow air distribution type, fresh white, impact resistant with a washable decoration panel. The supply air shall be distributed via motorized louvers which can be horizontally and vertically adjusted from 0 degrees to 90 degrees. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition. The unit shall be equipped with a programmed drying mechanism that dehumidifies while limiting changes in room temperature. The indoor units sound pressure shall range from 27 dB(A) to 34 dB(A) at low speed measured at 5 ft below the unit.

b. Indoor Unit:

1) Unit shall be completely factory assembled and tested. Included in the unit shall be factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, condensate drain pump, condensate safety shutoff and alarm, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.

2) Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.

3) Both refrigerant lines shall be insulated from the outdoor unit.

4) The round flow supply air flow can be field modified to 23 different airflow patterns to accommodate various installation configurations including corner installations.

5) Return air shall be through the concentric panel, which includes a resin net, mold resistant, antibacterial filter.

6) The indoor units shall be equipped with a condensate pan with antibacterial treatment and condensate pump. The condensate pump provides up to 33-1/2-in of lift and has a built in safety shutoff and alarm.

7) The indoor units shall be equipped with a return air thermistor.

8) The indoor unit will be separately powered with 208~230V/1-phase/60Hz.

9) The voltage range will be 253 volts maximum and 187 volts minimum.

c. Cabinet:

1) The cabinet shall be space saving and shall be located into the ceiling.

2) Three auto-swing positions shall be available to choose, which include standard, draft prevention and ceiling stain prevention.

3) The airflow of the unit shall have the ability to shut down outlets with multiple patterns allowing for simpler installation in irregular spaces.

4) Fresh air intake shall be possible by way of optional fresh air intake kit.

5) A branch duct knockout shall exist for branch ducting of supply air.

6) The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

7) Optional high efficiency MERV 13 air filters are available for each model unit.

d. Fan:

1) The fan shall be direct-drive turbo fan type with statically and dynamically balanced impeller with three fan speeds available.

2) The fan motor shall operate on 208/230 volts, 1 phase, 60 hertz with a motor output range from 0.08 HP to 0.16 HP.

3) The airflow rate shall be available in three settings.

4) The fan motor shall be equipped as standard with adjustable external static pressure (ESP) settings to allow operation with the MERV 13 filter options.

5) The fan motor shall be thermally protected.

e. Filter:

1) The return air shall be filtered by means of a washable long-life filter with mildew proof resin and antibacterial treatment.

2) Optional high efficiency disposable MERV 13 filters shall be available.

f. Coil:

1) Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.

2) The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.

3) The coil shall be a 2-row cross fin copper evaporator coil with 17 FPI design completely factory tested.

4) The refrigerant connections shall be flare connections and the condensate will be 1 ¼-in outside diameter PVC.

5) A condensate pan with antibacterial treatment shall be located under the coil.

6) A condensate pump with a 33 ½-in lift shall be located below the coil in the condensate pan with a built in safety alarm.

7) A thermistor will be located on the liquid and gas line.

g. Electrical:

1) A separate power supply will be required of 208/230 volts, 1 phase, 60 hertz. The acceptable voltage range shall be 187 to 253 volts.

2) Transmission (control) wiring between the indoor and outdoor unit shall be a maximum of 3,280 ft (total 6,560 ft).

3) Transmission (control) wiring between the indoor unit and remote controller shall be a maximum distance of 1,640 ft.

h. Controls:

1) The unit shall have controls provided by the manufacturer to perform input functions necessary to operate the system.

2) The unit shall be compatible with interfacing with a BMS system via optional LonWorks or BACnet gateways.

3) The unit shall be compatible with an intelligent Touch advanced multi-zone controller or an intelligent Manager III customizable BMS. Consult with unit Manufacturer prior to applying controls.

i. Optional accessories available:

1) A high efficiency disposable MERV 13 air filter kit.
2) Fresh air intake kit.
3) Supply air branch duct connections.
4) Remote “in-room” sensor kit.

2. VRF/VRV SYSTEM FOUR WAY CEILING CASSETTE UNIT (2'x2') (AC-07) FOR ENTRY

   a. General:

      1) Unit shall be a ceiling cassette fan coil unit, operable with R-32 refrigerant, equipped with an electronic expansion valve, for installation into the ceiling cavity equipped with an air panel grill. It shall be available in capacities from 7,500 Btu/hr to 18,000 Btu/hr. Unit shall be a four-way air distribution type, white, impact resistant with a washable decoration panel. The supply air shall be distributed via motorized louvers which can be horizontally and vertically adjusted from 0 degrees to 90 degrees. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition. The unit shall be equipped with a programmed drying mechanism that dehumidifies while limiting changes in room temperature. The indoor units sound pressure shall range from 29 dB(A) to 34 dB(A) at low speed measured at 5 ft below the unit.

   b. Indoor Unit:

      1) The indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, condensate drain pump, condensate safety shutoff and alarm, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.

         a) Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.

         b) Both refrigerant lines shall be insulated from the outdoor unit.

         c) The 4-way supply air flow can be field modified to 3-way and 2-way airflow to accommodate various installation configurations including corner installations.

         d) Return air shall be through the concentric panel, which includes a resin net mold resistant filter.

         e) The indoor units shall be equipped with a condensate pan and condensate pump. The condensate pump provides up to 21-in of lift and has a built in safety shutoff and alarm.

         f) The indoor units shall be equipped with a return air thermistor.

         g) All electrical components are reached through the decoration panel, which reduces the required side service access.

         h) The indoor unit will be separately powered with 208~230V/1-phase/60Hz.

         i) The voltage range will be 253 volts maximum and 187 volts minimum.

   c. Unit cabinet:

      1) The cabinet shall be space saving and shall be located into the ceiling.

2) Three auto-swing positions shall be available to choose, which include standard, draft prevention and ceiling stain prevention.

3) The airflow of the unit shall have the ability to shut down one or two sides allowing for simpler corner installation.

4) Fresh air intake shall be possible by way of direct duct installation to the side of the indoor unit cabinet.

5) A branch duct knockout shall exist for branch ducting supply air.

6) The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

d. Fan:

1) The fan shall be direct-drive turbo fan type with statically and dynamically balanced impeller with high and low fan speeds available.

2) The fan motor shall operate on 208/230 volts, 1 phase, 60 hertz with a motor output range from 0.06 HP to 0.12 HP.

3) The airflow rate shall be available in high and low settings.

4) The fan motor shall be thermally protected.

e. Filter:

1) The return air shall be filtered by means of a washable long-life filter with mildew proof resin.

f. Coil:

1) Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.

2) The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.

3) The coil shall be a 2-row cross fin copper evaporator coil with 17 FPI design completely factory tested.

4) The refrigerant connections shall be flare connections and the condensate will be 1 1/32-in outside diameter PVC.

5) A condensate pan shall be located under the coil.

6) A condensate pump with a 21-in lift shall be located below the coil in the condensate pan with a built in safety alarm.

7) A thermistor will be located on the liquid and gas line.

g. Electrical:

1) A separate power supply will be required of 208/230 volts, 1 phase, 60 hertz. The acceptable voltage range shall be 187 to 253 volts.

2) Transmission (control) wiring between the indoor and outdoor unit shall be a maximum of 3,280 ft (total 6,560 ft).

3) Transmission (control) wiring between the indoor unit and remote controller shall be a maximum distance of 1,640 ft.

h. Control:

1) The unit shall have controls provided by the manufacturer to perform input functions necessary to operate the system.

2) The unit shall be compatible with interfacing with a BMS system via optional LonWorks or BACnet gateways.

3) The unit shall be compatible with the manufacturer intelligent Touch advanced multi-zone controller or an intelligent Manager III customizable BMS. Consult with Manufacturer prior to applying controls.

i. Optional accessories available:

1) Direct fresh air intake kit.
2) Supply air duct connections.
3) Remote “in-room” sensor kit

3. VRF/VRV SYSTEM CONCEALED CEILING DUCTED UNIT (Med. Static) (AC-06 FOR MEETING ROOM, AC-08 FOR KITCHEN, AND AC-09 FOR STORAGE ROOM)

a. General:

1) Unit shall be a built-in ceiling concealed fan coil unit, operable with refrigerant R-32, equipped with an electronic expansion valve, direct-drive DC (ECM) type fan with auto CFM adjustment at commissioning, for installation into the ceiling cavity. It is constructed of a galvanized steel casing. It shall be available in capacities from 7,500 Btu/hr to 48,000 Btu/hr. It shall be a horizontal discharge air with horizontal return air configuration. All models feature a low height cabinet making them applicable to ceiling pockets that tend to be shallow. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition. The unit shall be equipped with a programmed drying mechanism that dehumidifies while limiting changes in room temperature. Included as standard equipment, a condensate drain pan and drain pump kit that pumps to 18 3/8-in from the drain pipe opening. The indoor units sound pressure shall range from 29 dB(A) to 40 dB(A) at low speed measured 5 ft below the ducted unit.

b. Indoor Unit:

1) The unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, condensate drain pump, condensate safety shutoff and alarm, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch. The unit shall be equipment with automatically adjusting external static pressure logic that is selectable during commissioning. This adjusts the airflow based on the installed external static pressure.

2) Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.

3) Both refrigerant lines shall be insulated from the outdoor unit.

4) The indoor units shall be equipped with a condensate pan and condensate pump. The condensate pump provides up to 18 3/8 of lift from the center of the drain outlet and has a built in safety shutoff and alarm.

5) The indoor units shall be equipped with a return air thermistor.

6) The indoor unit will be separately powered with 208~230V/1-phase/60Hz.

7) The voltage range will be 253 volts maximum and 187 volts minimum.

c. Unit Cabinet:

1) The cabinet shall be located into the ceiling and ducted to the supply and return openings.

2) The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

d. Fan:

1) The fan shall be direct-drive DC (ECM) type fan, statically and dynamically balanced impeller with three fan speeds available.

2) The unit shall be equipment with automatically adjusting external static pressure logic selectable during commissioning.

3) The fan motor shall operate on 208/230 volts, 1 phase, 60 hertz with a motor output range of 0.12 HP to 0.47 HP respectively.

4) The airflow rate shall be available in three settings.

5) The fan motor shall be thermally protected.

6) The fan motor shall be equipped as standard with adjustable external static pressure (ESP) settings.

e. Coil:

1) Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.

2) The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.

3) The coil shall be a 3 row cross fin copper evaporator coil with 13 fpi design completely factory tested.

4) The refrigerant connections shall be flare connections and the condensate will be 1 ¼-in outside diameter PVC.

5) A condensate pan shall be located under the coil.

6) A condensate pump with an 18 3/8-in lift shall be located below the coil in the condensate pan with a built in safety alarm.

7) A thermistor will be located on the liquid and gas line.

f. Electrical:

1) A Separate Power Supply Will Be Required Of 208/230 Volts, 1 Phase, 60 Hertz. The Acceptable Voltage Range Shall Be 187 To 253 Volts.

2) Transmission (Control) Wiring Between The Indoor And Outdoor Unit Shall Be A Maximum Of 3,280 ft (Total 6,560 ft).

3) Transmission (Control) Wiring Between The Indoor Unit And Remote Controller Shall Be A Maximum Distance Of 1,640 ft.

g. Control:

1) The unit shall have controls provided by the manufacturer to perform input functions necessary to operate the system.

2) The unit shall be compatible with interfacing with a BMS system via optional LonWorks or BACnet gateways.

3) The unit shall be compatible with an intelligent Touch advanced multi-zone controller or an intelligent Manager III customizable BMS.

h. Optional Accessories Available:

1) Remote “in-room” sensor kit.

PART 3 EXECUTION

3.1 INSTALLATION

A. All air conditioning equipment shall be installed in strict accordance with the manufacturer's recommendations.

END OF SECTION

SECTION 26 00 00 – ELECTRICAL WORK, GENERAL

PART 1 GENERAL

1.1 THE REQUIREMENT

A. Provide the electrical WORK, complete and operable, as indicated in accordance with the Contract Documents.

B. The provisions of this Section shall apply to all Sections in Division 26, except as otherwise indicated.

C. The WORK of this Section is required for operation of electrically-driven equipment provided under Specifications in other Divisions.

D. The CONTRACTOR'S attention is directed to the requirement for proper coordination of the WORK of this Section with the WORK of equipment Specifications, the WORK of instrumentation Sections, and the WORK of Section 26 05 10, Electric Motors.

E. Concrete, excavation, backfill, and steel reinforcement required for encasement, installation, or construction of the WORK of the various Sections of Division 26 is included as a part of the WORK under the respective Sections, including duct banks, manholes, handholes, equipment housekeeping pads, and light pole bases.

F. Equipment supports and foundations shall be in conformance with the requirements of Section 46 01 00, Equipment General Provisions.

1.2 REFERENCE STANDARDS

A. NEC (NFPA 70) National Electrical Code

B. NETA International Electrical Testing Association

C. NEMA 250 Enclosure for Electrical Equipment (1000 Volts Maximum)

D. Electrical equipment shall be listed by and shall bear the label of Underwriters' Laboratories, Inc. (UL) or an independent testing laboratory acceptable to the local code enforcement agency having jurisdiction.

E. Installation of electrical equipment and materials shall comply with OSHA Safety and Health Standards (29 CFR 1910 and 29 CFR 1926, as applicable), state building standards, and applicable local codes and regulations.

F. Where the requirements of the specifications conflict with UL, NEMA, NFPA, or other applicable standards, the more stringent requirements shall govern.

1.3 SIGNAGE AND MARKINGS

A. Identification

1. Provide danger, caution, and warning signs and equipment identification markings in accordance with applicable federal, state, OSHA, and NEC requirements.

B. Local Disconnect Switches

1. Legibly mark each local disconnect switch for motors and equipment in order to indicate its purpose, unless the purpose is indicated by the location and arrangement.

C. Warning Signs

1. 600 Volts Nominal, or Less

a. Mark entrances to rooms and other guarded locations that contain live parts with conspicuous signs prohibiting unqualified persons from entering.

1.4 PUBLIC UTILITIES REQUIREMENTS

A. Contact the serving utility and verify compliance with requirements before construction.

B. Coordinate schedules and payments for WORK by utilities.

C. Where conduits and conductors in the WORK are indicated to be larger, heavier schedule, or have greater protective coating than utility requirements, provide the larger size, heavier schedule, or greater protection.

D. Provide electrical service as indicated and as required by the serving utility.

E. Verify and provide service conduits, fittings, transformer pad, grounding devices, and service wires not provided by the serving utility.

F. Verify with the utility the exact location of each service point and type of service, and pay charges levied by the serving utilities as part of the WORK.

G. Electrical utility contact information is:

1. Portland General Electric (PGE), PortlandGeneral.com

2. PGE project number M3292151.

3. Design Project Manager:

Tamara O'Neill
Associate Design Project Manager
Tamara.O'Neill@pgn.com
Phone (503) 669-3346
Cell (503) 732-5534

4. Street address:

15962 Hunter Ave.
Oregon City, OR 97045

1.5 PERMITS AND INSPECTION

A. Obtain permits and pay inspection fees according to the General Conditions.
B. Pay connection and turn-on service charges required by the utility company.

1.6 CONTRACTOR SUBMITTALS

A. General

1. Furnish submittals in accordance with the requirements of Section 01 33 00, Contractor Submittals.
2. Custom-prepare Shop Drawings.
3. Drawings or data indicating "optional" or "as required" equipment will not be accepted.
4. Cross out options not proposed or delete from the Shop Drawings.

B. Shop Drawings: Include the following:

1. Complete material lists stating manufacturer and brand name of each item or class of material.
2. Shop Drawings for grounding WORK not specifically indicated.
3. Front, side, rear elevations, and top views with dimensional data.
4. Location of conduit entrances and access plates.
5. Component data.
6. Connection diagrams, terminal numbers, internal wiring diagrams, conductor size, and cable numbers.
7. Method of anchoring, seismic requirements, weight.
8. Types of materials and finish.
9. Nameplates.
10. Temperature limitations, as applicable.
11. Voltage requirement, phase, and current, as applicable.
12. Front and rear access requirements.
13. Test reports.
14. Grounding requirements.

C. Catalog Cuts

1. Submit catalog cuts or photocopies of applicable pages of bulletins or brochures for mass produced, non-custom manufactured material.
2. Stamp the catalog data sheets in order to indicate the Project name, applicable Specifications Section and Paragraph, model number, and options.

D. Materials and Equipment Schedules

1. Within 30 Days of the commencement date in the Notice to Proceed, deliver to the ENGINEER a complete list of materials, equipment, apparatus, and fixtures that are proposed for use.

2. Include in the list the type, size, name of manufacturers, catalog number, and such other information as required to identify the item.

E. Technical Manuals

1. Submit complete information in accordance with the requirements of Section 01 33 00, Contractor Submittals.

2. As-Built Drawings

a. Prepare as-built drawings, showing invert and top elevations and routing of duct banks and concealed below-grade electrical installations.

b. Furnish the drawings to the ENGINEER in accordance with the requirements of Section 01 33 00, Contractor Submittals.

1.7 AREA DESIGNATIONS

A. General

1. Designations for raceway system enclosures shall comply with the requirements of Section 26 05 33, Electrical Raceway Systems.

2. Designations for electrical WORK specifically indicated in other Sections shall comply with the requirements of those Sections unless indicated otherwise.

3. Designations for other electrical WORK not included in the above Paragraphs shall be as follows:

AREA	NEMA ENCLOSURE CLASSIFICATION					
	1	3R	4	4X	12	Notes
Outdoors		X				
Alum area, corrosive				X		PVC conduit and enclosures. Up to 2 ft above top of tanks.
Sodium Hypochlorite generator and tank areas, corrosive				X		PVC conduit and enclosures. Up to 2 ft above top of tanks.
Brine tank area, corrosive				X		PVC conduit and enclosures. Up to 2 ft above top of tanks.
Indoors, non-corrosive areas					X	NEMA 1 VFDs allowed.

4. Designations for electrical WORK not included in the above Paragraphs shall be NEMA 4X.

B. Material Requirements

1. Provide sealing fittings in chlorine areas and at thermal boundaries in accordance with the NEC.

2. Construct NEMA 4X enclosures of Type 304 or 316 stainless steel, except in chlorine and Alum areas where non-metallic enclosures shall be provided.

3. Do not coat NEMA 4X enclosures.

4. Construct NEMA 1, 3R, and 12 enclosures of steel, and prime and coat with ANSI 61 light grey paint.

1.8 TESTS

A. The CONTRACTOR shall be responsible for factory and field tests indicated in Division 16, as required by the ENGINEER, and as required by other authorities having jurisdiction.

B. Furnish necessary testing equipment.

C. Pay the costs of the tests, including replacement parts and labor, due to damage resulting from damaged equipment or from testing and correction of a faulty installation.

D. Reporting

1. Where test reporting is indicated, submit proof-of-design test reports for mass-produced equipment with the Shop Drawings.

2. Submit factory performance test reports for custom-manufactured equipment for approval prior to shipment.

3. Submit field test reports for review prior to Substantial Completion.

E. Remove and replace equipment or material that fails a test, or, if the ENGINEER approves, repair and retested for compliance.

F. Corrections to equipment or materials with a factory warranty shall be as recommended by the manufacturer and shall be performed in a manner that does not void the warranty.

1.9 DEMOLITION AND RELATED WORK

A. General

1. Perform electrical demolition WORK as indicated.

2. The CONTRACTOR is cautioned that demolition WORK may also be indicated on non-electrical Drawings.

3. Coordinate with all trades regarding electrical de-energization, disconnection, and removal, and the overall sequence of construction.

B. Electrical Requirements for Removed Equipment

1. Remove dedicated wiring and exposed conduits back to the source.

2. Abandon in place wiring that shares conduits with other equipment wiring, except power wiring.

3. Remove power wiring from the power source to the first pullbox or manhole remote from the panel, and abandon in place the remaining wiring.

4. Encased Conduits

   a. Abandon in place wiring routed through encased conduits.
   b. Cut encased conduits flush to the floor and grout flush with the floor.

5. Remove remote-mounted starters, disconnect switches, circuit breakers, sensors, and transmitters.

C. Where new lighting and receptacles are installed, remove old lighting, receptacles, switches, wiring, and conduits.

D. Junction Boxes

1. Wiring and conduits indicated to be extended shall be terminated in a new junction box with terminal strips.

2. Provide a junction box with a NEMA rating in accordance with the area in which it is located, and sized as required.

3. Properly identify wires and terminals before disconnection.

E. Removed materials and equipment not indicated to be returned to the OWNER shall, upon removal, become the CONTRACTOR'S property and shall be disposed of off- Site.

F. Remove and relocate material and equipment indicated to be relocated or reused, and reinstall with care in order to prevent damage.

G. Place materials indicated to be returned to the OWNER in boxes, with the contents clearly marked, and store at a location determined by the ENGINEER.

H. Identification

1. Where motor control centers, panelboards, etc. are indicated to have components, assemblies, or circuits removed and reconnected, provide the affected MCC compartments, etc. with new engraved nameplates worded as indicated and matching the existing, or modify the panelboard schedule to indicate the revised circuits.

2. Pencil or magic marker markings directly on the enclosures or panelboards breaker will not be accepted.

1.10 CONSTRUCTION SEQUENCING

A. General

1. Because the continuance of plant operation during the project is critical, the CONTRACTOR shall carefully examine the WORK to be provided in, on, or adjacent to existing equipment.

2. Schedule the WORK, subject to OWNER's approval, to minimize required shutdown time.

3. Submit a written sequencing request, including the sequence and duration of activities to be performed during plant shutdown.

4. Switching, safety tagging, and the like, as required for plant shutdown or to isolate existing equipment, shall be performed by the CONTRACTOR.

5. In no case shall the CONTRACTOR begin any WORK in, on, or adjacent to existing equipment without written authorization from the ENGINEER.

B. Modifications

1. Perform modifications or alterations to existing electrical facilities as required to successfully install and integrate the proposed electrical equipment as indicated.

2. Perform modifications to existing equipment, panels, and cabinets in a professional manner.

3. Repair coatings to match existing.

4. The costs for modifications to existing electrical facilities that are required for a complete and operating system shall be included as part of the WORK.

C. Existing Utilities

1. Exercise extreme caution when digging trenches to not damage existing underground utilities.
2. The cost of repairs of damages caused during construction shall be included as a part of the WORK.

D. Field Verifications

1. Visit the Site before submitting a Bid to become better acquainted with the WORK of this Contract.

2. The lack of knowledge will not be accepted as justification for extra compensation to perform the WORK.

3. The CONTRACTOR shall be responsible for identifying available existing circuit breakers in lighting panels for the intended use as required.

4. The CONTRACTOR shall be responsible for field verifying the available space in substation switchboards to integrate new power circuit breakers.

5. The cost for the above verifications shall be included as part of the WORK.

E. Installation of Temporary Equipment

1. To facilitate the continuous operation of existing equipment, provide the temporary equipment as indicated.

2. Submit installation and connection details for review and acceptance by the ENGINEER.

3. Costs associated with these temporary installations shall be included as part of the WORK.

4. Temporary wiring and equipment shall remain the property of the CONTRACTOR unless indicated otherwise.

PART 2 PRODUCTS

2.1 GENERAL

A. Provide equipment and materials that are new and are the products of experienced and reputable manufacturers in the industry.

B. Provide equipment and materials listed by UL and bearing the UL label, where UL requirements apply.

C. Provide similar items in the WORK as products of the same manufacturer.

D. Provide equipment and materials of industrial grade standard of construction.

E. Where a NEMA enclosure type is indicated in a non-hazardous location, use that type of enclosure despite the fact that certain modifications such as cutouts for control devices may negate the NEMA rating.

F. On devices indicated to display dates, display the year as 4 digits.

G. Temperature Ratings of Equipment Terminations

1. Provide terminations and lugs rated for use with 75-degree C conductors.

2. Wire sizes in the Contract Documents are based on NEC ampacity tables using the 75-degree C ratings.

2.2 MOUNTING HARDWARE

A. Miscellaneous Hardware

1. Provide nuts, bolts, and washers constructed of stainless steel.

2. Provide threaded rods for trapeze supports constructed from continuous threaded galvanized steel, 3/8-inch diameter minimum.

3. Struts

a. Construct struts for mounting of conduits and equipment of galvanized steel.

b. Where contact with concrete or dissimilar metals may cause galvanic corrosion, use suitable non-metallic insulators in order to prevent such corrosion.

c. Strut Manufacturer, or Equal: **Unistrut**; **B-Line**

4. End Caps

a. Provide plastic protective end caps for all exposed strut ends.
b. End Caps Manufacturer, or Equal: **Unistrut, Model P2860**

5. Anchors

a. Provide stainless steel expansion anchors for attaching equipment to concrete walls, floors, and ceilings.

b. Wood plugs will not be accepted.

c. Anchor Manufacturer, or Equal: **"Power-Bolt"** or **"Power-Stud"** as manufactured by **Power Fasteners, Inc.**; similar by **Star**.

2.3 ELECTRICAL IDENTIFICATION

A. Nameplates

1. Fabricate nameplates from white-letter, black-face laminated plastic engraving stock, such as **Formica Type ES-1** or equal.

2. Securely fasten each nameplate, using fasteners constructed of brass, cadmium-plated steel, or stainless steel, and screwed into inserts or tapped holes as required.

3. Provide engraved characters of the block style, with no characters smaller than 1/8 inch top to bottom.

B. Conductor and Equipment Identification

1. Provide imprinted plastic-coated cloth marking devices, such as manufactured by **Brady, Thomas & Betts**, or equal.

2. Alternatively, provide heat-shrunk plastic tubing, imprinted split-sleeve markers cemented in place.

2.4 PROTECTIVE MATTING

A. Provide full-width, high-voltage switchboard matting in front of indoor service equipment, panelboards, and motor starters.

B. For 600-volt equipment, provide matting that is 1/4 inch thick and 42 inches wide.

C. Matting Manufacturer

1. W.H.Salisbury and Company; Mats, Inc.; Rhino, or equal.

PART 3 EXECUTION

3.1 GENERAL

A. Incidentals

1. Provide materials and incidentals required for a complete and operable system, even if not required explicitly by the Contract Documents.

2. Typical incidentals are terminal lugs not furnished with vendor-supplied equipment, compression connectors for cables, splices, junction and terminal boxes, and control wiring required by vendor-furnished equipment to connect with other equipment indicated in the Contract Documents.

B. Field Control of Location and Arrangement

1. The Drawings diagrammatically indicate the desired location and arrangement of outlets, conduit runs, equipment, and other items.

2. Exact locations shall be determined by the CONTRACTOR in the field, based on the physical size and arrangement of equipment, finished elevations, and other obstructions.

3. Follow the locations on the Drawings, however, as closely as possible.

4. Conduits

a. Where conduit development drawings or "home runs" are indicated, route the conduits in accordance with those requirements.

b. Provide exposed or encased routings as indicated, except conceal conduit in finished areas unless indicated otherwise.

c. Size conduits encased in a slab for conduit OD not to exceed 1/3 of the slab thickness, and lay out and space as to not impede concrete flow.

5. Placement

a. Install conduit and equipment in such a manner as to avoid obstructions, to preserve headroom, and to keep openings and passageways clear.

b. Locate luminaires, switches, convenience outlets, and similar items within finished rooms as indicated.

c. Where exact locations are not indicated, such locations will be determined by the ENGINEER.

d. If equipment is installed without instruction and must be moved, the cost of moving shall be included as part of the WORK.

e. Slightly adjust luminaire locations in order to avoid obstructions and to minimize shadows.

6. Circuits

    a. Wherever conduits and wiring for lighting and receptacles are not indicated, it shall be the CONTRACTOR'S responsibility to provide lighting and receptacle-related conduits and wiring as required, based on the actual installed fixture layout and the circuit designations as indicated.

    b. Provide No. 12 AWG minimum wiring, and 3/4-inch minimum conduits (exposed) and one-inch minimum conduits (encased).

    c. Where circuits are combined in the same raceway, derate conductor ampacities in accordance with NEC requirements.

C. Workmanship

1. Install materials and equipment in strict accordance with the printed recommendations of the manufacturer, and using workers skilled in the WORK.

2. Coordinate installation in the field with other trades in order to avoid interferences.

D. Protection of Equipment and Materials

1. Fully protect materials and equipment against damage from any cause.

2. Cover materials and equipment, both in storage and during construction, in such a manner that no finished surfaces will be damaged, marred, or splattered with water, foam, plaster, or paint.

3. Keep moving parts clean and dry.

4. Replace or refinish damaged materials or equipment, including faceplates of panels and switchboard sections, as part of the WORK.

E. Provide power wiring in conduit for the Heating, Ventilating and Air Conditioning (HVAC) equipment as required by the equipment.

F. Provide starters shall be in accordance with the requirements of Section 26 05 15, Industrial Control Panels.

G. Provide control wiring operating at 120 volts and less as required by HVAC equipment.

3.2 CORE DRILLING

A. Perform core drilling as required for the installation of raceways through concrete walls and floors.

B. Base the locations of floor penetrations, as may be required, on field conditions.

C. Verify exact core drilling locations based on equipment actually furnished as well as exact field placement.

D. To the extent possible, identify the existence and locations of encased raceways and other piping in existing walls and floors with the OWNER prior to any core drilling activities.

E. Repair damage to encased conduits, wiring, and piping as part of the WORK.

3.3 CONCRETE HOUSEKEEPING PADS

A. Provide concrete housekeeping pads for indoor floor-standing electrical equipment.

B. Extend housekeeping pads for equipment, including future units, 3-1/2 inches above the surrounding finished floor or grade, and one inch larger in both dimensions than the equipment, unless otherwise indicated.

C. Provide concrete housekeeping curbs for conduit stub-ups in indoor locations that are not concealed by equipment enclosures.

D. Extend housekeeping curbs to 3 inches above the finished floor or grade.

3.4 EQUIPMENT ANCHORING

A. Floor-supported, wall, or ceiling-hung equipment and conductors shall be anchored in place by methods that will meet seismic requirements in the area where the Project is located, see Sheet GS-1.

B. Provide wall-mounted panels that weigh more than 100 pounds or that are within 18 inches of the floor with fabricated support pedestals.

C. Provide transformers hung from walls and weighing more than 100 pounds with auxiliary floor supports.

D. Manufacturer's Recommendations

1. Anchoring methods and leveling criteria in the printed recommendations of the equipment manufacturers are a part of the WORK of this Contract.

2. Submit such recommendations as Shop Drawings as indicated.

3.5 EQUIPMENT IDENTIFICATION

A. Provide nameplates for panelboards, control and instrumentation panels, starters, switches, and pushbutton stations.

B. In addition to nameplates, equip control devices with standard collar-type legend plates.

C. Identify control devices within enclosures as indicated and similar to the subparagraph above.

D. Provide suitable inscribed finish plates for toggle switches that control loads out of sight of switches and for multi-switch locations of more than 2 switches.

E. Use equipment names and tag numbers, where indicated, on nameplates.

F. Provide typewritten circuit directories for panelboards, that accurately reflect the outlets connected to each circuit.

G. Terminal Blocks

1. Label termination points on terminal blocks by identifiers on the blocks.
2. Provide identifiers that have been preprinted by the terminal manufacturer or custom-printed.
3. Hand-lettered markers will not be accepted.

H. Tag distribution equipment, stand-alone disconnects, starters, and VFDs with appropriate arc-flash labels.

3.6 CLEANING

A. Before final acceptance, thoroughly clean the electrical WORK of cement, plaster, and other materials.

B. Remove temporary tags, markers, stickers, and the like.

C. Remove oil and grease spots with a non-flammable cleaning solvent, by carefully wiping and scraping cracks and corners.

D. Apply touch-up paint to scratches on panels and cabinets.

E. Vacuum-clean electrical cabinets and enclosures.

F. Clean luminaires inside and out.

G. Dispose cleaning debris and refuse off-Site.

END OF SECTION

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SECTION 26 01 26 – ELECTRICAL TESTS

PART 1 GENERAL

1.1 THE SUMMARY

A. This Section specifies the WORK necessary to test, commission, and demonstrate that the electrical work satisfies the criteria of these Specifications and functions as required by the Contract Documents.

B. The WORK of this Section includes furnishing the labor, equipment, and power required to support the testing indicated in other Divisions of these Specifications. Electrical testing indicated herein and functional testing of power and controls not tested under Division 40, Instrumentation, shall be completed before commencement of the 7 Day test of Section 017500, Equipment Testing and Plant Startup. This scope may require the CONTRACTOR to activate circuits, shutdown circuits, run equipment, make electrical measurements, replace blown fuses, and install temporary jumpers, etc.

C. The requirements of Section 26 00 00, Electrical Work, General, apply to the WORK of this Section.

D. Carry out tests indicated herein for individual items of materials and equipment in other Sections. Testing shall be done in accordance with the manufacturer's instructions, these Specifications, and applicable NETA Acceptance Testing Specifications, NEMA, ANSI, NFPA, and ASTM Standards.

1.2 REFERENCES

A. General

1. The publications listed below form a part of this specification to the extent referenced.

2. Where a date is given for reference standards, the edition of that date shall be used. Where no date is given for reference standards, the latest edition available on the date of the Notice Inviting Bids shall be used.

B. American National Standards Institute (ANSI)

C. Institute of Electrical and Electronics Engineers, Inc. (IEEE)

D. IEEE 400-2024, Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems

E. IEEE 576-2000, Recommended Practice for Installation, Termination, and Testing of Insulated Power Cable as Used in Industrial and Commercial Applications

F. InterNational Electrical Testing Association (NETA)

G. NFPA 70, National Electrical Code (NEC)

1.3 SUBMITTALS

A. Submit in accordance with Section 01 33 00, Submittals.

B. Submit complete system test procedures for review. Test procedures shall include but not be limited to:

1. Detailed procedures in sufficient detail to verify conformance with these Specifications.

2. Incorporation of the Test Record Sheets included at the end of this Section.

3. Detailed comprehensive testing schedule including:

a. Each major piece of electrical distribution equipment.
b. Each major electrical subsystem.
c. Duration of each test.
d. Milestone test completion date.
e. Ambient Conditions at time of test
f. Date of test results submittals following completion of the tests.
g. Names and qualifications of the individual(s) responsible for performing the testing.

C. Following completion of the test submit the completed test results to the Engineer for review. The results shall include a dedicated section with the "as-left" settings of all devices, relays, circuit breakers, etc.

D. Test result shall be submitted in one submittal

E. Test reports shall be based on NETA's latest Acceptance Testing Specifications having a sign-off, pass/fail data filed for each line item covered by NETA's Acceptance Testing Specifications latest edition.

1.4 COMMISSIONING

A. Commissioning during the 7 Day test in Section 01 75 00 shall not be attempted until all subsystems have been found to operate satisfactorily. Commissioning shall only be attempted as a function of normal plant operation in which plant process flows and levels are routine and equipment operates automatically in response to flow and level parameters or computer command, as applicable. Simulation of process parameters shall be considered only upon receipt of a written request by the CONTRACTOR.

1. Power monitored amperes, voltage, and kilowatts for each phase shall be recorded every 5 minutes during commissioning.

PART 2 TESTING & REPORTS

2.1 PRE-ENERGIZATION AND OPERATING TESTS

A. The complete electrical system shall be performance tested when first installed on-site. Each protective, switching, and control circuit shall be adjusted in accordance with the recommendations of the protective device study and tested by actual operation using current injection or equivalent methods as necessary to ensure that each and every such circuit operates correctly to the satisfaction of the authority having jurisdiction.

1. Instrument Transformers. All instrument transformers shall be tested to verify correct polarity and burden.

2. Protective Relays. Each protective relay shall be demonstrated to operate by injecting current or voltage, or both, at the associated instrument transformer output terminal and observing that the associated switching and signaling functions occur correctly and in proper time and sequence to accomplish the protective function intended.

3. Switching Circuits. Each switching circuit shall be observed to operate the associated equipment being switched.

4. Control and Signal Circuits. Each control or signal circuit shall be observed to perform its proper control function or produce a correct signal output.

5. Metering Circuits. All metering circuits shall be verified to operate correctly from voltage and current sources, similarly to protective relay circuits.

6. Acceptance Tests. Complete acceptance tests shall be performed, after the station installation is completed, on all assemblies, equipment, conductors, and control and protective systems, as applicable, to verify the integrity of all the systems.

7. Relays and Metering Utilizing Phase Differences. All relays and metering that use phase differences for operation shall be verified by measuring phase angles at the relay under actual load conditions after operation commences.

B. Test Report. A test report covering the results of the tests required in the Pre-Energization and Operating Tests shall be delivered to the authority having jurisdiction prior to energization. Acceptance Testing shall be in accordance with NETA ATS-2025, *For Electrical Power Equipment and Systems*, published by the InterNational Electrical Testing Association.

2.2 TEST REQUIREMENTS

A. The following test requirements supplement test and acceptance criteria that may be stated elsewhere.

1. Lighting: Switching, include remote control, if present in system. Circuitry is in accordance with panel schedules. All interior and exterior lighting shall be checked for proper operation.

2. Power Instrumentation: Demonstrate that voltmeter and ammeter switches are functional. Demonstrate that kilowatt meters are within catalog accuracy as installed.

a. Visual and Mechanical Inspection

1) Compare equipment nameplate data with drawings and specifications.

2) Inspect physical and mechanical condition.

3) Verify tightness of electrical connections.

4) Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case-shorting contacts, as applicable.

5) Verify freedom of movement, end play, and alignment of rotating disk(s).

b. Electrical Tests

1) Verify accuracy of meters at all cardinal points.

2) Calibrate watthour meters according to manufacturer's published data.
3) Verify all instrument multipliers.
4) Verify that current transformer and voltage transformer secondary circuits are intact.

3. Demonstrate mechanical and/or electrical interlocking by attempting to subvert the intended sequence.

4. Activate ground fault tripping by operating test features provided with ground current protective systems and by injecting a known and reasonable current in the ground current sensor circuit. In general, ground fault tripping should occur at a ground current equivalent to 20 percent of phase current. Current injection is not required of circuit 400 amperes or less.

5. Low Voltage Cables-600 volts Maximum

   a. Visual and Mechanical Inspection

      1) Compare cable data with drawings and specifications.

      2) Inspect exposed sections of cables for physical damage and correct connection in accordance with single-line diagram.

      3) Inspect bolted electrical connections for high resistance using one of the following methods:

         a) Use of low-resistance ohmmeter

         b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS-2025, Table 100.12.

      4) Inspect compression-applied connectors for correct cable match and indentation.

      5) Inspect for correct identification and arrangements.

      6) Inspect cable jacket insulation and condition.

   b. Electrical Tests

      1) Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Test duration shall be one minute.

         a) Motor feeders tested with motors disconnected and controller open.

         b) Motor control circuits tested and verified for proper operation with control stations and overcurrent devices connected.

         c) Panelboard feeders tested with feeder breaker open and panel-board connected. If a lighting transformer is associated with the panelboard, it shall be connected and the test made for both primary and secondary sides.

         d) Conductors of main lighting feeders, including lighting panel with branch circuits open.

e) Prior to performing insulation resistance tests on cables, verify that they are not connected to a solid state device.

f) Equipment which may be damaged during this test shall be disconnected.

g) The Engineer shall be consulted if minimum insulation values cannot be obtained.

2) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

3) Perform continuity test to insure correct cable connection.

c. Test Values – Visual and Mechanical

1) Compare bolted connection resistance to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Bolt-torque levels should be in accordance with NETA ATS-202517, Table 100.12 unless otherwise specified by the manufacturer.

d. Test Values – Electrical

1) Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Insulation-resistance values shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS-2025 Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations shall be investigated.

3) Cable shall exhibit continuity.

4) Deviations in resistance between parallel conductors shall be investigated.

6. Test ground interrupter (GFI) receptacles and circuit breakers for proper operation by methods sanctioned by the receptacle manufacturer.

7. A functional test and check of electrical components is required prior to performing subsystem testing and commissioning. Compartments and equipment shall be cleaned as required by other provisions of these Specifications before commencement of functional testing. Functional testing shall comprise:

a. Visual and physical check of cables, circuit breakers, transformers, and connections associated with each item of new and modified equipment.

b. Verification that electrical equipment has been labeled with Arc Flash protection boundary and PPE levels, as required by Section 26 05 73, Protective Device Studies.

c. Setting of protective devices in conformance with results of the Short Circuit Study required by Section 26 05 73, Protective Device Studies and testing of devices to assure that devices will trip at the current value and time required by the Study.

d. Circuit Breakers

1) Circuit breakers that have adjustable time or pick-up settings for ground current, instantaneous overcurrent, short-time overcurrent, or long-time overcurrent, shall be field-adjusted by a representative of the circuit breaker manufacturer.

2) Time and pickup setting shall correspond to the recommendations of the Short Circuit Study.

3) Setting shall be tabulated and proven for each circuit breaker in its installed position.

4) Test results shall be certified by the person performing the tests and shall be submitted to the ENGINEER.

8. Complete ground testing of grounding electrodes per requirements below prior to operating the equipment.

B. Subsystem testing shall occur after the proper operation of alarm and status contacts has been demonstrated or otherwise accepted by the ENGINEER and after process control devices have been adjusted as accurately as possible. Alarm conditions shall be simulated for each alarm point, and alarm indicators shall be checked for proper operation. It is intended that the CONTRACTOR will adjust limit switches and level switches to their operating points prior to testing and will set pressure switches, flow switches, and timing relays as dictated by operating results.

C. Metering and indication lights for motors and other devices shall be tested for proper operation.

D. All control circuits such as motor, interlock and remote shall be tested for proper operation.

E. After initial settings have been completed, each subsystem shall be operated in the manual mode and it shall be demonstrated that operation is in compliance with the Contract Documents. Once the manual mode of operation has been proven, automatic operation shall be demonstrated to verify such items as proper start and stop sequence of pumps, proper operation of valves, proper speed control, etc.

F. Motor operated valves shall be tested after having been phased and tested for correct motor rotation and after travel and torque limit switches have been adjusted by a representative of the valve manufacturer. Tests shall verify status indication, proper valve travel, and correct command control from local and remote devices.

G. All lighting panels, circuits and fixtures; and power panels, circuits and receptacles shall be tested for proper operation.

H. Provide ground resistance tests on the main grounding electrode or system in the presence of the ENGINEER and submit results

1. Visual and Mechanical Inspection

a. Verify ground system is in compliance with drawings and specifications.

2. Electrical Tests

a. Perform fall-of-potential test or alternative in accordance with IEEE Standard 81 on the main grounding electrode or system.

b. The earth resistance of each ground electrode shall be measured and recorded before electrodes are connected to the grounding loop.

c. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points.

3. Test Values

a. The resistance between the main grounding electrode and ground shall be no greater than five ohms for commercial or industrial systems and one ohm or less for generating or transmission station grounds unless otherwise specified by the owner.

b. Investigate point-to-point resistance values which exceed 0.5 ohm.

I. Subsystems shall be defined as individual and groups of pumps, conveyor systems, chemical feeders, air conditioning units, ventilation fans, air compressors, etc.

2.3 TEST REPORTS

A. The test report shall include the following:

1. Summary of project.
2. Description of equipment tested.
3. Description of test.
4. Test data.
5. Analysis and recommendations.

B. Test data records shall include the following minimum requirements:

1. Identification of the testing organization.

2. Equipment identification.

3. Humidity, temperature, and other atmospheric conditions that may affect the results of the tests/calibrations.

4. Date of inspections, tests, maintenance, and/or calibrations.

5. Identification of the testing technician.

6. Indication of inspections, tests, maintenance, and/or calibrations to be performed and recorded.

7. Indication of expected results when calibrations are to be performed.

8. Indication of “as-found” and “as-left” results.

9. Sufficient spaces to allow all results and comments to be indicated.

C. The testing firm shall furnish a copy or copies of the complete report to the owner as required in the acceptance contract.

PART 3 TEST RECORD SHEETS

The test record sheets listed below shall be used to record testing of electrical equipment and of the electrical installation as required by these specifications. Sample copies of each sheet are attached.

Sheet No.	Title
1	Insulation Resistance (Power, Control Wire, and Cable) Test Record
2	Insulation Resistance (Instrument Wire and Cable) Test Record
4	Ground Electrode Testing Test Record
6	Bonding Resistance Readings (Nonelectrical Equipment/Structures) Test Record
7	Bonding Resistance Readings (Electrical Equipment) Test Record
8	Insulation Resistance (Transformer) Test Record
9	Insulation Resistance (Equipment) Test Record
10	Insulation Resistance (Rotating Equipment) Test Record
12	Record Feeder Breaker (480 V) Test Record
14	460 V Motor Circuit (480 V) Test Record
16	Electric Motor Run-In Test Record

INSULATION RESISTANCE

(POWER, CONTROL WIRE, AND CABLE)

TEST RECORD

TEST EQUIPMENT: _____ TEST VOLTAGE: _____

TEST EQUIPMENT: _____ TEST VOLTAGE: _____

AMBIENT TEMPERATURE: _____ºC _ ºF DATE: _____

NOTES:

1. Perform Insulation Resistance Test (megger) between each conductor and all other conductors and metallic sheath for cables with nonshielded conductors. Test between each conductor and shield for multiconductor cables with shielded conductors. Record lowest reading for each cable.
2. Use 1,000-V test set for cable rated 600 volts and 2,500-V test set for cable rated over 600 volts.
3. Readings will vary inversely with temperature and cable length. When the use of temperature correction factors is specified, attach a second sheet with computed values. Indicate on each sheet “measured” or “temperature corrected.”

Panel No.		Cable	Wire or Cable	Insulation				
Circuit No. Feeder No.	Wire Tagging	Rated Voltage	Quantity	Size	From	To	Resistance (megohms)*	Initials

*Minimum acceptable values:

Cable Rated Voltage	Test Duration	Resistance for Cable Only	Cable/Wire Size or Amperage (megohms)	Resistance When Cable Connected to Equipment (ohms)

DISTRIBUTION:

CONTRACTOR/Date _____

INSULATION RESISTANCE

(INSTRUMENT WIRE AND CABLE)

TEST RECORD

TEST EQUIPMENT: _____ TEST VOLTAGE: _____

TEST EQUIPMENT: _____ TEST VOLTAGE: _____

AMBIENT TEMPERATURE: _____ºC _ ºF DATE: _____

NOTES:

1. Record only the lowest value.
2. MP - Multi-pair cable. SP - Single pair cable.
3. Megger with instruments disconnected.
4. Use 250 volt (or lower voltage, when specified) range on DC test set.
5. Readings will vary with temperature and cable length.*

Cable Number or Instrument Number	Indicate MP or SP Type (2)	Conductor to Conduit (Single Pair Non-Shielded Cables) (megohms)	Conductor to Conductor (megohms) (1)	Shield to Conductor to Shield (megohms) (1)	Overall Shield to Shield (Multipair Cables Only) (megohms) (1)	Lead and Armor (Multipair Cables Only (megohms)	Shield to Conduit (Single Pair Cables Only) (megohms)	Initials

DISTRIBUTION:

CONTRACTOR/Date _____

GROUND ELECTRODE TESTING

TEST RECORD

TEST EQUIPMENT: _____ _____

(Note 1) (Note 2)

REFERENCE DRAWING: _____ _____

NOTES:

1. Record resistance-to-earth for each electrode with all other conductors disconnected. Resistance not to exceed 25 ohms for any single anode.
2. Check continuity from each electrode to any test bar or other electrode such that the complete ground loop is tested.

Rod Number	Resistance to Earth (ohms)	Ambient Temperature (ºC/ºF)	Weather	Taps ( )	Initials/Date

DISTRIBUTION:

CONTRACTOR/Date _____

BONDING RESISTANCE READINGS

(NONELECTRICAL EQUIPMENT/STRUCTURES)

TEST RECORD

TEST EQUIPMENT USED: _____ WEATHER: _____

NOTES:

1. Vessels, tanks, and structural steel bonded to the main grounding system, dedicated ground rod or foundation, as indicated on drawings listed below.
2. Measure resistance from ground wire tap (or anchor bolt) to tagged equipment frame or structural steel.

EQUIPMENT TAG NO. OR STRUCTURE	DRAWING	MEASURED RESISTANCE (ohms)	INITIALS/DATE

DISTRIBUTION:

CONTRACTOR/Date _____

BONDING RESISTANCE READINGS

(ELECTRICAL EQUIPMENT)

TEST RECORD

TEST EQUIPMENT USED: _____ WEATHER: _____

NOTES:

1. Electrical equipment bonded to the main grounding system or dedicated ground rod, as indicated on drawings listed below.
2. Measure resistance from ground wire tap to tagged equipment bus bars, tagged equipment enclosures, and any other points indicated on the drawings.

EQUIPMENT TAG NO. OR STRUCTURE	DRAWING	MEASURED RESISTANCE (ohms)	INITIALS/DATE

DISTRIBUTION:

CONTRACTOR/Date _____

INSULATION RESISTANCE

(EQUIPMENT)

TEST RECORD

TEST EQUIPMENT: _____ SUBSTATION: _____

AMBIENT TEMPERATURE: _____ºC _ ºF DATE: _____

REFERENCE DRAWING: _____ REF. SEC.: _____

NOTES:

1. Use 1,000-V test set for equipment rated 600 volts and below, 2,500/5,000-V test set for equipment rated over 600 volts.
2. For equipment with solid state control circuits, consult manufacturer's literature for maximum test voltages.

Switchgear MCC (other)	INSULATION RESISTANCE (megohms) *						Test Voltage (kV)	Rated Voltage (kV)	Initials/ Date
	∅A to G	∅B to G	∅C to G	∅A to ∅B	∅B to ∅C	∅C to ∅A			

*Minimum acceptable values:

EQUIPMENT VOLTAGE CLASS RESISTANCE (megohms)

TESTER'S INITIALS/DATE

_____

DISTRIBUTION:

CONTRACTOR/Date _____

INSULATION RESISTANCE

(ROTATING EQUIPMENT)

TEST RECORD

TEST EQUIPMENT: _____ TEST VOLTAGE: _

AMBIENT TEMPERATURE: _____ ºC ____ ºF DATE: _____

EQUIP. TEMP., IF KNOWN: _____ ºC ____ ºF HOW KNOWN: __

NOTES: 1. Use 1,000-V test set for equipment 600-volt and below, 2,500/5,000-V test set for equipment rated over 600 volts.

Test duration shall be 1 minute, note if otherwise: _____.

Isolate all motor leads from one another and from frame, test phase separately, wherever practical.

Document testing of low voltage and medium voltage equipment on separate sheets.

Readings will vary inversely with temperature. When the use of temperature correction factors is specified, attach second sheet with computed values. Indicate on each sheet "measured" or "temperature corrected."

Equipment Tag No.	INSULATION RESISTANCE (megohms) *						Rated Voltage	Equipment Initial/Date
	∅A to G	∅B to G	∅C to G	∅A to ∅B	∅B to ∅C	∅C to ∅A		

*Minimum acceptable values:

VOLTAGE CLASS RESISTANCE (megohms)

DISTRIBUTION:

CONTRACTOR/Date _____

FEEDER BREAKER

(480 V)

TEST RECORD

	EQUIPMENT DESIGNATION
LOAD (kW/kVA)	VOLTAGE F.L.A.
CIRCUIT BREAKER MFG.	RATING SETTING
CONDUCTOR SIZE POWER	GROUND

1. Check nameplate data of breaker against approved vendor drawings. _____
2. Check breaker components for cleanliness. _____
3. Check mechanical function of breaker. _____
4. Check wiring for proper identification. _____
5. Check conduits/cables for tagging. _____
6. Check components for identification. _____
7. Check equipment for conformance of area classification. _____
8. Check installation for seals, breathers, and drains. _____
9. Verify power conductor continuity. _____
10. Check that power cable insulation resistance test (megger) is completed. _____

DISTRIBUTION:

CONTRACTOR/Date _____

460 V MOTOR CIRCUIT

(480 V)

TEST RECORD

EQUIPMENT DESIGNATION	
MOTOR TAG NO.	VOLTAGE F.L.A.
KW/HP	RPM S.F.
CIRCUIT BREAKER MFG.	RATING SETTING
STARTER MFG.	SIZE O/L HTR. SIZE
C.T. RATIO	O/L RELAY SETTING
CONDUCTOR SIZE POWER	GROUND

1. Check motor starter for cleanliness. _____

2. Check nameplate data and tagging of motor starter components for conformance to approved vendor drawings. _____

3. Check conduits and/or cables for correct tagging. _____

4. Check equipment and installation for conformance to area classification. _____

5. Check main and auxiliary contacts of breaker and contactors. _____

6. Manually check mechanical operation of breaker, contactor, O/L relay, and O/L reset device. _____

7. Check continuity of power and control cables. _____

8. Complete functional operation check of the motor control circuit using the contract drawings and approved vendor drawings. Close and open the starter using all control devices. _____

9. Verify proper operation of motor winding space heater unit. _____

DISTRIBUTION:

CONTRACTOR/Date _____

ELECTRIC MOTOR RUN-IN

TEST RECORD

TEST EQUIPMENT: _____ REFERENCE DRAWING: ___

NOTES: 1. Duration of tests to comply with specifications.

TEST	REMARKS	INITIALS/DATE
RESISTANCE: Bonding resistance measured from motor frame to main ground/earth system tap. _____ ohms		
VOLTAGE: Actual voltage measured at Motor Control Center. _____ volts		
ROTATION CHECK: Bump motor to verify rotation. Motor to be uncoupled.		
NO LOAD CURRENT: At beginning of test _____ amps At end of test _____ amps		
TEMPERATURE OF BEARING: Check bearing for high temperature: Before start: 15 minutes after start 30 minutes after start 1 hour after start 2 hours after start 3 hours after start		
VIBRATION:		

Make visual inspection during run-test. Record any unusual vibration in remarks column.		
NOISE: Record any unusual noise in remarks column.		

DISTRIBUTION:

CONTRACTOR/Date _____

END OF SECTION

SECTION 26 05 15 – INDUSTRIAL CONTROL PANELS

PART 1 GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide complete industrial control panels and/or local control stations as indicated herein or in other Sections of the Specifications. The stations shall be designed to provide the sequence of operation in the Contract Documents.

B. This section also specifies miscellaneous electrical devices used throughout this project. These devices are not limited to use within industrial control panels or local control stations.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Industrial control panels and/or local control stations shall comply with THE SUMMARYs of NEC (including Article 409), NEMA, and UL.

1.3 CONTRACTOR SUBMITTALS

A. Furnish Shop Drawings in accordance with Sections 01 33 00, Contractor Submittals and 26 00 00, Electrical Work, General.

1. Ladder diagrams and written descriptions explaining ladder diagram operation and system operation.

2. Include catalog cuts of control equipment including enclosures, overcurrent devices, relays, pilot devices, terminations, and wire troughs.

PART 2 PRODUCTS

2.1 GENERAL

A. The CONTRACTOR shall provide the equipment, panels and stations to satisfy the functional requirements in the relevant mechanical equipment and Instrumentation and Control specifications and the Electrical Elementary Schematics. Each panel and station shall be fabricated with UL/NRTL labeled components. Equipment not specifically indicated as being WORK of other Sections shall be provided under this Section. All equipment, panels and stations shall be wired under this Section.

B. The controls shall be 120 V maximum. Where the electrical power supply is 240 V, single phase, the station shall be provided with a fused control power transformer. Control conductors shall be provided in accordance with Section 26 05 19, Wire and Cabling.

C. Each panel and/or station shall be provided with identified terminal strips for the connection of external conductors. The CONTRACTOR shall provide sufficient terminal blocks to connect 25 percent additional conductors for future use. Termination points shall be identified in accordance with Shop Drawings. The panels and/or stations shall be the source of power for all 120 VAC solenoid valves interconnected with the panels and/or stations. Equipment

associated with the panels and/or stations shall be ready for service after connection of conductors to equipment, controls, panels and/or stations.

D. Wiring to door-mounted devices shall be extra flexible and anchored to doors using wire anchors cemented in place. Exposed terminals of door-mounted devices shall be guarded to prevent accidental personnel contact with energized terminals.

E. Enclosures shall be NEMA rated in accordance with Section 26 00 00.1.7.

1. Enclosures shall be freestanding, pedestal-mounted, or equipment skid-mounted, as indicated. Internal control components shall be mounted on a removable mounting pan. Mounting pan shall be finished white.

2. Outdoor mounted enclosures shall be provided with thermostatically-controlled heaters. Heaters shall be operated at ½ rated voltage (240 volt heaters shall be sized and operated at 120 volts).

3. Provide screened weep holes for draining condensation.

F. Disconnect Switches

1. Heavy duty, non-fusible, single throw switches shall be rated at least 111% of the available fault current at the voltage and phases shown.

2. Horsepower rated for motor loads.

3. UL/NRTL listed.

4. Padlockable in "Off" position and door interlock.

5. Enclosure per area classification in Section 26 00 00 – Electrical Work, General.

6. Auxiliary control contact as applicable and where indicated.

7. As manufactured by **G.E., Eaton Electrical, Square D,** or equal.

G. Identification of panel-mounted devices, conductors, and electrical components shall be in accordance with Section 26 00 00, Electrical Work, General.

H. Panel-mounted devices shall be mounted a minimum of 3-feet above finished floor elevation, but not higher than 6’-6” above finished floor, unless noted otherwise.

2.2 PANEL/STATION COMPONENTS

A. Pushbuttons, selector switches, and pilot lights shall be the heavy-duty, oil-tight type, sized to 30-mm. Miniature style devices are not acceptable. Devices shall be as manufactured by **General Electric, Eaton Electrical, Square D,** or equal.

1. Lens colors shall be green for "run," "open," or "on"; red for "stopped," "closed," or "off"; and amber for alarm.

2. Pilot lights shall be full voltage, push-to-test, LED cluster type.

B. Relays shall be 3 PDT with 10 amp contacts, plug-in type with indicating light, rectangular blades and provided with sockets for screw-type termination and hold-down clips. Relays shall be as manufactured by **Square D, Potter Brumfield,** or equal.

C. Elapsed time meters shall be non-resettable type, read to a maximum of 99999.9 hours and shall be as manufactured by **General Electric, Eaton Electrical,** or equal.

D. Magnetic starters shall be:

1. NEMA rated, Size 1 minimum. IEC or dual NEMA/IEC rated type are not acceptable.

2. FVNR type unless indicated otherwise.

3. Combination starters with magnetic only instantaneous trip circuit breakers such as **Eaton Electrical HMCP, General Electric Mag-Break,** or equal. Breakers shall be rated 65 kA minimum.

4. Control transformers shall be provided with primary and secondary fuses, 120 V maximum control voltage. VA rating of transformer shall be based on devices on the control schematic.

E. Terminal strips shall be provided for every panel and shall be the flanged fork or ring lug type suitable for No. 12 AWG stranded wire minimum. Provide 25 percent spare terminals in each panel.

F. Time delay relays shall be combination on delay and off delay (selectable) with adjustable timing ranges. Provide socket with screw terminal connections and retaining strap. Time delay relays shall be **Square D, ATC, Eaton Electrical,** or equal.

2.3 FACTORY TESTING

A. Each panel/station shall be factory assembled and tested for sequence of operation prior to delivery.

2.4 SPARE PARTS

A. Provide a minimum of 10 percent spare lamps (minimum 2) and one spare lens for each color pilot lamp in each panel.

PART 3 EXECUTION

3.1 INSTALLATION

A. Panels/stations shall be installed in accordance with in Section 26 00 00, Electrical Work, General and in accordance with the manufacturer's recommendations.

B. Panels/stations shall be protected at the site from loss, damage, and the effects of weather. Panels/stations shall be stored in an indoor, dry location. Heating shall be provided in areas subject to corrosion and humidity.

C. Panels/station interiors and exteriors shall be cleaned, and coatings shall be touched up to match original finish upon completion of the WORK.

D. Conduit, conductors, and terminations shall be installed in accordance with Section 26 00 00 – Electrical Work, General.

3.2 FIELD TESTING

A. Each panel/station shall be tested again for functional operation in the field after the connection of external conductors and prior to equipment startup.

END OF SECTION

SECTION 26 05 19 - WIRE AND CABLING

PART 1 GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide wire and cable, complete and operable, in accordance with the Contract Documents.

B. In the event that motors provided are larger horsepower than the motors indicated, raceways, conductors, starters, overload elements, and branch circuit protectors shall be revised as necessary to control and protect the increased motor horsepower. Revisions are part of the WORK of this Section.

1.2 ACTION SUBMITTALS

A. The CONTRACTOR shall submit Shop Drawings in accordance with Sections 01 33 00, Contractor Submittals and 26 00 00, Electrical Work, General. Submit cable test results in accordance with this Section as well as Section 26 01 26, Electrical Tests.

1.3 DELIVERY, STORAGE AND HANDLING

A. The CONTRACTOR shall protect all cables from damage at all times.

B. Cable ends shall be protected from water entry in accordance with the manufacturer’s recommended procedures. Cable ends shall not be left open in manholes or other locations subject to submergence. If the cable ends become submerged prior to splicing or termination, the cables shall be replaced in their entirety.

C. Cables shall be pulled into raceways in accordance with the manufacturer’s requirements. Under no circumstances shall cable pulling tensions exceed the manufacturer’s written instructions.

D. Pulling tensions on raceway cables shall be within the limits recommended by the cable manufacturer. Wire pulling lubricant, where needed, shall be UL approved.

PART 2 PRODUCTS

2.1 EQUIPMENT

A. Conductors, include grounding conductors, shall be stranded copper. Aluminum conductor and/or solid conductor wire and cable will not be permitted. Insulation shall bear the UL label, the manufacturer's trademark, and identify the type, voltage, and conductor size. Conductors except flexible cords and cables, fixture wires, and conductors that form an integral part of equipment such as motors and controllers shall conform to the requirements of Article 310 of the National Electric Code, latest edition, for current carrying capacity. Flexible cords and cables shall conform to Article 400, and fixture wires shall conform to Article 402. Wiring shall have wire markers at each end.

B. Low Voltage Power and Lighting Wire

1. Wire rated for 600 volts in duct or conduit for power and lighting circuits shall be single conductor, Class B Type XHHW or XHHW-2 cross-linked polyethylene conforming to UL-44 - UL Standard for Thermoset-Insulated Wires and Cables. THHN/THWN wire shall not be permitted to be used for any power or control wiring in this project, except as specifically permitted within control panels per Section 26 05 15, Industrial Control Panels.

2. Conductors for feeders as defined in Article 100 of the NEC shall be sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combinations of such loads, and where the maximum total voltage drop on both feeders and branch circuits to the farthest connected load does not exceed 5 percent.

3. Conductors for branch circuits as defined in Article 100 of the NEC shall be sized to prevent voltage drop exceeding 3 percent at the farthest connected load or combinations of such loads and where the maximum total voltage drop on both feeders and branch circuits to the farthest connected load does not exceed 5 percent.

4. Wiring for 600 volt class power and lighting shall be as manufactured by **Okonite**, **General Cable**, **Southwire**, or equal.

C. Low Voltage Control Wire

1. Low voltage control wire in duct or conduit shall be the same type as power and lighting wire indicated above.

2. Control wiring shall be No.14 AWG minimum.

3. Control wires inside panels and cabinets shall be machine tool grade type MTW, UL approved, rated for 90 degrees C at dry locations, and be as manufactured by **American, General Cable,** or equal.

D. Instrumentation Cable

1. Instrumentation cable shall be rated at 300 volts, minimum.

2. Individual conductors shall be No. 16 AWG stranded, tinned copper. Insulation shall be color coded polyethylene: black-clear for 2 conductor cable and black-red-clear for 3 conductor cable.

3. Instrumentation cables shall be composed of the individual conductors, an aluminum polyester foil shield, a No. 18 or larger AWG stranded, tinned copper drain wire, and a PVC outer jacket with a thickness of 0.047-inches.

4. Single pair, No. 16 AWG, twisted, shielded cable shall be **Belden Part No. 8719,** similar by **General Cable,** or equal.

5. Single triad, No. 16 AWG, twisted, shielded cable shall be **Belden Part No. 8618,** similar by **General Cable,** or equal.

E. Low Voltage Power and Control, Multi-Conductor/Tray Cable

1. Multi-conductor tray cable shall be rated 600 volts, listed by UL as Type TC cable per Article 336 of the NEC. The individual conductors shall be UL listed as Type XHHW or XHHW-2, with a sunlight-resistant PVC overall jacket.

2. Minimum conductor sizes shall be the same as for power and lighting wire and control wire as specified above.

3. Multiple conductor power cables include the following:

Phase Conductor Size (AWG)	Minimum Ground Wire Size (AWG)	No. of Conductors (not incl. Ground)
12	12	2 3
10	10	2 3
8	10	3
6	8	3
4	6	3
2	6	3
1/0	6	3
2/0	4	3
4/0	4	3

4. Multi-conductor control cables include the following:

Conductor Size (AWG)	No. of Conductors (Including 1#14 AWG Ground)
14	3
14	4
14	5
14	7
14	9
14	12
14	19
14	37

F. VFD Power Cable

1. VFD power cable shall be three (3) conductor, stranded copper, PVC jacketed, shielded type, tray cable (TC) rated 600 volts with three (3) symmetrical ground conductors. The individual conductors shall be UL listed as Type XHHW-2 or RWH-2 rated for 90 degrees C at wet and dry locations, with XLPE insulation.

2. VFD Cables shall be as manufactured by **Belden, Alpha**, **General Cable,** or equal.

G. Cable Splices and Terminations

1. Where cable lugs are required for power cable terminations, utilize compression lugs – **3M Scotchlok 30000** and **31100 Series**, **Penn Union HBBLU** and **BLU**, **Burndy Hylug**, or equal.

Utilize compression tools as recommended by the manufacturer. Pressure type, twist-on connectors (wire nuts) will not be acceptable.

2. Pre-insulated fork tongue lugs shall be **Thomas & Betts, Burndy**, or equal.

3. General purpose insulating tape shall be **Scotch No. 33**, **Plymouth Slip-knot**, or equal. High temperature tape shall be polyvinyl as manufactured by **Plymouth, 3M,** or equal.

4. Labels for coding 600 volt wiring shall be computer printable or pre-printed, self-laminating, self-sticking, as manufactured by **W.H. Brady, 3M**, or equal.

PART 3 EXECUTION

3.1 INSTALLATION

A. The CONTRACTOR shall provide, terminate and test all power, control, and instrumentation conductors.

B. The CONTRACTOR shall, as a minimum, provide the number of control wires listed in the conduit schedule or on the Contract Drawings. Excess wires shall be treated as spares for future use.

C. Conductors shall not be pulled into any raceway until raceway has been cleared of moisture and debris.

D. Instrumentation wire shall not be run in the same raceway with power and control wiring except where specifically indicated.

E. Wire in panels, cabinets, and wireways shall be neatly grouped using nylon tie straps, and shall be neatly fanned out to terminals.

3.2 FIELD ASSEMBLY

A. General

1. Wire taps and splices shall be properly taped and insulated according to their respective classes.

2. In general, there shall be no cable splices.

3. Stranded conductors shall be terminated directly on equipment box lugs making sure that conductor strands are confined within lug. Use forked-tongue lugs where equipment box lugs have not been provided.

4. Excess control and instrumentation wires shall be long enough to terminate at any terminal block in the enclosure, be properly taped, be identified with origin, and be neatly coiled.

B. Control Wire and Cable

1. Control conductors shall be spliced or terminated only at the locations indicated and only on terminal strips or terminal lugs of vendor furnished equipment.

2. In control panels, control wire shall be terminated to terminal strips.

3. The CONTRACTOR shall provide as a minimum the number of control wires listed in the conduit schedule or as indicated in the Contract Documents. Excess wires shall be treated as spares.

C. Instrumentation Wire and Cable

1. Shielded instrumentation cables shall be grounded at one end only, preferably the receiving end on a 4 - 20 mA system.

2. Two and 3 conductor shielded cables installed in conduit runs which exceed available standard cable lengths may be spliced in pullboxes with the prior approval of the ENGINEER. Such cable runs shall have only one splice per conductor.

D. Power Wire and Cable

1. 120/208-volt, and 480/277-volt branch circuit conductors may be spliced in suitable fittings at locations determined by the CONTRACTOR.

2. Splices to motor leads in motor terminal boxes shall be wrapped with mastic material to form a mold and then shall be taped with a minimum of 2 layers of varnished cambric tape over-taped with a minimum of 2 layers of high temperature tape.

3. VFD shielded power cables shall have the shield grounded at all locations where it is exposed.

E. Cable Identification

1. General: Wire and cable shall be identified for proper control of circuits and equipment and to reduce maintenance effort. Identification shall be installed at every termination point.

2. Identification Numbers: The CONTRACTOR shall assign to each control and instrumentation wire and cable a unique identification number. Numbers shall be assigned to conductors having common terminals and shall be shown on "as built" drawings. Identification numbers shall appear within 3-inches of conductor terminals. "Control and Instrumentation Conductors" shall be defined as any conductor used for control, interlock, alarm, annunciator, or signal purposes.

   a. Multiconductor cable shall be assigned a number which shall be attached to the cable at intermediate pull boxes and at stub-up locations beneath free-standing equipment. It is expected that the cable number shall form a part of the individual wire number. Individual control conductors and instrumentation cable shall be identified at pull points as described above. The instrumentation cable numbers shall incorporate the loop numbers assigned in the Contract Documents.

   b. 120/208-volt system feeder cables and branch circuit conductors shall be color coded as follows: Phase A - black, Phase B - red, Phase C - blue, and Neutral - white. The 480/277-volt system conductors shall be color coded as follows: Phase A - Brown, Phase B - Orange, Phase C - Yellow, and Neutral - Gray. Branch circuit switch shall be

yellow. Insulated ground wire shall be green, and neutral shall be gray. Color coding and phasing shall be consistent throughout the Site, but bars at panelboards, switchboards, and motor control centers shall be connected Phase A-B-C, top to bottom, or left to right, facing connecting lugs. Color coding tape shall be used where colored insulation is not available. Colored identification tape may be used on conductors between the local disconnect and the load, where permitted by the NEC. Any phase changes necessary for proper rotation shall be made at the driven equipment where colored insulation is used. Phase changes may be made on the load side of the local disconnect, where phase colors are identified using tape.

c. General purpose AC control cable shall be red. General purpose DC control cable shall be blue.

d. Terminal strips shall be identified by computer printable, cloth, self-sticking marker strips attached under the terminal strip.

3.3 FIELD QUALITY CONTROL

A. Cable Assembly and Testing: Cable assembly and testing shall comply with applicable requirements of ICEA Publication No. S-95-658/NEMA WC70 - Ethylene-Propylene-Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy. Factory test results shall be submitted in accordance with Section 01 33 00, Contractor Submittals, prior to shipment of cable. The following field tests (in addition to the tests specified in Section 26 01 26, Electrical Tests) shall be the minimum requirements:

1. Power cable rated at 600 volts shall be tested for insulation resistance between phases and from each phase to a ground using a megohmeter.

2. Field testing shall be done after cable is installed in the raceways.

3. Field megger testing may be performed by the CONTRACTOR or a NETA-certified test organization. When tested by the CONTRACTOR, submit test equipment calibration sheets with the test results. Test results shall be submitted to the ENGINEER for review and acceptance.

4. Cables failing the tests shall be replaced with a new cable or be repaired. Repair methods shall be as recommended by the cable manufacturer and shall be performed by persons certified by the industry.

B. Continuity Test: Control and instrumentation cable shall be tested for continuity, polarity, undesirable ground, and origination. Such tests shall be performed after installation and prior to placing cable in service.

END OF SECTION

SECTION 26 05 26 – GROUNDING

PART 1 GENERAL

1.1 THE SUMMARY

A. Provide the electrical grounding system, complete and operable, as indicated in accordance with the Contract Documents.

B. The requirements of Section 26 00 00, Electrical Work, General apply to this Section.

C. Single Manufacturer

1. Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer's services.

1.2 ACTION SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00, Contractor Submittals and Section 26 00 00, Electrical Work, General.

1. Include with each submittal a copy of this specification section, with addenda updates included, and all referenced and applicable sections included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (√) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the CONTRACTOR, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The ENGINEER shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the CONTRACTOR with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

B. Shop Drawings

1. Submit manufacturer's product information for connectors, clamps, and all grounding system components, showing compliance with the requirements of this Section.

PART 2 PRODUCTS

2.1 EQUIPMENT

A. Components of the grounding electrode system shall be manufactured in accordance with UL 467 - Standard for Safety Grounding and Bonding Equipment, and shall conform to the applicable requirements of National Electrical Code Article 250 and local codes.

B. Grounding System

1. Grounding loop conductors shall be bare annealed copper conductors.

2. Conductors shall be No. 1/0 unless indicated otherwise.

3. Ground Rods

   a. Unless indicated otherwise, provide ground rods minimum of 3/4 inch in diameter, 10 feet long, and with a uniform covering of electrolytic copper metallically bonded to a rigid steel core.

   b. Provide corrosion-resistant copper-to-steel bond.

   c. The rods shall conform to UL 467.

   d. The rods shall be of the sectional type, joined by threaded copper alloy couplings.

4. Make buried, concrete-encased, or otherwise inaccessible cable-to-cable and cable-to-ground rod connections using exothermic welds by **Cadweld, Thermoweld,** or equal. Alternatively, non-reversible, compression connectors may be used for inaccessible grounding connections, constructed of high-copper alloy, and manufactured specifically for the particular grounding application. The connectors shall be **Burndy "Hyground"**, similar by **Thomas and Betts**, or equal.

5. Exposed Connectors

   a. Exposed grounding connectors shall be of the compression type (connector-to-cable), constructed of high-copper alloy, and manufactured specifically for the particular grounding application.

   b. The connectors shall be **Burndy, O.Z. Gedney**, or equal.

6. Use grounding clamps to bond each separately-derived system to the grounding electrode conductors.

7. Equipment Grounding Circuit Conductors

   a. The conductors shall be the same type and insulation as the load circuit conductors.

   b. The minimum size shall be as indicated. Where not indicated, sizes shall conform to Table 250.122 of the National Electrical Code.

   c. Metallic conduit systems shall have an equipment grounding wires as well as being equipment grounding conductors themselves.

8. Grounding Materials Manufacturer, or Equal

   a. Copperweld
   b. Thermoweld
   c. Burndy
   d. Thomas and Betts
   e. OZ Gedney

PART 3 EXECUTION

3.1 PREPARATION

A. Provide a separate grounding conductor, securely grounded in each raceway independent of raceway material.

B. Provide a separate grounding conductor for each motor and connect at motor box. Provide a supplemental ground connection for motor shaft grounding rings, where applicable.

C. Do not use bolts for securing the motor box to the frame or the cover for grounding connectors.

D. Sizes shall be as indicated on the Conduit Schedule and in accordance with NEC Article 250.

E. Route the conductors inside the raceway.

F. Provide a grounding-type bushing for secondary feeder conduits that originate from the secondary section of each panelboard.

G. Individually bond the raceway to the ground bus in the secondary section.

H. Provide a green insulated wire as grounding jumper from the ground screw to a box grounding screw, and, for grounding type devices, to the equipment grounding conductor.

I. Provide a separate grounding conductor in each individual raceway for parallel feeders. Connect the parallel ground conductors together at each end of the parallel run, as required by the NEC.

J. Interconnect the secondary panelboard neutral bus to the ground bus in the secondary switchgear compartment only at the service entrance point. For wye connected, 3 phase, separately derived systems with 3 wire distribution, connect the transformer neutral to the grounding electrode system at the transformer. Connections shall be in accordance with the NEC.

K. Provide the duct bank ground system as indicated, including trenching, splices, ground rods, and connections to equipment and structures.

L. Measure ground impedance in accordance with IEEE STD 81 after installation but before connecting the electrode to the remaining grounding system. Provide additional grounding system testing in accordance with Section 26 01 26, Electrical Tests.

M. Low Voltage Grounded System (600V or less)

1. A low-voltage grounded system is defined as a system where the local power supply is a transformer, with the transformer secondary grounded.

2. Grounding system connections for a premises-wired system supplied by a grounded AC service shall be provided with a grounding electrode connector connected to the grounded service conductor at each service, in accordance with the NEC.

3. The grounded circuit conductor shall not be used for grounding non-current-carrying parts of equipment, raceways, and other enclosures except where specifically listed and permitted by the NEC.

N. Embedded Ground Connections

1. Underground and grounding connections embedded in concrete shall be UL-listed ground grid connectors.

2. The connection shall be made in accordance with the manufacturer's instructions.

3. Do not conceal or cover ground connections until the ENGINEER or an authorized representative has established that every grounding connection conforms to the requirements of the Contract Documents and has given the CONTRACTOR written confirmation.

O. Ground Ring

1. Furnish trenching and materials as necessary to install the ground ring as indicated.
2. The bonding conductor shall be in direct contact with the earth and of the indicated size.
3. Provide a minimum burial depth of 36 inches or as indicated on the Drawings, whichever is greater.
4. Re-compact disturbed soils to their original density in 6-inch lifts.

P. Duct Bank Ground

1. Embed a grounding conductor in every duct bank as indicated. The ground conductor shall be terminated at the ground grid at each end of the duct bank. Where no ground grid is installed, terminate at a suitable grounding electrode conductor near the end of the duct bank in accordance with the NEC.

Q. Ground Rods

1. Provide ground rods at the indicated locations.

2. A single electrode that does not have resistance-to-ground of 5 ohms or less shall be augmented by additional electrodes to obtain this value.

3. Take the resistance-to-ground measurement during dry weather, a minimum of 48 hours after a rainfall.

4. Rods forming an individual ground array shall be equal in length.

R. Instrumentation Shield Grounding

1. Shielded instrumentation cable shall have its shield grounded at one end only unless the approved Shop Drawings indicate that the shield will be grounded at both ends.

2. The grounding point shall be at the control panel or at the receiving end of the signal carried by the cable.

3. The termination of the shield drain wire shall be on its own terminal screw.

4. Jumper together the terminal screws, using manufactured terminal block jumpers or a No. 14 green insulated conductor.

5. Connect the ground bus via a green No. 12 conductor to the main ground bus for the panel.

END OF SECTION

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SECTION 26 05 33 - ELECTRICAL RACEWAY SYSTEMS

PART 1 GENERAL

1.1 THE SUMMARY

A. Provide electrical raceway systems, complete and in place, as indicated in accordance with the Contract Documents.

B. In the event that individual equipment loads provided are larger than indicated in the Contract Documents, revise raceways, conductors, starters, overload elements, and branch circuit protectors as necessary in order to control and protect the increased connected load in conformance to NEC requirements as part of the WORK.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00, Contractor Submittals, and Section 26 00 00, Electrical Work, General.

B. Shop Drawings

1. Submit complete catalog cuts of raceways, fittings, boxes, supports, and mounting hardware, marked where applicable to show proposed materials and finishes.

2. As-Built Drawings

a. Prepare as-built drawings of encased concealed and exposed raceways, ducts, raceways, junction boxes, pull boxes, and electrical and instrumentation equipment.

b. Furnish the drawings to the ENGINEER in accordance with the requirements of Section 01 33 00, Contractor Submittals.

PART 2 PRODUCTS

2.1 GENERAL

A. Pull and junction boxes, fittings, and other indicated enclosures that are dedicated to the raceway system shall comply with the requirements of this Section.

2.2 CONDUIT

A. Rigid Galvanized Steel (RGS) Conduit

1. Provide rigid steel conduit manufactured from mild steel, hot-dip galvanized inside and out.

2. Provide rigid steel conduit manufactured in accordance with NEMA C80.1 – Electrical Rigid Steel Conduit, and UL-6 – Electrical Rigid Metal Conduit - Steel.

3. Manufacturer, or Equal

    a. Allied Tube & Conduit
    b. Triangle
    c. Wheatland Tube

B. PVC Rigid Non-Metallic Conduit

1. Provide rigid non-metallic conduit manufactured from Schedule 40 or 80 PVC, as indicated, and sunlight-resistant.

2. Provide rigid non-metallic conduit manufactured in accordance with NEMA TC-2 - Electrical Plastic Tubing and Conduit, and UL-651 - Standard for Rigid Non-metallic Conduit.

3. Manufacturer, or Equal

    a. Carlon
    b. Cantex

C. Rigid PVC-Coated Galvanized Steel (RPGS) Conduit

1. The conduit shall meet the requirements for RGS conduit as indicated above.

2. Bond a PVC coating to the outer surface of the galvanized conduit.

3. Ensure that the bond between the coating and the conduit surface is greater than the tensile strength of the coating.

4. Provide the inside surfaces and threads of the conduit with a 2-mil urethane coating.

5. Provide a PVC coating thickness not less than 40 mils.

6. The PVC-coated RGS shall be manufactured in accordance with the following standards:

    a. UL-6

    b. ANSI C80.1

    c. NEMA RN1 - PVC Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit

7. Manufacturer, or Equal

    a. Robroy Industries
    b. O'Kote
    c. Thomas & Betts

D. Liquid-Tight Flexible Conduit

1. Provide liquid-tight flexible conduit constructed of a flexible galvanized metal core with a sunlight-resistant thermoplastic outer jacket.

2. Provide liquid-tight flexible conduit manufactured in accordance with the requirements of UL-360 - Steel Conduits, Liquid-Tight Flexible.

3. Manufacturer, or Equal

   a. Anaconda, Sealtite
   b. Electriflex, Liquatite

E. Electrical Metallic Tubing (EMT) or Intermediate conduit (IMC) will not be accepted.

2.3 FITTINGS AND BOXES

A. General

1. For use with metallic conduit, provide cast and malleable iron fittings of the threaded type with 5 full threads.

2. Fittings and Boxes

   a. Provide fittings and boxes with neoprene gaskets and non-magnetic stainless steel screws.
   b. Attach covers by means of holes tapped into the body of the fitting.
   c. Covers for fittings attached by means of clips or clamps will not be accepted.

3. Provide boxes larger than standard cast or malleable types manufactured of Type 304 or Type 316 stainless steel, NEMA 4X.

4. Terminations

   a. In outdoor areas, terminate conduit in rain-tight hubs as manufactured by **Myers, O.Z. Gedney, Appleton**, or equal.

   b. In other than outdoor areas, provide sealed locknuts and bushings.

B. Malleable Iron Fittings and Boxes

1. For use with galvanized steel conduit, provide fittings and boxes constructed of malleable iron or gray-iron alloy with zinc plating.

2. Manufacturer, or Equal

   a. O.Z. Gedney
   b. Crouse-Hinds
   c. Appleton

C. PVC Fittings and Boxes

1. For use with rigid non-metallic conduit, provide fittings manufactured of solvent-welded PVC.

2. Provide boxes manufactured of PVC or fiberglass reinforced polyester (FRP).

3. Manufacturer, or Equal

    a. Carlon
    b. Crouse-Hinds
    c. Hoffman

4. Provide welding solvent as required for the installation of non-metallic conduit and fittings.

D. PVC-Coated RGS Fittings

1. For use with PVC-coated RGS, provide PVC-coated coated that are the products of the same manufacturer as the conduit.

2. Provide male and female threads and internal surfaces with a 2-mil urethane coating.

E. Stainless Steel Boxes

1. Provide stainless steel boxes with PVC-coated RGS conduit and where indicated.

2. Provide NEMA 4X stainless steel boxes, constructed of Type 316 stainless steel.

3. Provide stainless steel of a minimum of 14-gauge thickness, with a brushed finish.

4. Door Hinges

    a. Provide doors with full-length stainless steel piano hinges.
    b. Non-hinged boxes will not be accepted.

5. Manufacturer, or Equal

    a. Hoffman
    b. Rohn
    c. Hammond

F. Sheet Steel Boxes

1. Sheet steel boxes shall be galvanized steel outlet and switch boxes.

2. Manufacturer, or Equal

    a. Raco
    b. Steel City
    c. Appleton Electric

2.4 CABLE TRAYS

A. Provide cable tray systems composed of straight sections, fittings, and accessories as defined in the latest NEMA Standards publication VE-1 - Ventilated Cable Tray.

1. Provide cable trays and fittings shall constructed of steel, hot-dip galvanized after fabrication or stainless steel.

2. Provide cable trays of the open rung type with 6-inch spacing.

3. Provide tray sizes with a 4-inch minimum usable load depth, as indicated.

4. Provide loading capacities that meet the NEMA weight classification with a safety factor of 1.5.

5. In corrosive locations, provide cable trays manufactured of stainless steel.

6. Manufacturer, or Equal

   a. Husky
   b. B-Line
   c. T.J. Cope

2.5 WIREWAY

A. General

1. Provide wireway of the lay-in type and NEMA-rated for the area in which it is to be installed in accordance with the requirements of Section 26 00 00, Electrical Work, General.

2. Separate power, control, signal and communications cables by grounded metallic dividers in wireways or run in separate wireways.

B. Fittings and Covers

1. Provide fittings and sections with non-magnetic stainless steel screws.
2. Attach covers by hinges and clamps to the bodies.
3. Covers attached by means of clips or screws will not be accepted.
4. Provide covers and bodies constructed of aluminum or minimum 14-gauge steel.

C. Grounding

1. Ground the steel and aluminum wireway bodies.

2. Provide steel dividers with steel wireways or aluminum dividers with aluminum wireways, and ground by means of an individual grounding conductor.

3. Non-metallic dividers will not be accepted.

D. Terminations

1. In outdoor areas, terminate conduit in rain-tight hubs as manufactured by **Myers, O.Z. Gedney**, or equal.

2. In other than outdoor areas, provide sealed locknuts and bushings.

PART 3 EXECUTION

3.1 GENERAL

A. Run wiring in raceway unless indicated otherwise.

B. Install raceways between equipment as indicated.

C. Provide raceway systems that are electrically and mechanically complete before conductors are installed.

D. Bends and Offsets

1. Provide bends and offsets that are smooth and symmetrical, and accomplished with tools designed for this purpose.

2. Provide factory elbows wherever possible.

E. Combined Raceways

1. Raceways other than those containing power conductors may be combined in strict accordance with the NEC and with prior written permission from the ENGINEER.

2. In general, combine only raceways containing the same type (control, signal, and the like) and voltage of conductors/cables, or dedicated conduits from one source to one device/equipment, in accordance with the NEC.

3. Permission from the ENGINEER shall not relieve the CONTRACTOR of responsibility to meet national, state and local requirements.

4. Do not combine wiring for redundant systems into single raceways.

F. Routing

1. Where raceway routings are indicated, follow those routings to the extent possible.

2. Where raceways are indicated but routing is not indicated, such as home runs or on conduit developments and schedules, raceway routing shall be the CONTRACTOR's choice and provided in strict accordance with the NEC as well as customary installation practice.

3. Provide the raceway encased, exposed, concealed, or under-floor as indicated, except conceal conduit in finished areas unless specifically indicated otherwise.

4. Adjust routings in order to avoid obstructions.

G. Coordination

1. Coordinate between trades prior to installing the raceways.

2. The lack of such coordination shall not be justification for extra compensation, and any costs for removal and re-installation to resolve conflicts shall be part of the Contract Price.

H. Support wireways in accordance with the manufacturer's recommendations for the seismic requirements indicated in Section 26 00 00, Electrical Work, General.

I. Provide cable tray anchoring that meets or exceeds the manufacturer's recommendations for the seismic zone indicated in Section 26 00 00, Electrical Work, General.

J. Install exposed raceways parallel or perpendicular to structural beams.

K. Expansion Fittings

1. Install expansion fittings with external bonding jumpers wherever exposed raceways cross building expansion joints.

2. Install expansion/deflection fittings where conduit movement is expected in more than one dimension, and where conduits transition out of structures in locations where differential settlement may occur.

3. Encased Expansion Fittings

a. Install encased expansion fittings wherever encased conduits cross building expansion joints.

b. Deflection type fittings shall not be required for encased conduits crossing an expansion joint within a single structure.

4. Provide expansion and expansion/deflection fittings constructed of the same material as the raceway to which they are installed.

L. Install expansion fittings with bonding jumpers wherever raceways cross building expansion joints.

M. Install exposed raceways at least 1/2 inch from walls or ceilings except that at locations above finished grade where damp conditions do not prevail, install exposed raceways at least 1/4 inch from the face of walls or ceilings by the use of clamp backs or struts.

N. Wherever contact with concrete or dissimilar metals can produce galvanic corrosion of equipment, provide a means of suitable insulation in order to prevent such corrosion.

3.2 CONDUIT

A. Provide exposed conduit manufactured of rigid galvanized steel, except as follows and unless indicated otherwise:

1. In areas with chlorine, alum or sodium hypochlorite, provide Schedule 80 PVC conduit 8' AFF and below, and schedule 40 PVC above 8' AFF.

2. For conduit containing only grounding system bonding conductors, provide Schedule 80 PVC conduit.

B. Power conduit encased in concrete shall be constructed of Schedule 40 PVC.

C. Concrete Encasement

1. Where PVC or RGS conduit is stubbed up from a concrete encasement, provide a PVC-coated RGS elbow.

2. The conduit shall emerge from the concrete in a direction perpendicular to the surface whenever possible.

3. Do not encase conduit in the bottom floor slab below grade.

D. Size

1. Provide exposed conduit of 3/4-inch minimum trade size.
2. Provide encased conduit of one-inch minimum trade size.

E. Install supports at distances required by the NEC.

F. Concrete cover for conduit and fittings shall not be less than 1-1/2 inches for concrete exposed to earth or weather, or less than 3/4 inch for concrete not exposed to weather or in contact with the ground.

G. Penetrations

1. Provide conduit passing through walls or floors with plastic sleeves.

2. Perform core drilling in accordance with the requirements of Section 26 00 00, Electrical Work, General.

3. Conduits passing through a slab, wall, or beam shall not significantly impair the strength of the construction.

H. Conduits embedded within a slab, wall, or beam (other than those merely passing through) shall meet the following requirements:

1. Conduits with their fittings embedded within a column shall not displace greater than 4 percent of the gross area of cross section;

2. Conduits shall not be larger in outside dimension than 1/3 the overall thickness of the slab, wall, or beam in which it is embedded; and,

3. Conduits shall not be spaced closer than 3 outside diameters on centers.

I. Place the conduit such that cutting, bending, or displacing reinforcement from its proper location will not be required.

J. Coat threads with a conductive lubricant before assembly.

K. Joints

1. Provide joints that are tight, thoroughly grounded, secure, and free of obstructions in the pipe.

2. Adequately ream the conduit in order to prevent damage to the wires and cables inside.

3. Use strap-wrenches and vises to install the conduit, in order to prevent wrench marks on the conduit.

4. Replace conduit with wrench marks.

5. Where installed in chemical or fuel containment areas, the conduit shall not have joints or fittings located below the top of the containment area to prevent entry of chemicals or fuel into the conduit system.

L. Slope

1. Wherever possible, slope the conduit runs to drain at one or both ends of the run.

2. Wherever conduit enters a substructure below grade, slope the conduit in order to drain water away from the structure.

3. Take extreme care in order to avoid pockets or depressions in the conduit.

M. Where conduits from duct banks enter building walls below grade, transition to PVC-coated RGS at least 12" outside the wall. Installation of PVC-coated rigid steel conduit though a core-drilled hole in an exterior wall below-grade shall utilize a sealing device as manufactured by **Link Seal**, or equal.

N. Connections

1. Make connections to lay-in-type grid lighting fixtures by using flexible metal conduit not exceeding 4 feet in length.

2. Make connections to motors and other equipment subject to vibration by using liquid-tight flexible conduit not exceeding 3 feet in length.

3. Provide equipment subject to vibration that is normally provided with wiring leads with a cast junction box for the make-up of connections.

O. Provide conduit seal fittings in hazardous classified locations, in strict accordance with the NEC.

P. Provide conduit, fittings, and boxes required in hazardous classified areas that are suitably rated for the area, and provide in strict accordance with NEC requirements.

Q. Duct sealant shall be foam duct sealant such as **Polywater FST or approved equal.** Provide duct sealant at the following locations:

1. Where required by NEC Article 300.7.

2. In areas where chlorine gas or fumes from sodium hypochlorite exist to prevent passage of gas through the raceway system.

R. Empty Conduits

1. Tag empty conduits at both ends to indicate the final destination.

2. Where it is not possible to tag the conduit, identify the destination by means of a durable marking on an adjacent surface.

3. Install a pull-cord in each empty conduit in floors, panels, manholes, equipment, and the like.

4. Install a removable plug on empty conduits that terminate below grade, in vaults, manholes, handholes, and junction or pullboxes.

S. Identification of Conduits

1. Identify conduits at ends and at pulling points.

2. Identification shall be the unique conduit number assigned in the Contract Documents.

3. Other than 120 VAC panelboard circuits, if a conduit has not been assigned a unique number in the Contract Documents, assign a unique number following the numbering scheme used in the Contract Documents.

4. Assign a unique number to 120 VAC panelboard circuits, similar to the cable numbering scheme used in the Contract Documents.

5. Provide conduit identification by a stamped or engraved non-corroding metal tag attached to the conduit bushing.

6. Provide an engraved phenolic nameplate in accordance with the requirements of Section 26 00 00, Electrical Work, General, or a computer printed self-adhesive label attached to the equipment or enclosure inside which the conduit terminates.

7. Markings with a pen or paint will not be accepted.

T. Identification of Pullboxes and Junction Boxes

1. Identify pullboxes and junction boxes.

2. Identification shall be the unique conduit number assigned in the Contract Documents, or if not assigned a unique number the CONTRACTOR shall assign one following the numbering scheme used in the Contract Documents.

3. Provide box identification by a stamped or engraved non-corroding metal tag or an engraved phenolic nameplate, in accordance with the requirements of Section 26 00 00, Electrical Work, General, and attached to the box or enclosure.

4. Markings with a pen or paint will not be accepted.

U. Provide conduit for data cables in accordance with the equipment manufacturer’s recommendations, especially regarding separation from power raceways.

3.3 CABLE TRAYS

A. Provide cable trays in strict accordance with the manufacturer's printed instructions.

B. Allowable cable fill areas shall meet NEC Article 392 - Cable Trays requirements.

C. Verify cable tray fills prior to installation based on cables and trays actually provided.

D. Maintain continuous grounding of cable trays including bonding jumpers in accordance with the requirements of NEC Article 392.

E. Install cable trays using hangers and supports on 8-foot centers, maximum.

F. Install cable trays to walls as the primary method of support.

G. If support from the ceiling is the only alternative, use hangers and supports on 6-foot centers, maximum.

END OF SECTION

SECTION 26 05 36 - WIRING DEVICES

PART 1 GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide wiring devices, complete and operable, as indicated in accordance with the Contract Documents.

B. The requirements of Section 26 00 00, Electrical Work, General apply to this Section.

C. Single Manufacturer

1. Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer's services.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00, Contractor Submittals.

B. Shop Drawings

1. Submit complete catalog cuts of switches, receptacles, enclosures, covers and appurtenances, marked to clearly identify the proposed materials.

2. Submit documentation showing that the proposed materials comply with the requirements of NEC and U.L.

3. Submit documentation of the manufacturer's qualifications.

PART 2 PRODUCTS

2.1 GENERAL

A. Devices shall carry the U.L. label, and shall be designed for use with stranded copper conductors.

B. Color

1. General purpose duplex receptacles and toggle switch handles shall be Brown everywhere except unless otherwise indicated.

2. Special purpose receptacles shall have a body color as indicated.

C. Receptacles and switches shall be of specification grade and shall conform to NEMA WD-1, Federal Specifications W-C-596E and W-S-896E, respectively.

2.2 LIGHTING SWITCHES

A. Toggle switches shall be AC only type switch.

1. 20A, 120/277V, Single, Double, 3-Way and 4-Way, Respectively

a. **Leviton**: 1221-2, 1222-2, 1223-2, 1224-2
b. **Hubbell:** HBL1221, HBL1222, HBL1223, HBL1224
c. **Pass and Seymour:** PS20AC1, PS20AC2, PS20AC3, PS20AC4
d. Or Equal

2.3 GENERAL PURPOSE RECEPTACLES

A. Duplex receptacles shall be of the polarized 3-wire type for use with a 3-wire cord with grounded lead, and one designated stud shall be permanently grounded to the conduit system in accordance with NEC article 406.4.

B. Dry Areas

1. NEMA Configuration #5-20R: duplex receptacle rated 125V, 20A

a. Leviton: #5362
b. Hubbell: #HBL5362
c. Pass and Seymour: #5362A
d. Or Equal

2. NEMA Configuration #5-30R single receptacle rated 125V, 30A

a. Leviton: #5371
b. Hubbell: #HBL9308
c. Or Equal

C. Damp/Wet Areas

1. Receptacles for damp/wet locations shall be weather-resistant with extra duty, in-use listed covers in accordance with NEC Article 406.8.

D. GFCIs

1. Ground-fault circuit-interrupting receptacles (GFCIs) shall be installed at the indicated locations and as required by the NEC.

2. GFCIs shall be duplex receptacles, of specification grade, and tripping at 5 mA.

3. GFCI ratings shall be 125V, 20 amperes, NEMA WD-1, Configuration 5-20R, and capable of interrupting 5,000 amperes without damage.

4. GFCIs shall be weather resistant-listed in accordance with NEC Article 406.8.

5. Feed-through-type GFCIs serving standard receptacles will not be permitted.

a. **Leviton:** G5362-WT
b. **Hubbel:** GFR5362SG
c. Or Equal

2.4 ENCLOSURES AND COVERS

A. Surface-mounted switches and receptacles shall be housed in FS or FD-type weatherproof conduit fittings.

B. Switch and receptacle covers on surface-mounted boxes shall be constructed of die-cast copper-free aluminum.

1. Appleton: FSK
2. Crouse-Hinds: DS185 and WLRD-1
3. Hubbell Killark: FZ and FC
4. Or Equal

C. In finished areas, switch and receptacle covers shall be constructed of stainless steel.

D. Wet Locations

1. Receptacles in wet locations shall be provided with a hinged non-metallic extra-duty (extra deep) clear cover/enclosure marked "Suitable for Wet Locations when in use" and "UL Listed."

2. Provide a gasket between the enclosure and the mounting surface, and between the hinged cover and mounting plate/base.

a. Appleton: WCIU
b. Crouse-Hinds: TP74
c. Hubbell TayMac: Extra Duty
d. Or Equal

2.5 RECEPTACLE – SPECIAL PURPOSE

A. Special purpose receptacles shall be provided with the ratings and number of poles as indicated or required for the proposed purpose.

B. Provide a matching plug with cord-grip features with each special purpose receptacle.

2.6 FLOOR RECEPTACLE BOXES

A. Floor receptacles and jacks shall be installed in rectangular floor boxes.

B. The floor boxes shall be 1-, 2- or 3-gang as required for each installation.

C. The floor boxes shall be constructed of cast iron, bronze or other durable metal and sized for the depth of the floor slab. Nonmetallic boxes shall not be provided.

D. Carpet flanges shall be provided.

E. Covers shall be constructed of brass, bronze or other durable metal, with openings for duplex receptacle, voice, data, etc. jacks. Nonmetallic covers shall not be provided.

F. Floor boxes shall be as manufactured by **Hubbell**, or equal

2.7 NAMEPLATES

A. Provide nameplates or equivalent markings on the switch enclosures to indicate the ON and OFF positions of each switch.

B. ON and OFF for 3-way or 4-way switches will not be accepted.

C. Provide receptacles for special purposes with nameplates indicating their use.

D. Nameplates shall meet the requirements of Section 26 00 00, Electrical Work, General.

PART 3 EXECUTION

3.1 GENERAL

A. Perform WORK in accordance with the requirements of the NEC.

3.2 CONNECTION

A. Rigidly attach wiring devices in accordance with the NEC and as indicated, avoiding interference with other equipment.

B. Securely fasten nameplates using screws, bolts, or rivets centered under or on the device, unless otherwise indicated.

C. Receptacles indicated to be powered by uninterruptible power supplies (UPS) shall have a nameplate installed directly above the receptacle that reads:

1. (first line) “UPS-POWERED”
2. (second line) “NO TOOLS”

D. Nameplates shall meet the requirements of Section 26 00 00 – Electrical Work, General, and shall consist of a red plate with white letters a minimum of 1/4 inch tall.

3.3 GROUNDING

A. Devices, including switches and receptacles, shall be grounded in accordance with NEC, Article 250, and Section 26 05 26, Grounding.

B. Switches and associated metal plates shall be grounded through the switch mounting yoke, outlet box, and raceway system.

C. Receptacles served from an uninterruptible power supply shall be provided with an isolated grounding conductor from the serving power panelboard.

3.4 FIELD TESTING

A. Provide checkout, field, and functional testing of wiring devices in accordance with Section 26 00 00, Electrical Work, General.

B. Test each receptacle for polarity and ground integrity, using a standard receptacle tester.

END OF SECTION

SECTION 26 05 43 - UNDERGROUND RACEWAY SYSTEMS

PART 1 GENERAL

1.1 THE SUMMARY

A. Provide underground raceway systems, complete and in place, as indicated in accordance with the Contract Documents.

B. Manholes, pullboxes, and fittings that are dedicated to the underground raceway system shall comply with the requirements of this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00, Contractor Submittals, and Section 26 00 00, Electrical Work, General.

B. Shop Drawings

1. Submit complete catalog cuts of all raceways, fittings, pullboxes, and manholes, marked where applicable in order to show proposed materials and finishes.

C. As-Built Drawings

1. Prepare as-built drawings of encased concealed and exposed raceways, ducts, raceways, junction boxes, pull boxes, and electrical and instrumentation equipment.

2. Show routings, burial depths, manhole and handhole locations and sizes, and where applicable, connections to drainage systems.

3. Furnish the drawings to the ENGINEER in accordance with the requirements of Section 01 33 00, Contractor Submittals.

PART 2 PRODUCTS

2.1 PULLBOXES

A. Equip manholes and pullboxes with pulling-in irons, opposite and below each ductway entrance.

B. Provide manholes and pullboxes with closed bottoms; open-bottom manholes and pullboxes will not be accepted.

C. Provide PVC ductbank conduits with end bells.

D. Precast Pullboxes Manufacturer, or Equal

1. Jensen Precast
2. Mack
3. Quikset
4. U.S. Precast

2.2 DUCTBANKS

A. Provide underground ducts constructed of Schedule 40 PVC.

B. Duct banks are not required to be encased concrete.

C. Ductbanks

1. Ductbanks shall contain a No. 1/0 bare stranded copper ground wire.

2. The ground wire shall be continuous through the ductbank and terminate at power distribution equipment and the grounding grid.

D. Identification Tape

1. Provide continuous lengths of underground warning tapes located 12 inches above and parallel to the ductbanks. Where the warning tape is more than 24 inches below grade provide a second warning tape 12 to 24 inches below grade.

2. Provide tape consisting of 6-inch wide polyethylene film, imprinted with "CAUTION - ELECTRIC UTILITIES BELOW."

3. Provide tape that contains a non-ferrous metal foil conductor sandwiched in the tape for detection purposes.

4. Tape Manufacturer, or Equal: **Brady**

PART 3 EXECUTION

3.1 GENERAL

A. Install underground raceways between manholes and pullboxes as indicated.

B. Raceway systems shall be electrically and mechanically complete before conductors are installed.

C. Provide bends and offsets that are smooth and symmetrical, and fabricated with tools designed for this purpose.

D. Use factory elbows wherever possible.

E. To the extent possible, follow the raceway routings as indicated on the Drawings.

F. Adjust the indicated routings as necessary in order to avoid obstructions.

G. Coordination with Other Trades

1. Coordinate with other trades prior to installation of raceways.
2. The lack of coordination shall not be justification for extra compensation.
3. Perform removal and re-installation to resolve conflicts as part of the WORK.

3.2 DUCTBANKS

A. Install ductbanks in accordance with the following criteria:

1. Assemble the duct using high-impact, non-metallic spacers and saddles in order to provide conduits with vertical and horizontal separation.

2. Set the plastic spacers every 5 feet.

3. Anchor the duct array every 5 feet in order to prevent movement during the placement of concrete.

4. Lay the duct on a grade line of at least 3 inches per 100 feet, sloping towards pullboxes or manholes.

5. Install the duct and adjust the pullbox and manhole depths such that the top of the concrete envelope is a minimum of 18 inches below grade and a minimum of 24 inches below roadways.

6. Accomplish changes in direction of the duct envelope by more than 10 degrees horizontally or vertically by using bends with a minimum radius 24 times the duct diameter.

7. Stagger duct couplings a minimum of 6 inches.

8. Provide select backfill or sand for the bottom of the trench.

9. Cleaning

   a. Clean each bore of the completed ductbank by drawing through it a standard flexible mandrel, one foot long and 1/4 inch smaller than the nominal size of the duct.

   b. After passing the mandrel, draw through a wire brush and swab.

10. For spare raceways that are not indicated to contain conductors, provide a 1/8-inch polypropylene pull cord installed throughout the entire length of the raceway.

B. Grout duct entrances smooth, and terminate ducts with flush end bells.

C. Assemble sections of pre-fabricated manholes and pullboxes using waterproof mastic, and set on a 12-inch bed of gravel as recommended by the manufacturer or as required by field conditions.

D. Provide watertight ductbank penetrations through walls of manholes, pullboxes, and building walls below grade.

E. Terminate concrete-encased ductbanks at building foundations.

F. Where ducts enter buildings, provide duct sealant in every duct at the building-end of the duct run to prevent water or condensation entry from the duct bank into the building. Duct sealant shall be **Polywater FST, Polywater FST-Mini,** or equal.

G. When duct enters the building on a concrete slab on grade, do not encase the duct but transition to rigid steel PVC-coated conduits on stub-ups.

H. Sealing

1. Where an underground conduit enters a structure through a concrete roof or a membrane-waterproofed wall or floor, provide a **Link-Seal** or equal sealing device.

2. Use the sealing device with rigid steel conduit.

3. Transition from PVC to rigid steel conduit prior to building entry.

END OF SECTION

SECTION 26 05 73 – PROTECTIVE DEVICE STUDIES

PART 1 GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall perform the indicated short circuit and protective device studies for the electrical power system in accordance with the Contract Documents, and provide labels on all electrical equipment as required by the National Electrical Code, state and local regulations.

B. The WORK of this Section shall include protection studies for motors with solid state overload and overcurrent protection devices.

C. It is the responsibility of the CONTRACTOR to obtain the information required from the electric utility and appropriate vendors.

1.2 QUALIFICATIONS

A. Short circuit studies, protective device evaluation studies, arc-flash hazard analysis studies, and protective device coordination studies shall be performed by a firm who has been regularly engaged in short circuit and protective device coordination services for a period of at least 5 years.

B. The indicated studies shall be signed by the professional electrical engineer, registered in the State of Oregon, responsible for the studies.

C. The studies shall utilize computer programs with proven reliability and accuracy for performing 3-phase fault-duty calculations.

1.3 CONTRACTOR SUBMITTALS

A. The indicated studies shall be submitted and approved by the ENGINEER prior to final approval of the distribution equipment Shop Drawings and release of equipment for manufacture.

B. An initial short circuit study shall be submitted and reviewed before the ENGINEER will approve the Shop Drawings for 480-volt distribution equipment.

C. Submit an initial protective device coordination study shall be submitted with 90 days after the approval of the initial short circuit study.

D. The short circuit, arc-flash hazard analysis, and protective device coordination studies shall be updated prior to Project Substantial Completion; utilize characteristics of as-installed equipment and materials.

E. The adequacy of the equipment "withstand" and interruption ratings shall be approved by the ENGINEER.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.1 GENERAL

A. The studies shall include development of single-line and impedance diagrams of the power system down to the 120vac panelboard level.

B. The diagrams shall identify components considered in the study and the ratings of power devices, including transformers, circuit breakers, relays, fuses, busses, and cables.

C. The resistances and reactances of cables shall be identified in the impedance diagram.

D. The studies shall contain written data from the electric utility company regarding maximum available short circuit current, voltage, and X/R ratio of the utility power system.

E. The studies shall include every protective device and feeder included or modified within the WORK.

F. The first upstream overcurrent device outside the WORK shall be used as a fixed reference.

G. The studies shall include all portions of the electrical distribution system for normal and standby power sources down to and including the 480-volt distribution system.

3.2 SHORT CIRCUIT STUDY

A. The short circuit study shall be performed with the aid of a digital computer program, and shall be in accordance with the following Standards:

ANSI/IEEE 141, Recommended Practice for Electrical Power Distribution for Industrial Plants

ANSI/IEEE 242, Recommended Practice for Protection, and Coordination of Industrial, and Commercial Power Systems

ANSI/IEEE C 37.010, Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

ANSI/IEEE C 37.13, Low-Voltage AC Power Circuit Breakers Used in Enclosures

3.3 PROTECTIVE DEVICE EVALUATION STUDY

A. A protective device evaluation study shall be performed in order to determine the adequacy of circuit breakers, molded case switches, and fuses.

B. Any problem areas or inadequacies in the equipment due to prospective short-circuit currents shall be promptly brought to the attention of the ENGINEER.

C. Do not utilize series-rated circuit breakers to meet short circuit requirements for this project.

D. Devices shall be fully rated to withstand available fault currents.

3.4 PROTECTIVE DEVICE EVALUATION STUDY

A. A protective device coordination study shall be performed in order to develop the necessary calculations to select power fuse ratings, protective relay characteristics and settings, ratios and characteristics of associated current transformers, and low-voltage breaker trip characteristics and settings.

B. Any problem areas or inadequacies in the equipment due to prospective short-circuit currents shall be promptly brought to the ENGINEER's attention.

3.5 TIME/CURRENT COORDINATION CURVES

A. As a minimum, the time/current coordination curves for the power distribution system shall include the following items plotted on 5-cycle log-log graph paper:

1. time/current curves for each protective relay, circuit breaker, or fuse demonstrating graphically that the settings will provide protection and selectivity within industry standards

2. Each curve shall be identified, and tap and time dial settings shall be specified.

3. Provide individual curves for each feeder unless identical to others.

4. Selectivity

a. Time/current curves for each device shall be positioned to provide the maximum selectivity to minimize system disturbances during fault clearing.

b. Where selectivity cannot be achieved, the ENGINEER shall be notified as to the cause.

c. Recommendations shall be included for alternate methods that would improve selectivity.

5. Time/current curves and points for cable and equipment damage.

6. Circuit interrupting device operating and interrupting times.

7. Indicate maximum fault values on the graph.

8. Sketch of bus and breaker arrangement.

9. Magnetizing inrush points of transformers.

10. Thermal limits of dry-type and liquid-insulated transformers (ANSI damage curve).

11. Every restriction of the ANSI and National Electrical Code shall be followed, and proper coordination intervals and separation of characteristics curves shall be maintained.

3.6 ARC FLASH STUDY

A. An arc flash study shall be performed with the aid of a digital computer program in order to determine the “Arc Flash Protection Boundary” and “Personal Protective Equipment” (PPE)

levels for applicable electrical distribution equipment, stand-alone disconnects, starters, and VFDs in the power distribution system.

B. The arc flash study shall be performed in conjunction with short circuit calculations and protective device coordination.

C. The arc flash study shall be in accordance with the latest version of the following Standards:

NFPA 70E, Standard for Electrical Safety Requirements for Employee Workplaces

IEEE 1584, IEEE guide for performing Arc Flash Hazard Calculations

OSHA (29 CFR PART 1910), Occupational Safety and Health Standards for General Industry

ANSI Z535.4, Product Safety Signs and Labels

D. The recommended values for the "Arc Flash Protection Boundary" and PPE levels, based on the arc flash study results, shall be tabulated in the study.

E. Labeling

1. The digital computer program shall provide the "Arc Flash Protection Boundary" and PPE values in a format that can be directly printed on to labels. **Labels for all equipment shall include all the information listed in NEC Article 110.16(B) to allow workers to select the appropriate PPE in accordance with NFPA 70E.**

2. The CONTRACTOR shall provide these labels in accordance with Section 26 00 00 – Electrical Work, General.

3.7 FINAL SUMMARY REPORT

A. Summarize the results of the indicated power system studies in a final report.

B. The report shall include the following items:

1. single-line diagram

2. impedance diagram

3. tabulation of all protective devices identified on the single line diagram

4. time/current coordination curves

5. specific recommendations, if any

6. test instrumentation, condition, and connections, as applicable, for each study

7. computerized fault current calculations

8. any suggested changes to the protection scheme or equipment selection that will result in improved system reliability and safety

9. recommendations to minimize the arc flash energy

C. The report shall include information concerning the computer program used for the study, as well as a general discussion of the procedure, items, and data considered in the preparation of the study.

D. Submit copies of the report to the ENGINEER.

3.8 PROTECTIVE DEVICE TESTING, CALIBRATION, AND ADJUSTMENT

A. Test, calibrate, and adjust the protective relays and circuit breaker trip devices in accordance with the recommendations in the power system coordination study.

B. Calibrate the MCPs as in accordance with the recommendations in the power system study.

C. Adjustments shall be made prior to energizing any electrical equipment.

END OF SECTION

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SECTION 26 12 16 – PANELBOARDS AND DRY TYPE TRANSFORMERS

PART 1 GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide panelboards and general purpose dry-type transformers, complete and operable, in accordance with the Contract Documents.

B. Single Manufacturer: Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer's services.

1.2 CONTRACTOR SUBMITTALS

A. General: Submittals shall be in accordance with Section 01 33 00, Contractor Submittals and Section 26 00 00, Electrical Work, General.

B. Shop Drawings

1. Transformers

   a. Dimension drawings

   b. Technical certification sheets

   c. Drawing of conduit entry/exit locations

   d. Transformer ratings, including:

      1) Voltage
      2) Continuous current
      3) Basic impulse level for equipment over 600 volts
      4) KVA

   e. Descriptive bulletins

   f. Product sheets

2. Panelboards

   a. Breaker layout drawings with dimensions and nameplate designations

   b. Component list

   c. Drawings of conduit entry/exit locations

   d. Assembly ratings including:

      1) Short circuit rating
      2) Voltage
      3) Continuous current

e. Cable terminal sizes

f. Descriptive bulletins

g. Product sheets

h. Installation information

i. Seismic certification and equipment anchorage details

PART 2 PRODUCTS

2.1 GENERAL

A. Transformers

1. The transformers shall be dry-type, designed, manufactured, and tested in accordance with the latest applicable standards of ANSI and NEMA.

2. Transformers shall be UL-listed and bear the UL label.

B. Panelboards

1. Panelboards shall be dead front factory assembled. Panelboards shall comply with NEMA PB-1-Panelboards, as well as the provisions of UL 50 - Safety Enclosures for Electrical Equipment and UL 67 - Safety Panelboards. Panelboards used for service equipment shall be UL labeled for such use. Lighting panelboards shall be rated for 120/208 volt, 3 phase operation. Power panelboards shall be rated for 480 volts, 3 phase, 4 wire operation, unless indicated otherwise.

2. The manufacturer of the panelboard shall be the manufacturer of the major components within the assembly, including circuit breakers.

2.2 TRANSFORMERS

A. Energy Efficiency: Standard dry-type transformers shall meet the energy efficiency requirements of the Department of Energy Code of Federal Regulations (10 CFR PART 431), DOE 2016 Efficiency Levels.

B. Ratings

1. KVA and voltage ratings shall be as indicated.

2. Transformers shall be designed for continuous operation at rated kVA, for 24 hours a day, 365 days a year operation, with normal life expectancy as defined in ANSI C57.96 - Guide for Loading Dry Type Distribution and Power Transformers

3. Transformer sound levels shall not exceed the following ANSI and NEMA levels for self-cooled ratings:

Up to 9 kVA	40 dB
10 to 50 kVA	45 dB
51 to 150 kVA	50 dB

C. Construction

1. Insulation Systems

a. Transformers shall be insulated as follows:

1) 2 kVA and smaller: 150 deg C insulation system based upon 80 deg C rise.
2) 3 to 15 kVA: 185 deg C insulation system based upon 115 deg C rise.
3) 15 kVA and larger: 220 deg C insulation system based upon 150 deg C rise.

b. Required performance shall be obtained without exceeding the above indicated temperature rise in a 40 deg C maximum ambient.

c. Insulation materials shall be flame-retardant and shall not support combustion as defined in ASTM D 635 - Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position.

2. Transformer windings shall be copper.

3. Transformers shall have four 2-1/2 percent taps, 2 above and 2 below 480 volts.

4. Transformer shall include vibration dampeners between the core and the enclosure to minimize and isolate sound transmission.

D. Manufacturers: General Electric, Eaton, Schneider Electric/Square D Company, or equal.

2.3 PANELBOARDS

A. Ratings

1. Panelboard busses, main and branch circuit breakers rated 240 VAC or less shall have short circuit ratings not less than 22,000 amperes RMS symmetrical, as shown on the drawings, or as indicated by the Short Circuit Study, whichever is greater.

2. Panelboards busses, main and branch circuit breakers rated 480 VAC shall have short circuit ratings not less than 65,000 amperes RMS symmetrical or as indicated by the Protective Device Study, whichever is greater.

3. Panelboards shall be labeled with a UL short circuit rating. Reliance on series ratings to achieve the short circuit rating are not acceptable.

B. Construction

1. Lighting and power distribution panels shall have tin-plated copper bus bars.

2. Breakers shall be one, 2, or 3 pole as indicated, with ampere trip ratings as required by the equipment. Breakers shall be quick-make and quick-break, inverse time trip characteristics, to trip free on overload or short circuit, and to indicate trip condition by the handle position.

3. The panels shall have hinged doors with combination catch and latch. The front panels shall be so arranged that when the plates are removed, the gutters, terminals and wiring will be

exposed and accessible. The doors shall have inner doors within the plates to have only the breaker operating mechanism exposed when they are opened. Live conductors and terminals shall be concealed behind the plates.

4. Panelboards shall be rated for the intended voltage.

5. Circuit breakers shall be interchangeable and capable of being operated in any position as well as being removable from the front of the panelboard without disturbing adjacent units. No plug-in circuit breakers will be acceptable.

6. Lighting and power distribution panels which are not part of a motor control center shall be constructed in accordance with Section 26 00 00 – Electrical Work, General. Panels shall have the necessary barriers, supports, and liberal wiring gutters. Trim screws shall be stainless steel. Panelboard parts of metal other than copper, aluminum, or stainless steel shall be cadmium plated.

7. Panelboards shall be UL listed.

8. Panelboards shall be suitable for use as service entrance where indicated.

C. Manufacturers: General Electric, Eaton, Schneider Electric/Square D Company, or equal.

D. Surge Protection Devices (SPD)

1. Provide SPDs. SPDs shall be listed to the latest UL 1449 edition.
2. SPD units shall be rated for the voltage and phase service of the panel at 120 kA per phase.
3. SPD units shall have indicators for the status of each phase.

PART 3 EXECUTION

3.1 GENERAL

A. WORK of this Section shall be installed as indicated in Section 26 00 00, Electrical Work, General.

END OF SECTION

SECTION 26 50 00 - LIGHTING

PART 1 GENERAL

1.1 THE SUMMARY

A. Provide design of interior and exterior lighting system, controls, luminaires and accessories, complete and operable, in accordance with the to meet state and local Code requirements for the location and Contract Documents. Submit and have approved stamped and signed lighting design documents for permit review by the Authority Having Jurisdiction (AHJ).

B. Interior lights will be controlled to meet the requirements as listed on the Contract Drawings or required by Code. All interior lights except exit lights shall be controllable by the lighting control system. Provide lighting controller(s), occupancy sensors, daylight sensors, dimming light switches, etc. as needed.

C. Egress lighting will be automatically turned on during power outages and fire alarm activation to provide the NFPA 101 lighting level for all egress paths shown on the architectural drawings.

D. Outdoor lights will be controlled to be off during daylight. Outdoor lights over egress doors will be automatically turned on during power outages and fire alarm activation to provide the NFPA 101 lighting level for all egress paths shown on the architectural drawings.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Codes

NFPA 70	National Electric Code: 2023 Edition
NEMA 250	Enclosures for Electrical Equipment (1,000 Volts Maximum)
International Building Code (IBC)	Earthquake Requirements
UL-924	Standard for Safety Emergency Lighting and Power Equipment

2021 Oregon Electrical Specialty Code (OESC)

2021 Oregon Energy Efficiency Specialty Code (OEESC)

1.3 CONTRACTOR SUBMITTALS

A. Furnish the following product information in accordance with the requirements of Section 01 33 00, Contractor Submittals and 26 00 00, Electrical Work, General.

B. Furnish the following information:

1. Interior Luminaires

    a. Catalog data sheets and photos

b. Luminaire finish and metal gauge

c. Lens material, pattern, and thickness

1) Candlepower distribution curves in 2 or more planes

d. Candlepower chart, 0 to 90 degrees

e. Lumen output chart

f. Average maximum brightness data in foot-lamberts

g. Coefficients of utilization for zonal cavity calculations

h. Mounting or suspension details

i. Heat exchange and air handling data

2. Exterior Luminaires

a. Catalog data sheets and photos
b. Luminaire finish and metal gauge
c. Lens material, pattern, and thickness
d. IES lighting classification and isolux diagram
e. Fastening details to wall or pole
f. Location, and method of fastening
g. For light poles: wind loading; complete dimensions; and finish

3. Lamps

a. Voltages
b. Colors
c. Approximate life (in hours)
d. Approximate initial lumens
e. Lumen maintenance curve
f. Lamp type and base

4. Photocells

a. Voltage and power consumption
b. Capacity
c. Contacts and time delay
d. Operating levels
e. Enclosure type and dimensions
f. Temperature range

5. Interior and exterior lighting design drawings, etc. as submitted to the permit reviewer / Authority Having Jurisdiction (AHJ).

6. Interior and exterior lighting design drawings, etc. as approved by the permit reviewer / Authority Having Jurisdiction (AHJ).

PART 2 PRODUCTS

2.1 LUMINAIRES

A. General

1. Additional WORK requirements are indicated in the Contract Drawings.

2. The fixtures shown on the Luminaire schedule are only included to be indicative of one specific example the type of light fixtures and placement that meet the energy budget requirements and are not shown to meet all the Code controls requirements.

B. Provide luminaires and mounting accessories compatible with the mounting locations.

C. All lamps shall be LED and similar to those indicated on the Contract Drawings.

D. Provide NEMA-rated enclosures in accordance with the area classifications in which they are installed.

E. Provide minimum 18 AWG wire leads.

F. Exterior Installations

1. Installations shall be UL-labeled as suitable for damp or wet locations as appropriate.

2. When factory-installed photocells and/or motion sensors are provided, the entire assembly shall be UL-labeled.

G. Egress Lighting

1. Power shall be from the dedicated building lighting UL 924 uninterruptible power supply (UPS) with no battery backup in the individual fixtures.

H. Exit Signs

1. Power shall be from the dedicated building lighting UL 924 uninterruptible power supply (UPS) with no battery backup in the individual fixtures.

2.2 POLES – SEE CIVIL DRAWINGS

A. Rating (with luminaire): 100-mph steady winds without incurred damage (Clackamas County, Oregon.

B. Provide factory manufactured bases.

C. Provide anchors and hardware.

D. Provide grout between base and bottom of fixture.

PART 3 EXECUTION

3.1 GENERAL

A. In office and commercial type rooms installation methods normal for those types of rooms are permitted.

B. In treatment, chemical, mechanical and electrical equipment rooms the more stringent methods listed in the Contract Documents apply. All unarmored conductors and cables shall be enclosed in raceways, wireways or cable trays.

C. Lighting power and control conductors and raceways shall not be used by non-lighting loads.

3.2 LUMINAIRES

A. General

1. Install in accordance with the manufacturer's recommendations.

2. Provide necessary hangers, pendants, canopies, and other accessories.

3. Provide additional ceiling bracing, hanger supports, and other structural reinforcements to the building as required to safely mount the luminaire.

4. Install the luminaire plumb and level.

5. The mounting heights indicated for wall-mounted or pendant-mounted luminaires are from the bottom of the luminaire to finished floor or finished grade, whichever is applicable.

6. Coordinate luminaire locations with shelving, cabinets, tall furniture, tall equipment, etc. to avoid obstructions, shadows, illuminate the face of such items, and provide future maintenance access.

7. Install each luminaire outlet box with a galvanized stud.

8. Provide additional seismic restraints where needed.

9. In office and commercial type rooms installation methods normal for those types of rooms are permitted.

10. In treatment, chemical, mechanical and electrical equipment rooms the more stringent methods listed in the Contract Documents apply. All wires shall be enclosed in raceways, wireways or cable trays.

B. Pendant Mounting

1. Provide swivel-type hangers and canopies to match the luminaires, unless otherwise indicated.

2. Provide supports on each fixture mounted in a continuous-row arrangement.

3. Provide twin-stem hangers on single luminaires.

C. Pole Mounting

1. Provide a pre-made concrete base.

2. Install the pole base flush with the finished grade where located in grassy areas not subject to vehicular traffic, and 30 inches above the finished grade when the pole is located in areas subject to damage from vehicular traffic.

3. Set the luminaire poles on anchor bolts and secure with double nuts on each bolt.

4. After the luminaire has been leveled and plumbed, dry-pack the luminaire base with grout.

D. Finished Areas

1. Install the luminaires symmetrically with tile pattern.

2. Locate with the centerline of tile or with centerline of the joint between adjacent tile runs.

3. Install recessed luminaires tight to the finished surface such that no spill light will show between the ceilings and the sealing rings.

4. When installing on combustible low-density cellulose fiberboard, provide spacers and mount luminaires 1-1/2 inches from ceiling surface, or use luminaires suitable for mounting on low-density ceilings.

5. Junction Boxes

   a. Flush and Recessed Luminaires: Locate a minimum of one foot from the luminaire.

   b. In concealed locations, install junction boxes to be accessible by the removal of the luminaire.

6. Wiring and Conduit

   a. Provide wiring of a suitable temperature rating as required by the luminaire.
   b. Provide flexible steel conduit.

7. Provide plaster frames when required by ceiling construction.

8. Independent Supports

   a. Provide each recessed luminaire with 2 safety chains or 2 No. 12 soft-annealed galvanized steel wires of length needed to secure the luminaire to the building structure, independent of the ceiling structure.

   b. Ensure that the tensile strength of chain or wire, and the method of fastening to the structure, is adequate to support the weight of the luminaire.

   c. Fasten the chain or wire to each end of the luminaire.

E. Unfinished Areas

1. Locate the luminaires to avoid conflicts with other building systems and blockage of the luminaire light output.

2. Luminaire Suspension

   a. Provide 3/8- inch minimum threaded steel hanger rods.
   b. Scissor-type hangers will not be accepted.

3. For attachments to steel beams, provide flanged beam clips and straight or angled hangers.

3.3 CLEAN-UP

A. Remove labels and other markings, except the UL listing mark.

B. Wipe the luminaires inside and out in order to remove construction dust.

C. Clean the luminaire plastic lenses with an antistatic cleaner only.

D. Touch up painted surfaces of the luminaires and the poles with matching paint provided by the manufacturer.

E. Replace defective lamps at the Date of Substantial Completion.

END OF SECTION

SECTION 27 15 26 - FIBER OPTIC CABLING

PART 1 GENERAL

1.1 THE SUMMARY

A. The CONTRACTOR shall provide the fiber optic cable system, complete and operable, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. ANSI C8.47 Polyolefin-Insulated Thermoplastic Jacketed Communication Cables

B. EIA - 359 Standard Colors for Color Identification and Coding

C. EIA - 455(Addendum 1 through 5) Standard Test Procedures for Fiber Optic Fibers, Cables, Transducers, Connecting and Terminating Devices

D. EIA - 455-27A Method of Measuring (Uncoated) Diameter of Optical Waveguide Fibers

E. EIA - 455-28A Method For Measuring Tensile Failure Point of Optical Waveguide Fibers

F. EIA - 455-34 Interconnection Device Insertion Loss Test

G. EIA - 455-89 Fiber Optic Cable Jacket Elongation and Tensile Strength

H. MIL - 202 Test Methods for Electronic and Electrical Component Parts

I. MIL - 454 Standard General Requirements for Electronic Equipment

J. MIL - 810 Environmental Test Methods and Engineering Guidelines

K. NEMA TC - 2 Conduit

L. NEMA TC - 3 Accessories

M. UL Standard 514 Accessories

N. UL Standard 651 Conduit

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00, Contractor Submittals.

B. Shop Drawings

1. Catalog Data: Catalog data on conduit system, pullboxes, conduit fittings, conduit plugs, pull rope, identification tape, and warning signs.

2. Detailed bill of materials.

3. Drawings indicating the locations of all pullboxes with station numbers.

4. Catalog data on all testing devices proposed for use plus certifications of accuracy, calibration, and traceability to standards of the National Institute for Standards and Testing.

5. Cable pulling calculations for all conduit runs. Indicate on the submittal any additional pullboxes that are required, including station number and a written description of the location.

6. A cable pulling work plan shall be submitted a minimum of 45 Days prior to the planned initiation of cable pulling. The pulling plan and pull tension calculations may be prepared by using a software program such as **Pull-Planner-4.0** by **American Polywater Corp.**, or equal. The cable pulling work plan must be approved a minimum of 15 Days prior to pulling cable. Work plan shall include the following:

    a. Pull tension calculations.
    b. Calculated amount of lubrication required.
    c. Detailed description of pull operation methods for all conduit runs.
    d. Tools and equipment to be used for cable installation and testing.
    e. Physical location of equipment setup and type.
    f. Safety and manual assist cable pulling operations.
    g. Detailed schedule for pulling and testing cables.

7. Information on at least one successfully performing fiber optic cable installation of comparable size and complexity installed in the recent past with name, address, and telephone number of facility owner, name of project and completion date, and type of conduit system and length of cable pulled.

8. The name and qualifications of the supervisory personnel that will be directly responsible for the installation of the conduit system.

C. Quality Assurance Submittals:

1. Test Report showing compliance with this Section.
2. Manufacturer certification that cable is suitable for installation in conduit underground.

D. Sample of Cable

1.4 QUALITY ASSURANCE

A. The cable manufacturer shall be ISO 9001 registered.

B. The CONTRACTOR shall submit laboratory test reports on representative samples of similar cable design to demonstrate compliance with the following requirements prior to cable installation:

1. Tensile strength per EIA-RS-455-33A and EIA-RS-455-28A
2. Jacket shrinkage per EIA-RS-455-86
3. Cable twist per EIA-RS-455-85
4. Environmental temperature cycling per EIA-RS-455-3A
5. Flexing per EIA-RS-455-104
6. Impact resistance per EIA-RS-455-25A

7. Compressive strength per EIA-RS-455-41
8. Freezing test per EIA-RS-455-98A
9. Mechanical bend test per EIA-RS-455-37

1.5 WARRANTY

A. The CONTRACTOR shall furnish an unconditional warranty on cable for a minimum period of 2 years.

PART 2 PRODUCTS

2.1 MATERIALS

A. Conduit: Conduit shall be 3- or 4-inch diameter Schedule 80 PVC electrical conduit as indicated. Fittings shall be appropriate for underground installation.

B. Pullboxes: Pullboxes shall be designed for H-20 traffic loading with closed bottoms. Covers for pullboxes in paved areas shall be galvanized steel, rated for H-20 traffic loading. Covers for pullboxes in sidewalks and unpaved areas shall be concrete. Bolts shall be 316 stainless steel. Covers shall have the indicate their service usage in raised letters on the top. Covers shall have locking devices and form a watertight seal to prevent surface water from entering. Knockouts in the sidewalls shall permit underground conduit side entry and exit.

C. Conduit Duct Plugs: **Jackmoon Simplex Duct Plugs**, or equal, with bushing sleeves.

D. Pull Rope: Low friction, polyethylene jacketed polypropylene rope with 1800 psi tensile strength, **Vikamatic Fiber Glide**, or equal.

E. Fiber Optic Cable:

1. Cable Type: All dielectric indoor/outdoor plant stranded loose-tube, gel-filled single-mode fiber optic cable, rated for the location, **Corning**, or **Lucent**.

2. Number of fibers: 24 fibers in each cable.

3. Buffer Tubes

a. Optical fibers shall be grouped inside a loose buffer tube. Tubes shall be color coded and arranged symmetrically around the central member.

b. The fibers shall not adhere to the inside walls of the loose buffer tube. Buffer tubes shall be kink resistant within the specified minimum bend radius.

c. Each buffer tube shall be filled with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. The gel shall be free from dirt and foreign matter. The gel shall be readily removable with conventional nontoxic solvents.

d. Buffer tubes shall be stranded around a central member using the reverse oscillation, or "S-Z", stranding process.

e. Binders shall be applied with sufficient tension to secure the buffer tubes to the member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking and dielectric with low shrinkage.

4. Each fiber shall be numbered and color-coded. The colors of the individual fibers shall be stable across the indicated storage and operating temperature range and not be subject to fading or smearing onto each other or into the gel filling material. Colors shall not cause fibers to stick together.

5. Cable Core

   a. Filler may be included in the cable core composition to lend symmetry to the cable cross section where needed.

   b. A central anti-buckling member shall be included in the cable. The anti-buckling member shall be composed of a glass reinforced plastic rod.

   c. The cable core shall contain a water-blocking material. The water blocking material shall be non-nutritive to fungus, electrically non-conductive and homogenous. It shall also be free from dirt and foreign matter and shall be readily removable with conventional nontoxic solvents.

   d. Tensile strength shall be provided by a combination of high tensile strength dielectric yarns. The high tensile strength dielectric yarns shall be helically stranded evenly around the cable core.

6. The dielectric cable jacket shall be suitable for use is duct both indoor and outdoor. The minimum nominal jacket thickness shall be 1.4-mm. Jacketing material shall be applied directly over the tensile strength members and water blocking material. The jacket or sheath shall be free of holes, splits, and blisters. The cable jacket shall contain no metallic elements and shall be of a consistent thickness.

7. The cable shall contain at least one ripcord under the sheath for easy sheath removal.

F. Fan-Out Termination for Loose Tube Cables

1. Individual fibers within the loose tube cable require handling protection inside the termination cabinets. Fan-out kits shall be installed in the patch panel enclosures to transition the loose tube fibers to ruggedized tight-buffered fiber pigtail cables. Fan-out tubes or furcation kits shall not be used. Optical fusion splices shall connect the loose tube fibers to the tight-buffered pigtail cables. The optical splice loss shall comply with the specifications for optical splices. Splice protection sleeves shall protect all splices. A fixed mounted splice center shall house the splices and serve to fully protect excess lengths of loose tube fibers from exposure.

2. The tight-buffered pigtails shall be terminated with connectors to match the equipment terminations.

G. Fan-Out Pigtail Cable Specifications: Single mode fiber (**Corning**, or equal) shall be used in the pigtails. Optical characteristics shall comply with the optical fiber performance specifications.

Buffer material	Thermoplastic
Buffer OD	900 um
Strength Member	Kevlar
Jacket Material	**PVC**
Jacket OD	3.0-mm minimum
Temperature Range	-20 to + 70 degrees C

H. Fiber Optic Termination Patch Panels

1. Where indicated, the fiber optic cable shall terminate inside a server rack on a termination patch panel. Fiber sub-cables within the cable shall be terminated with LC connectors to match the equipment. The patch panel shall have a fiber capacity equal to the total number of fibers (connected and spare) for all cables to be connected. Patch panels shall be designed for either mounting on a standard equipment rack. The patch panel shall contain couplings. Unused couplings shall have protective dust covers. Panels shall be furnished with locking doors. Factory-terminated, tight-buffered, aramid-reinforced fiber optic jumper assemblies or interconnect cables, standard 3.0-mm OD, shall connect the optical cable terminations to the patch panel couplings.

2. The termination patch panel shall be equipped with a suitable means for routing and securing of cables and shall provide a suitable means of protection for the mounted fiber connectors, to prevent damage to fibers and connectors during all regular operation and maintenance functions. Cables shall be provided with strain relief. Bend diameters on cable fibers and jumpers shall be greater than 4-inches for optical and mechanical integrity of the optical fibers, or larger per the manufacturer's recommendations.

I. Optical Connectors

1. Connectors shall be field-installable and perfectly matched to the cable used. The connectors shall provide tight fitting termination to the cladding and buffer coating. Epoxy-based or hot melt adhesives shall be used to bond the fiber and buffer to the connector ferrule and body prior to polishing the end face. No dry-termination or quick crimp connectors are allowed.

2. After termination with connectors, the fiber ends shall be visually inspected at a magnification of not less than 100 power to check for cracks or pits in the end face of the fiber. If irregularities cannot be removed by further polishing, the entire process shall be redone by cutting off and disposing of the connector body.

3. Connectors shall have a maximum allowable connection loss of 0.3 dB per mated pair, as measured per EIA-455-34. No index-matching gel is to be used; only dry interfaces will be accepted.

4. Each connector shall be of the industry standard type compatible with the termination equipment, designed for singlemode tolerances, and shall meet or exceed the applicable

provisions of EIA-455-5, 455-2A, and 455-34, and shall be capable of 100 repeated matings with a maximum loss increase of 0.1 dB.

J. Fiber optic cables shall not be spliced between buildings.

PART 3 EXECUTION

3.1 CONDUIT INSTALLATION

A. General

1. Conduit sections shall be joined in accordance with the manufacturers' recommendations. Joints shall be watertight.

2. Conduit shall be cleaned and tested prior to installation of cables.

3. CONTRACTOR shall install pull rope in the conduit.

4. Conduits entering pullboxes shall be sealed with **Jackmoon Simplex** duct plugs.

5. The conduit shall gradually and smoothly slope up to the elevation of the pullbox entrance. Use of manufactured bends shall be limited to an absolute minimum. Factory bends, if required, shall be no more than 222 degrees and of the long-sweep type.

6. Identification Tape: A 6-inch wide magnetically detectable warning tape with built in trace wire and orange protective polyethylene jacket resistant to alkalis, acids, and other destructive elements shall be installed along the entire length of the conduit route. The polyethylene tape shall be continuously imprinted "CAUTION-FIBER OPTIC CABLE". The warning tape shall be by **3M, Vikamatic**, or equal.

3.2 FIBER OPTIC CABLE INSTALLATION

A. General

1. The CONTRACTOR shall determine a suitable cable installation method to meet all cable installation requirements in all conduit segments. WORK shall be carried out in accordance with and consistent with the highest standards of quality and craftsmanship in the communication industry with regard to the electrical and mechanical integrity of the connections; the finished appearance of the installation; and the accuracy and completeness of documentation.

2. The CONTRACTOR shall make a physical survey of the Site for the purpose of establishing the exact cable routing and cutting lengths prior to the commencement of any WORK or committing any materials.

3. The cable shall be carefully inspected for jacket defects as it is removed from the reel. If defects are noticed, the pulling operation shall be terminated immediately and the ENGINEER notified.

4. Fiber optic cables shall be installed in continuous lengths without intermediate splices throughout the project. Cable installation personnel shall be familiar with the manufacturer's recommended procedures including at least the following:

    a. Pulling using direct attachment to internal strength members.
    b. Cable tensile limitations and tension monitoring procedures.
    c. Cable bending radius limitations.
    d. Cable twisting limitations.

B. Cable Protection During Installation

1. Fiber optic cable shall be pulled in conduit unless indicated otherwise. Care shall be exercised to reduce the possibility of damage to the outer jacket of the fiber optic cable. The requirements herein shall be followed at a minimum, but the CONTRACTOR shall be responsible for additional measures if necessary to protect the cable. Damage shall be repaired by the CONTRACTOR as part of the WORK.

2. The CONTRACTOR shall comply with the cable manufacturer's recommended installation procedures at all times. Cable installation procedures shall conform to **Telcordia (Belcore)** guidelines.

3. A cable feeder guide shall be used between the cable reel and the face of the duct and conduit to protect the cable and guide it off the reel and into the duct. The cable shall be carefully inspected for jacket defects as it is removed from the reel. If defects are noticed, the pulling operation shall be terminated immediately and the ENGINEER notified.

4. Precautions shall be taken during installation to prevent the cable from being kinked, crushed or twisted. A pulling eye shall be attached to the cable end to pull the cable through the duct and conduit system. As the cable is pulled off the reel and into the cable feeder guide, it shall be lubricated.

5. Crushed or kinked cable shall be replaced with new cable.

6. Dynamometers or break away pulling swings shall be used to ensure the pulling line tension does not exceed the installation tension values specified by the cable manufacturer. The mechanical stress placed upon the cable during installation shall not be such that the cable is twisted and stretched. Maximum allowable cable strain during installation shall be less than 0.75 percent.

C. Lubrication: As the cable is pulled into the conduit system, it shall be coated with a water-based lubricant approved by the cable manufacturer. Lubricant shall be applied at a rate to provide a continuous 10-mil coating or as recommended by the manufacturer. Lubricant shall be **Polywater F7** manufactured by **American Polywater Corp.**, or equal.

D. To accommodate long continuous installation lengths, bi-directional "center pull" techniques for pulling of the fiber optic cable are acceptable.

1. From the midpoint, pull the fiber optic cable into the conduit from the shipping reel in accordance with the manufacturer's specifications.

2. When this portion of the pull is complete, the remainder of the cable shall be removed from the reel to make the inside end available for pulling in the opposite direction.

3. This shall be accomplished by hand pulling the cable from the reel and laying it into large "figure 8" loops on the ground. The purpose of the "figure 8" pattern is to avoid cable tangling and kinking.

4. The loops shall be laid carefully one upon the other to prevent subsequent tangling and shall be in a protected area.

5. The inside end of the cable is then available for installation.

6. In some cases, it may be necessary to set up a winch at an intermediate cable vault.

7. The required length of cable shall be pulled to that point, and brought out of the cable vault and coiled into a figure eight.

8. The figure eight is then turned over to gain access to the free cable end. This can then be reinserted into the duct system for installation into the next segment of the conduit.

E. When power equipment is used to install fiber optic cables, the pulling speed shall not exceed 30 meters per minute. The pulling tension, bending radius, and twist limitation for fiber optic cable shall not be exceeded under any circumstances.

F. Large diameter wheels, pulling sheaves, and cable guides shall be used to maintain the appropriate bending radius. Tension monitoring shall be accomplished using commercial dynamometers or load cell instruments.

G. The pulling eye/sheath termination hardware on the fiber optic cables shall not be pulled over any sheave blocks.

H. Pulls shall be documented by a graph which is annotated with the following information:

1. Reel number.
2. Station from and station to.
3. Date and time.
4. Explanations of abnormalities in readings or interruptions.
5. Sign-off by CONTRACTOR and ENGINEER.

I. Under no conditions shall the cable be left exposed or unattended.

J. Repairs: Repair of cable jacket will not be permitted. Jacket damage shall require removal and re-installation of new cable at the CONTRACTOR's expense.

K. Installation at Pullboxes

1. Pulling of the cable shall be hand assisted at each handhole or pullbox. The cable shall not be crushed, kinked, or forced around a sharp corner. Sufficient slack shall be left at each end of the cable to allow proper cable termination.

2. The cable shall be looped in all pullboxes as indicated to provide approximately 15-feet of extra cable in the pullbox. At termination points such as at cabinets or computers, a 15-

foot loop shall also be provided wherever space permits. The fiber optic cable shall be coiled and secured with cable ties in the pullbox. The CONTRACTOR shall not compromise the minimum bending radius of the fiber optic cable when preparing this stored cable slack.

3. Imprinted plastic coated cloth identification/warning tags shall be securely attached to the cables in at least two locations in each handhole. Tags shall be by **Brady** or **Thomas & Betts**.

4. When cables at each pullbox are securely racked, unused conduits and voids around conduit containing cables shall be sealed.

5. Cable Marking: At each pullbox and at each cabinet, the cable shall be visibly marked with yellow warning tape as follows:

"CAUTION - FIBER OPTIC CABLE"

L. Splicing

1. Splicing of fiber optic cable will not be permitted.

3.3 PULLBOXES

A. Field Location of Pullboxes

1. The need for and exact locations shall be determined by the CONTRACTOR based on physical size and arrangement of equipment, finished elevations, calculated cable pulling tensions, field obstructions, and the criteria below. Pullboxes shall be located according to the following criteria:

a. At no point shall the cable pulling tension exceed 600 pounds. If cable pulling tension is calculated to exceed 600 pounds, additional pullboxes shall be provided at no extra cost to the OWNER.

b. The CONTRACTOR shall install pullboxes at locations wherever the cumulative change of direction of the conduit exceeds 180 degrees.

c. The minimum bending radius for conduit shall be at least six times the cable manufacturer's minimum bending radius.

d. A pullbox shall be installed on one side of a tunneled crossing. However, for any crossing which requires more than 180 degrees of conduit bends to account for elevation differences or route adjustments, a pullbox shall be provided on both sides of the crossing.

e. Pullboxes shall be installed a minimum of 12-inches away from all structures.

B. Construction

1. The CONTRACTOR shall install the pullbox covers so that the top of the cover is flush with the restored pavement. Pullboxes installed in soil areas shall be installed so that the top of the cover is at least one-inch but not more than 4-inches above the final grade level of the restored surface to prevent accumulation of dirt, silt, and debris on the top of the hand

hole cover. Pullboxes installed in areas not subject to flooding or standing water shall have a minimum of five 5-inch drainage holes in the bottom of the box.

2. CONTRACTOR shall perform conduit integrity tests for each section between pullboxes after backfilling and compaction using the test and procedures described in this Section. These tests shall be performed prior to installation of the pull rope.

3. Pullbox conduit entries shall be sealed with duct plugs to prevent the intrusion of water and debris into the pullboxes.

4. Pullboxes shall be installed on a compacted level foundation consisting of 4-inches of granular material complying with Section 03 13 00, Earthwork.

5. Compaction around pullboxes and associated details shall be performed in accordance with Section 03 13 00, Earthwork.

6. Upon final acceptance of the conduit system all pullboxes shall be free of debris and water, and be ready for installation.

3.4 MODIFICATIONS

A. All dimensions and exact locations of underground substructures shall be field verified. Minor changes in locations of pullboxes which result in no additional costs for material or labor shall be made at no additional cost to the OWNER. However, the CONTRACTOR shall prepare proposals consisting of detailed material lists, cost estimates, and schedules for rerouting the conduit around existing unforeseen underground utilities and structures which result in additional cost. The CONSTRUCTION MANAGER will consider the proposals in accordance with the provisions of the General Conditions.

B. The CONTRACTOR shall consider the following when preparing proposals:

1. Manufactured bends shall be minimized.
2. Required bends shall be less than 222 degrees.

3.5 CONDUIT SYSTEM CLEANING AND TESTING

A. Following the backfill placement and compaction, all conduits shall be cleared of loose material by brush and compressed air.

B. Conduit shall be tested for leakage by air testing at 5 psi, maintaining the pressure for one hour without showing any leakage.

C. Following the leakage test, a test mandrel d inch smaller than the inside diameter shall be passed through all conduits to detect alignment and deformation problems. Mandrel shall be passed in both directions.

D. Cleaning and testing of the conduit shall be performed by the CONTRACTOR and witnessed by the CONSTRUCTION MANAGER. The cleaning and testing operation shall be conducted for each conduit section between adjacent pullboxes, a section at a time, for the entire route. The results of tests shall be documented by the CONTRACTOR and signed by the CONSTRUCTION MANAGER and the CONTRACTOR.

E. The CONTRACTOR shall provide a 5 Day advance notice of the schedule and location of test to the CONSTRUCTION MANAGER.

F. The CONTRACTOR shall remove and replace conduit which fails either test and shall repeat the test.

3.6 FIBER OPTIC CABLE TESTING

A. General: The CONTRACTOR shall perform pre-installation and post-installation fiber optic cabling (FOC) tests. The CONSTRUCTION MANAGER shall be notified a minimum of 10 Days in advance so that these tests are witnessed. All test equipment shall be traceable to LIST standards.

B. Test equipment: The CONTRACTOR shall use the following to perform pre-installation and post-installation FOC tests:

1. **Optical Time Domain Reflectometer (OTDR):** The OTDR shall be laser precision, **Corning**, or equal.

C. Pre-Installation Tests

1. The purpose of these tests is to perform acceptance tests on the cable prior to installation to verify that the cable conforms to the manufacturer's specifications, and is free of defects, breaks and damages by transportation and manufacturing processes.

2. Prior to removal of each cable from the delivery reel, all optical fibers within the cables shall be tested by the CONTRACTOR using an OTDR. The OTDR tests shall consist of end-to-end length and fiber attenuation (dB/km) measurements to ensure proper performance of the fiber optic cable. The tests shall be performed from both ends of each fiber to ensure complete fiber continuity within the cable structure.

3. Pre-installation, "on-reel" test results shall be compared with the manufacturer's test report delivered with the cable. Gross dissimilarities shall be noted and remedied between the contractor and manufacturer In all cases, all fibers must meet the optical attenuation specifications prior to cable installation.

4. The CONTRACTOR shall perform tests on all reels of cable. The CONSTRUCTION MANAGER shall be notified a minimum of 15 Days prior to any test.

5. The CONTRACTOR shall document each test and submit the report to the CONSTRUCTION MANAGER for review. Documentation shall consist of both hard copy and 32-inch electronic disk complete with all application software.

6. Cable shall not be installed until the CONSTRUCTION MANAGER has reviewed the test report.

7. Maximum allowable attenuation is 0.5 dB/km at 1310 and 1550 nm. The CONTRACTOR shall replace any cable in which any fiber does not meet this requirement.

D. Post-Installation Tests: After FOC has been installed the following tests shall be performed:

1. A recording OTDR shall be used to test for end-to-end continuity and attenuation of each optical fiber. The OTDR shall be equipped with a 1310 nm and 1550 nm light source for the single mode fiber (SMF). The OTDR shall have an X-Y plotter to provide a hard copy record of each trace of each fiber. The OTDR shall be equipped with sufficient internal masking to allow the entire cable section to be tested. This may be achieved by using an optical fiber pigtail of 30-feet or more to display the required cable section.

2. The maximum permissible end-to-end loss shall be 0.5 dB/km. The CONTRACTOR shall replace any cable in which any fiber does not meet this requirement.

3. The OTDR shall be calibrated for the correct index of refraction to provide proper length measurement for the known length of reference fiber.

4. A transmission test shall be performed with the use of a 1310 and 1550 nm stabilized light sources and 1310 nm/1550 nm power meters for SMF. This test shall be conducted in both directions on each fiber of each cable.

5. Hard and electronic copy of test documentation shall be submitted to the CONSTRUCTION MANAGER. The documentation shall include the trace plot, index, dB/km loss, cable length, date and time of test, wavelength, pulse width, the test site, cable ID, fiber number and type, and operator's initials. The CONTRACTOR shall compare the pre-installation test results to the post-installation results. If a deviation of greater than one dB occurs, the CONSTRUCTION MANAGER shall be notified in writing by the CONTRACTOR, and the cable shall be removed and replaced at no additional cost to the OWNER.

6. Upon completion of the previous tests all FOC coils shall be secured with ends capped to prevent intrusion of dirt and water.

E. Required OTDR Trace Information

1. All traces shall display the entire length of cable under test, highlighting any localized loss discontinuities (installation-induced losses and/or connector losses). The trace shall display fiber length (in kilofeet), fiber loss (dB), and average fiber attenuation (in dB/km) as measured between two markers placed as near to the opposite ends of the fiber under test as is possible while still allowing an accurate reading. Care shall be taken to ensure that the markers are placed in the linear region of the trace: away from the front-end response and far-end Fresnel reflection spike. Time averaging shall be used to improve the display signal to noise ratio. The pulse width of the OTDR shall be set to a sufficient width to provide adequate injected power to measure the entire length of the fiber under test.

2. If connectors exist in the cable under test, then two traces shall be recorded. One trace shall record the fiber loss (dB) and average attenuation (dB/km) of the entire cable segment under test, including connectors. The second trace shall display a magnified view of the connector regions, revealing the connector losses (dB). All connector losses shall be measured using the 5 point splice loss measurement technique.

3. The OTDR trace shall also include the following information:

    a. The date and time of the test.
    b. The cable ID number.
    c. The cable segment ID number.
    d. The fiber color or sub-cable number.
    e. Launch point connector number.
    f. The optical wavelength used for the test.
    g. The refractive index setting of the OTDR.
    h. The pulse width setting of the OTDR.
    i. The averaging interval of the test.

3.7 RECORD DRAWINGS

A. In compliance with Section 01 77 00, Project Closeout, the CONTRACTOR shall upon completing the construction of the fiber optic system, shall submit to the CITY Record Drawings showing the following:

1. Horizontal alignment of fiber optic conduit.
2. Vertical alignment of fiber optic conduit.
3. Location of all pullboxes.

END OF SECTION

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SECTION 31 05 13 - SOILS FOR EARTHWORK

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes range of soil and subsoil materials intended to be referenced by other sections, generally for fill and grading purposes. Materials are indicated by "Type" to assist in referencing from other sections and on Drawing notes.

B. Section includes:

1. Subsoil materials
2. Topsoil materials

C. Related Sections

1. Section 31 05 16 - Aggregates for Earthwork
2. Section 31 10 00 – Site Clearing
3. Section 31 22 13 - Rough Grading
4. Section 31 23 16 – Excavation
5. Section 31 23 17 - Trenching
6. Section 31 23 18 – Rock Removal
7. Section 31 23 23 - Fill
8. Section 31 37 00 - Riprap

1.2 REFERENCES

A. American Association of State Highway and Transportation Officials:

1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop ASTM International (ASTM)

2. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)

3. ASTM D2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)

4. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

1.3 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.
B. Materials Source: Submit name of imported materials source.
C. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.4 QUALITY ASSURANCE

A. Furnish materials of each type from same source throughout the Work.

B. Soil Testing:

1. Soil sampling and testing to be completed by an independent laboratory approved by the Engineer.

2. Frequency of testing shall be determined by the Engineer.

3. All soil testing shall be paid for by the Contractor.

C. Compaction Tests:

1. Maximum density at optimum moisture content determined by ASTM D1557 (AASHTO T180).

2. In-place density in accordance with Nuclear Testing Method, ASTM D6938.

D. Soil Classification: All imported materials shall be classified in accordance with ASTM D2487.

PART 2 PRODUCTS

2.1 SUBSOIL MATERIALS

A. Subsoil Type S1, Select Native Material:

1. Select earth obtained from on-site excavations approved for use by Engineer.

2. Graded.

3. Free of peat, humus, vegetative matter, organic matter, and rocks larger than 6 inches in diameter.

4. Processed as required to be placed in thickness as prescribed and at the optimum moisture content to obtain level of compaction required by these specifications.

B. Subsoil Type S2, Imported Fill Material:

1. Imported earth approved for use by Engineer.
2. Meeting the requirements of Subsoil Type S1.

2.2 TOPSOIL MATERIALS

A. Topsoil Type TS1, Select Native Topsoil Material:

1. Top 6 - 12 inches of existing soil containing organic matter.

2. Engineer decision shall be final as to determination of what material is topsoil quality.

3. Graded.

4. Free of roots, rocks larger than ½-inch subsoil, debris, large weeds, and foreign matter.

a. Screening: Single screened.

B. Topsoil Type TS2, Imported Topsoil Material:

1. Imported borrow.

2. Friable loam.

3. Reasonably free of roots, rocks larger than ½-inch, subsoil, debris, large weeds, and foreign matter.

   a. Screening: Single screened.

4. Acidity range (pH) of 5-1/2 to 7-1/2.

5. Containing minimum of 4 percent and maximum of 25 percent inorganic matter.

2.3 SPOILS

A. All excess material not suitable or not required for backfill and grading shall be hauled off site and disposed of at a location provided by the Contractor and approved by the Engineer.

B. Make arrangements for disposal of the material at no additional cost to the Owner.

C. Landfill permit to be obtained by the Contractor and provided to Engineer prior to commencement of disposal.

2.4 SOURCE QUALITY CONTROL

A. Testing and Analysis of Subsoil Material: Perform in accordance with ASTM D1557.

B. When tests indicate materials do not meet specified requirements, change material, or vary compaction methods and retest. Additional testing shall be completed and paid for by the Contractor with no reimbursement by the Owner.

C. Furnish materials of each type from same source throughout the Work.

PART 3 EXECUTION

3.1 EXCAVATION

A. Excavate material of every nature and description to the lines and grades as indicated on the Drawings and/or as required for construction of facilities.

B. Site within clearing limits shall be stripped of topsoil as required to obtain additional topsoil necessary to complete Work indicated in the Drawings or as specified.

C. When practical, do not excavate wet topsoil.

D. Stockpile excavated material meeting requirements for subsoil materials and topsoil materials.

E. Remove excess excavated subsoil and topsoil not intended for reuse from Site.

F. Remove excavated materials not meeting requirements for subsoil materials and topsoil materials from Site.

3.2 STOCKPILING

A. Stockpile soils at locations as approved by Engineer for redistribution as specified.

1. Site may not have sufficient area to stockpile excavated material that will be required for fill later in the Project. If additional stockpile area is required to complete the Project on schedule, arrange off-site stockpile areas.

2. No additional payments will be made for stockpiling excavated materials off-site.

B. Stockpile in sufficient quantities to meet Project schedule and requirements.

C. Prepare stockpile site by clearing and smoothing.

D. Construct stockpiles in neat, regular form occupying as small an areas as possible.

E. Begin by spreading material over entire stockpile base.

F. Build upward in successive layers not exceeding 3 feet in depth.

G. Stockpile topsoil 8 feet high maximum.

H. Do not end dump, shove, or conveyor stack over the sides of the pile.

I. Separate differing materials with dividers or stockpile apart to prevent mixing.

J. Prevent intermixing of soil types or contamination.

K. Direct surface water away from stockpile site to prevent erosion or deterioration of materials.

1. Grade surface of stockpiles to prevent ponding of water.

2. Cover stockpiles to minimize the infiltration of water.

L. Stockpile unsuitable and/or hazardous materials on impervious material and cover to prevent erosion and leaching, until disposed of.

3.3 STOCKPILE CLEANUP

A. Remove stockpile, leave area in clean and neat condition. Grade site surface to prevent free standing surface water.

B. When borrow area is indicated, leave area in clean and neat condition. Grade site surface to prevent free standing surface water.

END OF SECTION

SECTION 31 05 16 - AGGREGATES FOR EARTHWORK

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes a range of coarse and fine aggregate materials intended to be referenced by other Sections, generally for fill and grading purposes. Materials are indicated by "Type" to assist in referencing from other Sections and in Drawing notes.

B. Section Includes:

1. Coarse aggregate materials
2. Fine aggregate materials

C. Related Sections

1. Section 31 05 13 - Soils for Earthwork
2. Section 31 22 13 - Rough Grading
3. Section 31 23 17 - Trenching
4. Section 31 23 19 - Dewatering
5. Section 31 23 23 - Fill
6. Section 31 37 00 - Riprap
7. Section 32 11 23 - Aggregate Base Courses
8. Section 33 11 10 - Water Utility Distribution and Transmission Piping
9. Section 33 41 10 - Storm Utility Drainage Piping
10. Section 33 31 10 - Sanitary Utility Sewage Piping

1.2 REFERENCES

A. American Association of State Highway and Transportation Officials:

1. AASHTO M147 - Standard Specification for Materials for Aggregate and Soil-Aggregate Subbase, Base and Surface Courses

2. AASHTO T27 - Sieve Analysis of Fine and Coarse Aggregates

3. AASHTO T180 - Standard Method for Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop

4. AASHTO TP61 - Standard Method of Test for Determining the Percentage of Fracture in Coarse Aggregate

B. ASTM International (ASTM):

1. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

2. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3))

3. ASTM D2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)

4. ASTM D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

5. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

1.3 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.
B. Materials Source: Submit name of imported materials suppliers.
C. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.
D. Results of aggregate sieve analysis and standard proctor tests for all granular material.

1.4 QUALITY ASSURANCE

A. Furnish each aggregate material from single source throughout the Work.

B. Aggregate Testing:

1. Aggregate sampling and testing to be completed by an independent laboratory approved by the Engineer.

2. The frequency of testing shall be determined by the Engineer.

3. All aggregate testing shall be paid for by the Contractor.

C. Compaction Tests:

1. Maximum density at optimum moisture content determined by ASTM D1557 (AASHTO T180).

2. In-place density in accordance with Nuclear Testing Method, ASTM D6938.

D. Aggregate Classification: All imported materials shall be classified in accordance with ASTM D2487.

PART 2 PRODUCTS

2.1 COARSE AGGREGATE MATERIALS

A. Coarse Aggregate Type A1, Dense-Graded Aggregate: Crushed rock with ¾-inch-0, 1-inch-0, 1-1/2-inch-0, 2-inch-0 and 2-1/2-inch-0 gradation as shown in the Drawings and meeting the requirements provided below.

1. Grading - Dense-graded base aggregate shall be crushed rock, including sand. Uniformly grade the aggregates from coarse to fine.

2. Sieve analysis shall be determined according to AASHTO T27.

3. The aggregates shall conform to one of the grading requirements Table 31 05 16-A below.

Table 31 05 16-A
Grading Requirements for Dense-Graded Aggregate
Separated Sizes
Percent Passing (by weight)

Sieve Size	2-1/2" - 0	2" - 0	1-1/2" - 0	1" - 0	3/4" - 0
3”	100				
2-1/2”	95 - 100	100			
2”	-	95 - 100	100		
1-1/2"	-	-	95 - 100	100	
1-1/4”	55 - 75	-	-	-	
1”	-	55 - 75	-	90 - 100	100
3/4"	-	-	55 - 75	-	90 - 100
1/2"	-	-	-	55 - 75	-
3/8”	-	-	-	-	55 - 75
1/4"	30 - 45	30 - 45	35 - 50	40 - 55	40 - 60
No. 4*	-	-	-	-	-
No. 10	[1]	[1]	[1]	[1]	[1]

[1] Of the fraction passing the 1/4-inch sieve, 40 percent to 60 percent shall pass the No. 10 sieve.
* Report percent passing sieve when no grading requirements are listed.

B. Coarse Aggregate Type A2, Granular Drain Backfill Material: Crushed or uncrushed rock or gravel as shown in the Drawings.

1. Material shall be clean and free draining.

2. Sieve analysis shall be according to AASHTO T27.

3. Grading: Meeting the gradation requirements provided in Table 31 05 16-B below.

Table 31 05 16-B
Grading Requirements for Granular Drain Backfill Material
Separated Sizes
Percent Passing (by weight)

Sieve Size	Separated Sizes 1-1/2-inch – 3/4-inch	Separated Sizes 3/4-inch – 1/2-inch
2-inch	100	
1-1/2-inch	90 - 100	
1-inch	20 - 55	100
3/4-inch	0 - 15	85 - 100
1/2-inch	-	0 - 15
3/8-inch	0 - 5	-

2.2 SAND

A. Sand: Sand material shall consist of granular material, naturally produced, or produced from crushed gravel, or dredge sand that is reasonably free of organic material, mica, clay, fly ash, and other deleterious material, meeting the gradations of Table 31 05 16-C below.

Table 31 05 16-C
Grading Requirements for Sand
Separated Sizes
Percent Passing (by weight)

Sieve Size	Coarse Sand	Medium Sand	Fine Sand
1-inch	100	100	100
3/8-inch	95 - 100	95 - 100	-
#4	80 - 100	70 - 95	90 - 100
#30	10 - 30	10 - 45	-
#100	-	2 - 10	2 - 10
#200	0 - 8	0 - 7	0 - 4
Sand Equivalent	50 min.	50 min.	50 in.

2.3 SOURCE QUALITY CONTROL

A. Coarse Aggregate Material - Testing and Analysis: Perform in accordance with ASTM C136 and ASTM D1557 (AASHTO T180).

B. Sand - Testing and Analysis: Perform in accordance with ASTM C136 and ASTM D1557 (AASHTO T180).

C. When tests indicate materials do not meet specified requirements, change material and retest. Additional testing shall be completed and paid for by the Contractor with no reimbursement by the Owner.

PART 3 EXECUTION

3.1 STOCKPILING

A. Stockpile materials imported to site as shown in the Drawings or at locations as approved by Engineer for redistribution as specified.

B. Separate different aggregate materials with dividers or stockpile individually to prevent mixing.

C. Prevent intermixing of aggregate types or contamination.

D. Direct surface water away from stockpile site to prevent erosion or deterioration of materials.

1. Grade surface of stockpiles to prevent ponding of water.
2. Cover stockpiles to minimize the infiltration of water.

3.2 STOCKPILE CLEANUP

A. Remove stockpile, leave area in clean and neat condition. Grade site surface to prevent free standing surface water.

B. When borrow area is indicated, leave area in clean and neat condition. Grade site surface to prevent free standing surface water.

END OF SECTION

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SECTION 31 10 00 - SITE CLEARING

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes clearing site of incidental paving and curbs, debris, grass, trees, and other plant life in preparation for site or building excavation work.

B. Related Sections:

1. Section 01 56 39 – Temporary Tree and Plant Protection
2. Section 02 41 00 - Demolition
3. Section 31 22 13 - Rough Grading
4. Section 31 23 18 - Rock Removal

1.2 DEFINITIONS

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

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

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

D. Limits of Disturbance: Work area boundary as shown on the Plans.

E. Root Wad: Tree stump and root mass including all roots greater than 1-inch diameter.

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

1.3 SUBMITTALS

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

B. Clearing, Grubbing, and Stripping Plan: Drawings clearly showing proposed limits to clearing, grubbing, and stripping activities at Site.

C. Certification or disposal permit for landfill and/or waste disposal site.

D. A copy of written permission of private property owners, with copy of fill permit for said private property, as may be required for disposal of materials.

1.4 QUALITY ASSURANCE

A. Existing Conditions: Determine the extent of Work required and limitations before proceeding with Work.

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

C. Conform to applicable local, state, and federal codes for environmental requirements and disposal of debris,

1. Burning on Project Site will not be permitted.
2. Use of herbicides will not be permitted.

D. Permits: The Contractor is responsible for obtaining all necessary permits required for completion of the Work described in this Section.

E. Protection of Persons and Property: Meet all federal, state, and local safety requirements for the protection of laborers, other persons, and property in the vicinity of the work and requirements of the General Provisions.

PART 2 PRODUCTS

2.1 MATERIALS

A. Existing Materials: All materials, equipment, miscellaneous items, and debris involved, occurring or resulting from demolition, clearing, and grubbing work shall become the property of the Contractor at the place of origin, except as otherwise indicated in the Drawings or specifications.

B. Wound Paint: Emulsified asphalt formulated for use on damaged plant tissues.

PART 3 EXECUTION

3.1 GENERAL

A. Clear, grub, and strip areas needed for waste disposal, borrow, or Site improvements within limits shown in approved Clearing, Grubbing, and Stripping Plan.

B. Remain within the property lines at all times.

C. Do not injure or deface vegetation or structures that are not designated for removal.

3.2 EXAMINATION

A. Verify existing plant life designated to remain is tagged or identified.
B. Identify waste and salvage areas for placing removed materials.

3.3 PREPARATION

A. Carefully coordinate the work of this Section with all other work and construction.

B. Call Local Utility Line Information service at 1-800-332-2344, not less than three working days before performing Work.

C. Request underground utilities to be located and marked within and surrounding construction areas.

1. Disconnect or arrange for disconnection of utilities (if any) affected by required work.

2. Keep all active utilities intact and in continuous operations.

D. Prepare Site only after:

1. Erosion and sediment controls are in place.

a. Limit areas exposed uncontrolled to erosion during installation of temporary erosion and sediment controls and in compliance with Clackamas County Erosion and Sediment Control Manual, Oregon City Addendum, and ESC Permits.

2. Tree and vegetation protection is installed.

a. Protect existing site improvements, trees, and shrubs to remain to preclude damage during construction.

b. Follow the provisions set forth in 01 56 39, Temporary Tree and Plant Protection for all temporary tree and plant protection measures.

3. Temporary fencing is installed along the Limits of Disturbance.

4. Notification of utility agencies; disconnect or arrange for disconnection of utilities (if any) affected by required work. Keep all active utilities intact and in continuous operation.

3.4 PROTECTION

A. Utilities: Locate, identify, and protect utilities located by utilities and indicated in the Drawings to remain from damage.

B. Survey control: Protect benchmarks, survey control points, and existing structures from damage or displacement.

C. Preservation and Trimming of Trees, Shrubs, and Other Vegetation:

1. Avoid injury to trees, shrubs, vines, plants, grasses, and other vegetation growing outside of the areas to be cleared and grubbed and those trees and shrubs designated to be preserved.

2. Protect existing trees and shrubs against cutting, breaking, or skinning of roots, skinning and bruising of bark, smothering of roots by stockpiling construction materials, excavated materials, excess foot or vehicular traffic, and parking of vehicles within drip line.

3. Provide temporary guards, as necessary, to protect trees and vegetation to be left standing.

4. Temporarily cover exposed roots with wet burlap to prevent roots from drying out, cover with earth as soon as possible.

5. Provide protection for roots and limbs over 1-1/2-inch diameter cut during construction operations. Coat cut faces with emulsified asphalt.

6. Repairable damage to trees and shrubs designated to remain shall be made by a professional tree surgeon approved by the Engineer. Cost shall be borne by the Contractor.

7. Follow Tree Protection Plans and Details as shown in the Drawings.

D. Landscaped Areas:

1. When any portion of the Work crosses private property or landscaped areas, excavate topsoil separately and pile it on the opposite side of the trench from the subsoil.

2. Conduct Work in a manner that will restore original conditions as nearly as practicable.

3. Remove and replace any trees, shrubs, plants, sod, or other vegetative material as needed to complete Work.

4. All shrubs or plants shall be balled by experienced workers, carefully handled and watered, and replaced in their original positions without damage. Sod shall be handled in a similar manner.

5. Wherever sod cannot be saved and restored, the ground must be reseeded and cared for until a stand of grass is reestablished.

6. Plants or shrubs killed or destroyed shall be replaced and paid for by the Contractor.

7. It is the intent of this paragraph that the Contractor shall leave the surface and plantings in substantially the same conditions as before the Work is undertaken.

E. Miscellaneous Site Features: Protect all existing miscellaneous site features from damage by excavating equipment and vehicular traffic, including but not limited to existing structures, fences, mailboxes, sidewalks, paving, and curbs.

F. Repair and Replacement:

1. Damaged items, including but not restricted to those noted above, shall be repaired or replaced with new materials as required to restore damaged items or surfaces to a condition equal to and matching that existing prior to damage or start of work of this contract.

2. Any damage to existing facilities or utilities to remain as caused by the Contractor's operations shall be repaired at the Contractor's expense.

3.5 LIMITS

A. As follows, but not to extend beyond Limits of Disturbance.

1. Excavation: 5 feet beyond top of cut slopes.

2. Trench Excavation: 6 feet from trench centerline, regardless of actual trench width.

3. Fill:

a. Clearing and Grubbing: 5 feet beyond toe of permanent fill.
b. Stripping: 2 feet beyond toe of permanent fill.

4. Structures: 15 feet outside of new structures.

5. Roadways: Clearing, grubbing, scalping, and stripping 5 feet from roadway shoulders.

6. Other Areas: As shown.

B. Remove rubbish, trash, and junk from entire area within the Limits of Disturbance as material is generated. Stockpiling shall not be permitted without written approval of Owner.

3.6 CLEARING AND GRUBBING

A. Clear and grub areas within limits shown in approved Clearing, Grubbing, and Stripping Plan.

B. Except in areas to be excavated, all holes resulting from the clearing and grubbing operations shall be backfilled and compacted in accordance with the applicable sections of these Specifications.

C. Clearing:

1. Remove trees, saplings, snags, stumps, shrubs, brush, vines, grasses, weeds, and other vegetative growth within the clearing limits shown in the Drawings, except those trees and shrubs noted to remain in the Drawings or as directed by the Engineer.

2. Clearing shall be performed in such a manner as to remove all evidence of the presence of vegetative growth from the surface of the Project Site and shall be inclusive of sticks and branches of thickness or diameter greater than 3/8-inch and of grasses, weeds, exceeding 12 inches in height except as otherwise indicated.

3. Clear undergrowth and deadwood, without disturbing subsoil.

D. Grubbing: Clear areas required for access to site and execution of Work and remove all stumps, root wads, and roots over 1-inch diameter to the following depths:

1. Future Structures and Building Areas	24 Inches
2. Roads and Parking Areas	18 Inches
3. All other Areas	12 Inches

3.7 TREE REMOVAL

A. Exercise care in cutting, felling, trimming, and handling of those trees shown for removal to prevent damage to neighboring trees and structures to remain.

B. Tree Salvage: As shown on the Plans.

C. No trees may be removed unless approved and permitted by the Engineer.

D. Do not top trees unless otherwise specified or approved by Owner in writing.

3.8 REMOVAL AND DISPOSAL

A. Native vegetation may be mulched and used on Site.

B. Asphalt and Gravel Surfaces:

1. Asphalt, concrete, and gravel surfaces designated for removal shall be done to full depth.

2. Asphalt, concrete, and gravel removed at Site may be reused at Site where shown in the Drawings or following approval of the Engineer.

3. Haul removed asphalt, concrete, and gravel which is unsuitable for reuse or that exceeds quantity required.

C. Remove debris, rock, abandoned piping, and extracted plant life from Site.

D. Remove from the Site all debris, materials, equipment, and items found thereon and materials and debris resulting from the Work, except as otherwise indicated.

1. All existing improvements designated on the Drawings or specified to be removed including but not limited to structures, pipelines, walls, footings, foundations, slabs, pavements, curbs, fencing, and similar structures occurring above, at, or below existing ground surface shall be included in the Work.

2. Unless otherwise specified, any resulting voids shall be thoroughly cracked out for drainage and backfilled with suitable excavated or imported material compacted to the density of the adjacent soil.

E. Continuously clean-up and remove waste materials from site. Do not allow materials to accumulate on site.

F. Do not burn or bury materials on site. Leave site in clean condition.

G. Removal: All material resulting from demolition, clearing, and grubbing, and trimming operations shall be removed from the Site and disposed of in a lawful manner. Materials placed on property of private property owners shall be by written permission only.

H. Cleanup: During and upon completion of work, promptly remove all unused tools and equipment, surplus materials, and debris.

I. Adjacent areas shall be returned to their existing condition prior to the start of Work.

3.9 CLEANUP

A. During the time Work is in progress, make every effort to maintain the Site in a neat and orderly condition.

B. All refuse, broken pipe, excess fill material, cribbing, and debris shall be removed as soon as practicable.

C. Should the Work not be maintained in a satisfactory condition, the Owner may cause the work to stop until the cleanup of the Work has been done to the satisfaction of the Engineer.

D. The Work will not be considered complete, or the final payment certificate issued until all rubbish, unused material, or equipment shall have been removed and the premises left in a condition satisfactory to the Owner and the Engineer.

END OF SECTION

SECTION 31 22 13 - ROUGH GRADING

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes rough grading and filling associated with contouring of Site in preparation for building excavation and subsequent site work.

B. Section Includes:

1. Excavating topsoil
2. Excavating subsoil
3. Cutting, grading, filling, and rough contouring of Site

C. Related Sections:

1. Section 01 45 00 - Quality Control
2. Section 31 05 13 - Soils for Earthwork
3. Section 31 05 16 - Aggregates for Earthwork
4. Section 31 10 00 - Site Clearing
5. Section 31 23 16 - Excavation
6. Section 31 23 17 - Trenching
7. Section 31 23 18 - Rock Removal
8. Section 31 23 23 - Fill

1.2 REFERENCES

A. American Association of State Highway and Transportation Officials:

1. AASHTO 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

B. ASTM International (ASTM):

1. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

2. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3))

3. ASTM D2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate

4. ASTM D2434 - Standard Test Method for Permeability of Granular Soils (Constant Head)

5. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)

6. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)

1.3 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.
B. Soils for Earthwork: As specified in Section 31 05 13, Soils for Earthwork.
C. Aggregates for Earthwork: As specified in Section 31 05 16, Aggregates for Earthwork.

1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents: Accurately record actual locations of utilities remaining by horizontal dimensions, elevations or inverts, and slope gradients.

1.5 QUALITY ASSURANCE

A. Perform Work in accordance with ASTM C136, ASTM D2419, and ASTM D2434.

B. Tolerances

1. Top Surface of Subgrade: Plus or minus 1/10 from final grade elevation.

PART 2 PRODUCTS

2.1 MATERIALS

A. Subsoil Fill: Type S2 as specified in Section 31 05 13, Soils for Earthwork.

B. Topsoil: As specified in Section 31 05 13, Soils for Earthwork.

1. Type TS1, Select Native Topsoil Material, as may be available.
2. Type TS2, Imported Topsoil Material, as may be required.

C. Structural Fill: Type A1, Dense-Graded Aggregate as specified in Section 31 05 16, Aggregates for Earthwork. Size of aggregate as shown in the Drawings.

D. Granular Fill: Type A2, Granular Drain Backfill Material as specified in Section 31 05 16, Aggregates for Earthwork. Size of aggregate as shown in the Drawings.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify survey benchmark and intended elevations for the Work are as indicated on Drawings.

3.2 PREPARATION

A. Call Local Utility Line Information service at 1-800-332-2344 not less than 3 working days before performing Work.

1. Request underground utilities to be located and marked within and surrounding construction areas.

2. Notify Engineer of any potential conflicts resulting from utility locations and the Drawings.

3. Notify utility company to remove and relocate utilities, as may be necessary.

B. Identify required lines, levels, contours, and datum.

C. See Section 31 10 00, Site Clearing for additional requirements in protection of existing utilities, survey control, plant life, and landscaped areas in coordination with the Work of this Section.

3.3 TOPSOIL EXCAVATION

A. Excavate and stockpile topsoil as specified in Section 31 05 13, Soils for Earthwork.

3.4 SUBSOIL EXCAVATION

A. Excavate subsoil from areas to be further excavated, re-landscaped, or re-graded as shown in the Drawings.

B. When practical, do not excavate wet subsoil. When wet subsoil must be excavated and is to be reused on site for the Work, process wet material to obtain optimum moisture content.

C. Stockpile excavated material in area designated onsite in accordance with Section 31 05 13, Soils for Earthwork.

D. When excavating through roots, perform Work by hand and cut roots with sharp axe.

E. Benching Slopes: Horizontally bench existing slopes greater than 1:2 to key placed fill material to slope to provide firm bearing.

F. Stability: Replace damaged or displaced subsoil as specified for fill.

3.5 FILLING

A. General:

1. Grading and filling operations shall not take place when weather conditions and moisture content of fill materials prevent the attainment of specified density.

2. Vertical curves or roundings at abrupt changes in slope shall be established as approved by Engineer.

3. Bring all graded areas to a relatively smooth, even grade and slope by blading or dragging. Remove high spots and fill depressions.

B. Fill areas to contours and elevations shown in the Drawings with unfrozen materials.

C. Topsoil Fill:

1. Scarify prepared subgrade to depth of 4 inches immediately prior to placing topsoil.

2. Place topsoil in areas to be seeded to depths indicated in the Drawings, minimum depth of 6 inches.

3. Place topsoil material loose; do not compact, do not place in wet or muddy conditions.

D. Place material in continuous layers as follows:

1. Subsoil Fill: Maximum 8 inches compacted depth.
2. Structural Fill: Maximum 8 inches compacted depth.
3. Granular Fill: Maximum 12 inches compacted depth.

E. Maintain optimum moisture content of fill materials to attain required compaction density.

F. Slope grade away from building minimum 2 percent slope for minimum distance of 10 feet, unless noted otherwise.

G. Make grade changes gradual. Blend slope into level areas.

H. Repair or replace items indicated in the Drawings to remain which are damaged by excavation or filling. All costs shall be borne by the Contractor.

3.6 TOLERANCES

A. Top Surface of Subgrade: Plus or minus 1/10th of a foot from required elevation.

3.7 FIELD QUALITY CONTROL

A. Perform laboratory material tests in accordance with AASHTO T-180.

B. Perform in place compaction tests in accordance with the following:

1. Density Tests: ASTM D2922
2. Moisture Tests: ASTM D3017

C. Frequency and location of testing is dependent upon type of material placed. See Section 01 45 00, Quality Control for testing requirements.

D. When tests indicate Work does not meet specified requirements, remove Work, replace, and retest at the sole expense of the Contractor.

END OF SECTION

SECTION 31 23 16 – EXCAVATION

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes excavation required for building foundations,], site structures, or under slabs-on-grade or paving. Excavating for utilities outside building is included in Section 31 23 17, Trenching.

B. Section Includes:

1. Excavating for building foundations
2. Excavating for paving, roads, and parking areas
3. Excavating for slabs-on-grade
4. Excavating for site structures
5. Excavating for landscaping

C. Related Sections:

1. Section 01 45 00 - Quality Control
2. Section 02 41 00 - Demolition
3. Section 26 42 00 - Cathodic Protection
4. Section 31 05 13 - Soils for Earthwork
5. Section 31 05 16 - Aggregates for Earthwork
6. Section 31 10 00 - Site Clearing
7. Section 31 22 13 - Rough Grading
8. Section 31 23 17 - Trenching
9. Section 31 23 18 - Rock Removal
10. Section 31 23 19 - Dewatering
11. Section 31 23 23 - Fill
12. Section 31 50 00 - Excavation Support and Protection
13. Section 33 11 10 - Water Utility Distribution and Transmission Piping.
14. Supplementary Information: Geotechnical report; bore hole locations, and findings of subsurface materials.

1.2 DEFINITIONS

A. Common Excavation: All excavation required for Work, regardless of the type, character, composition, or condition of the material encountered. Common Excavation shall further include all debris, junk, broken concrete, and all other material. All excavation shall be classified as Common Excavation, unless provided as Rock for under Section 31 23 18, Rock Removal below.

B. Common Material: All soils, aggregate, debris, junk, broken concrete, and miscellaneous material encountered in Common Excavation, excluding rock as defined below.

C. Concrete Excavation: The removal of pieces of concrete larger than 1 cubic yard in volume that requires drilling, splitting and breaking methods, or a necessitating a trench width increase of 18 inches or more than the width of the preceding 10 feet of trench. Concrete excavation includes materials composed of Portland cement that are not identified other than manholes, structures, sewer pipe, or other appurtenances.

D. Exploratory Excavation: The removal and replacement of material from locations shown on the Drawings, or as directed for the purpose of investigating underground conditions and identifying potential utility conflict between existing and proposed utilities.

E. Overbreak: Material beyond and outside of the slope limits established by the Owner's Representative, which becomes displaced or loosened during excavation and is excavated.

F. Pothole Excavation: Pothole excavation is the removal and replacement of all materials via coring, vacuum extraction, or similar method, not classified as exploratory excavation, for the purposes of locating an underground utility and to investigate underground conditions.

G. Rock Removal: As defined in Section 31 23 18, Rock Removal.

H. Spoils: Excavated materials from Site unsuitable for use as fill or not required for backfill and grading.

I. Unsuitable Materials: See Spoils.

1.3 REFERENCES

A. Local utility standards when working within 24 inches of utility lines.

1.4 SUBMITTALS

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

B. Excavation Protection Plan: At a minimum, to include the following:

1. Methods and sequencing of mass excavation.
2. Proposed onsite and off-site spoil disposal locations.
3. Anticipated difficulties and proposed resolutions.
4. Proposed routes for Owner's access to Owner's facilities impacted by excavation Work.
5. Proposed haul routes.

1.5 QUALITY ASSURANCE

A. Allowable Tolerances: Final grades shall be plus or minus 0.1-foot.

B. Provide adequate survey control to avoid unauthorized over-excavation.

C. Weather Limitations:

1. Material excavated when frozen or when air temperature is less than 32 degrees Fahrenheit (F) shall not be used as fill or backfill until material completely thaws.

2. Material excavated during inclement weather shall not be used as fill or backfill until after material drains and dries sufficiently for proper compaction.

1.6 QUALIFICATIONS

Special minimum experience qualifications apply to the reservoir excavation and subgrade preparation for this Project. The Earthwork Contractor must be qualified by the Engineer prior to bidding. A Statement of Qualifications Form shall be submitted to the Engineer for review and approval by those prospective earthwork contractors not already listed as prequalified contractors in Section 00 21 13, Instructions to Bidders. Refer to Section 00 21 13, Instructions to Bidders and Section 00 20 60, Earthwork Contractor Statement of Qualifications Form for prequalification information.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.1 PREPARATION

A. Prior to commencing work in this Section, become familiar with site conditions. In the event discrepancies are found, notify the Engineer as to the nature and extent of the differing conditions.

B. Call Local Utility Line Information service at 1-800-332-2344 not less than 3 working days before performing Work.

1. Request underground utilities to be located and marked within and surrounding construction areas.

2. Coordinate with and notify utility companies should it be necessary to remove or relocate facilities.

C. Identify required lines, levels, contours, and datum.

D. See Section 31 10 00, Site Clearing for additional requirements in protection of existing utilities, survey control, plant life, and landscaped areas in coordination with Work in this Section.

3.2 SITE CONDITIONS

A. Quantity Survey: The Contractor shall be responsible for calculations for quantities and volume of cut and fill from existing site grades to finish grades established under this contract as indicated in the Drawings or specified and shall include the cost for all earthwork in the total basic bid.

B. Dust Control: Must meet all federal, state, and local requirements. Protect persons and property from damage and discomfort caused by dust. Water surfaces as necessary and when directed by Engineer to quell dust.

C. Soil Control: Soil shall not be permitted to accumulate on surrounding streets or sidewalks nor to be washed into sewers.

3.3 EXISTING UNDERGROUND UTILITIES

A. Protect active utilities encountered, located or otherwise, and notify persons or agencies owning same.

B. Remove inactive or abandoned utilities from within the project grading limits in accordance with Section 33 11 50, Existing Pipe Abandonment.

C. For sewer and other miscellaneous drainage facilities, fill and plug pipes as follows:

1. General:

a. Remove all structures to a minimum of 3 feet below subgrade, unless otherwise noted.

b. Cover top surface of all abandoned structures with two sheets of nonwoven geotextile, extended at least 1-foot beyond the outside walls of the abandoned manhole, sump, or basin.

c. Plug all abandoned pipes with permanent plugs as specified in Section 33 05 50, Existing Pipe Abandonment.

2. Sumps:

a. Remove existing sediment, soil, and water. Properly dispose of these materials in accordance with the requirements of these specifications.

b. Remove top cone and first solid concrete section to a depth of approximately 8 to 10 feet below ground.

c. Fill sump with CLSM.

d. Backfill remaining voids for facilities within existing or proposed roadways with approved materials meeting the requirements of Section 32 11 23, Aggregate Base Courses.

3. Salvaging Manhole Frames, Covers, and Grates:

   a. Remove manhole frames, covers, and grates scheduled for salvage and store in approved location.

   b. Frames, grates, and covers meeting Specifications may be salvaged from structures to be adjusted and may be reused in the Work if of suitable size and condition.

   c. Replace, at no additional cost to the Owner, all items damaged or lost by the Contractor with similar items that are comparable in all respects with those they are to replace, and which are adequate for the intended purpose.

   d. Clean salvaged components to be reused of foreign material by methods that will not harm the components.

3.4 PRESERVATION OF EXISTING IMPROVEMENT

A. Protect adjacent existing structures which may be damaged by excavation work.

1. Conduct operations in such a manner that existing street facilities, utilities, railroad tracks, structures, and other improvements, which are to remain in place, will not be damaged. Furnish and install cribbing and shoring or whatever means necessary to support material around existing facilities, or to support the facilities themselves, and maintain such supports until no longer needed.

2. Open slopes shall not be cut within 5 feet of any existing spread footings unless approved by the Engineer.

3. Do not interfere with 45 degree bearing splay of foundations unless approved by the Engineer

4. Excavated material shall not be placed adjacent to existing or proposed structures.

3.5 EXCAVATION

A. General:

1. Method of excavation shall be the Contractor's option, but care shall be exercised as final grade is approached to leave it in undisturbed condition.

2. If the final grade for supporting structures is disturbed, it shall be restored to requirements of these Specifications and satisfaction of the Engineer at no additional cost to Owner.

3. The Contractor is advised that footings should be poured as soon as possible to minimize unfavorable final grade conditions from developing.

4. Provide all measures to ensure public safety.

B. Control of Water:

1. Provide and maintain equipment to remove and dispose of water during the course of the work of this Section and keep excavations dry and free of frost or ice.

2. Bearing surfaces that become softened by water or frost must be re-excavated to solid bearing at Contractor's expense and backfilled with compacted crushed rock at Contractor's expense.

3. Grade top perimeter of excavation to prevent surface water from draining into excavation.

4. See additional requirements in Section 31 23 19, Dewatering.

C. Frozen Ground: Frost protection shall be provided for all structural excavation work. Foundation work shall not be placed on frozen ground.

D. Excavate material of every nature and description to the lines and grades as indicated in the Drawings and/or as required for construction of the facility.

1. Allow for forms, shoring, working space, granular base, topsoil, and similar items, wherever applicable.

2. Trim excavations to neat lines. Remove loose matter and lumped subsoil.

E. Excavated Materials: Soils excavated at Site will be treated and used as one of two general categories of material as provided below.

1. Fill:

a. Subsoil Type S1, Select Native Fill, as approved for use by Engineer.

2. Spoils:

a. Ensure there is sufficient suitable material available to complete embankments and other required fillings prior to disposing of any excavated materials.

b. Make arrangements for disposal of spoils and include as part of contract work in preparing of project bids.

c. Landfill permit or written permission from private property owner to be obtained by the Contractor and provided to the Engineer.

F. Shoring:

1. The Contractor shall be solely responsible for excavation protection and worker safety and shall provide sheeting and shoring wherever required, all in accordance with current local, state, and federal laws, codes, and ordinances.

2. Where shoring, sheet piling, sheeting, bracing, lagging, or other supports are necessary to prevent cave-ins or damage to existing structures, it shall be the responsibility of the Contractor to design, furnish, place, maintain, and remove such supports in accordance with applicable ordinances and safety requirements.

3. The design, planning, installation, and removal of all sheeting accomplished in such a manner as to maintain the undisturbed state of the soil below and adjacent to the excavation.

G. Slope existing banks with machine to angle of repose or less until shored.

1. Shape, trim, and finish cut slopes to conform to lines, grades, and cross-sections shown, with proper allowance for topsoil or slope protection, where shown.

2. Protection of excavation side slopes:

a. Use excavation methods that will not shatter or loosen excavation slopes.

b. Where practical, excavate materials without previous loosening and in limited layers or thickness to avoid breaking the material back of the established slope line.

c. Avoid overbreaks. Overbreak is incidental to the Work, except in cases where the Owner's Representative determines that such overbreak was unavoidable.

d. Excavation in rock or rocky cuts:

1) Once completed, thoroughly test the slopes with bars or other approved means to remove all loose, detached, broken, or otherwise unstable material.

2) Remove jutting points. Scale slopes using mine scaling rods or other approved methods to remove loose or overhanging materials and provide a safe, trim, neat, and stable condition.

3) Dispose of the materials removed under this subparagraph in the same manner as other excavated material.

e. Remove all exposed roots, debris, and all stones more than 3 inches in size which are loose or could become loosened.

3. Construct slopes free of all exposed roots.

4. Construct slopes free of unstable rock and loose stones exceeding 3 inches in diameter.

5. Round tops of cut slopes in soil to not less than a 6-foot radius, provided such rounding does not extend off-site, outside of easements, outside of rights-of-way, or adversely impacts existing facilities, adjacent property, or completed Work.

6. Trim all surfaces neatly and smoothly.

H. Compact disturbed load bearing soil in direct contact with foundations to original bearing capacity; perform compaction in accordance with Section 31 23 17, Trenching and Section 31 23 23, Fill.

I. Notify Engineer of unexpected subsurface conditions.

J. Over-excavation for Unsuitable Foundation Conditions:

1. Cross-sectional dimensions and depths of excavations shown in the Drawings shall be subject to such changes as may be found necessary by the Engineer to secure foundations free from soft, weathered, shattered, and loose material or other objectionable materials.

2. Unsuitable materials encountered shall be removed and replaced with Coarse Aggregate Type A1, 2-1/2-inch – 0 gradation, as specified in Table 31 05 16-A of Section 31 05 16, Aggregates for Earthwork. All material placed shall be compacted to 95 percent of maximum dry density.

3. Unsuitable materials shall be removed and replaced only as directed in writing by Engineer.

K. Rock Removal:

1. Remove boulders and rock up to 1/2 cubic yard measured by volume per the requirements of this Section.

2. Remove larger boulders and rock material as specified in Section 31 23 18, Rock Removal.

3. Concrete removal, as defined herein, shall be treated as Rock Removal.

L. Stockpile excavated material in area(s) designated on or off site in accordance with Section 31 05 13, Soils for Earthwork.

3.6 FIELD QUALITY CONTROL

A. Perform excavation and controlled fill operations in accordance with the requirements of this Section.

B. Coordinate the visual inspection and approval of all bearing surfaces by Engineer before installing subsequent work.

3.7 PROTECTION

A. Prevent displacement or loose soil from falling into excavation; maintain soil stability and store excavated materials at a distance from top of excavation.

B. Protect structures, utilities, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth operations.

END OF SECTION

SECTION 31 23 16.26 - ROCK REMOVAL

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes removal of subsurface rock during excavation by mechanical method. The use of explosives for rock removal is not permitted for this Project.

B. Section Includes:

1. Removing identified and discovered rock during excavation.
2. Expansive tools to assist rock removal.

C. Related Sections:

1. Section 31 22 13 - Rough Grading
2. Section 31 23 16 - Excavation: Building excavation
3. Section 31 23 17 - Trenching: Trenching and backfilling for utilities
4. Section 31 23 23 - Fill: Backfill materials
5. Section 31 37 00 - Riprap

D. Supplemental Information: Geotechnical report; bore hole locations and findings of subsurface materials.

1.2 REFERENCES – NOT USED

1.3 DEFINITIONS

A. Common Excavation: All excavation required for Work, regardless of the type, character, composition, or condition of the material encountered. All excavation shall be classified as Common Excavation, unless provided for under Rock Removal below.

B. Common Material: All soils, aggregate, debris, junk, broken concrete, and miscellaneous material encountered in Common Excavation, excluding rock as defined below.

C. Rock: Solid mineral material, including boulders, solid bedrock, or ledge rock, with volume in excess of 1/2 cubic yard or solid material which, by actual demonstration, cannot be reasonably excavated with suitable machinery as defined herein. The Engineer may waive the requirements for actual demonstration if the material encountered is well-defined rock.

D. Rock Removal: Removal of rock as defined herein by systematic and continuous drilling, hammering, breaking, splitting, or other methods approved by the Engineer.

E. Suitable Machinery: A track-mounted hydraulic excavator of the 52,800- to 72,500-pound class equipped with a single shank ripper.

1.4 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Submittal procedures.

B. Shop Drawings: Indicate proposed method of rock removal.

C. Equipment: Manufacturer information regarding pound class of machinery proposed for rock removal.

D. Survey Report: Submit survey report mapping extent and locations of rock encountered, to be used in calculating total volume of rock removal.

1.5 QUALITY ASSURANCE – NOT USED

1.6 PROJECT CONDITIONS

A. Conduct survey of rock uncovered in excavation for structures or trenching for utilities prior to removal of material.

1.7 SCHEDULING – NOT USED

PART 2 PRODUCTS

2.1 MATERIALS – NOT USED

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify site conditions and note subsurface irregularities affecting Work of this section.

3.2 PREPARATION

A. Identify required lines, levels, contours, and datum.

B. Engineer Approval for Rock Removal:

1. Prior to commencement of rock removal, expose all material anticipated to be rock by removing the common material above it and then notify the Engineer.

2. The Engineer, in association with the Contractor or the Contractor's representative, will measure the amount of material to be removed in an effort to reach a mutually agreeable volume for anticipated rock removal.

3. Prior to commencing the proposed rock removal, the Contractor must receive written approval by the Engineer stating the approximate volume of expected rock removal to receive payment.

4. During rock removal activities, should it become apparent the previously agreed upon volume of rock removal will be exceeded, notify the Engineer immediately. Should the Contractor proceed with rock removal in excess of the previously agreed upon volume, the Contractor will do so at their own risk and expense.

3.3 ROCK REMOVAL BY MECHANICAL METHOD

A. Excavate and remove rock by mechanical method.

1. Use single shank ripper to fracture rock.
2. Drill holes and use expansive tools and wedges to fracture rock.

B. Cut away rock at bottom of excavation to form level bearing.

C. Remove shaled layers to provide sound and unshattered base for footings and foundations.

D. In utility trenches, excavate to 6 inches below invert elevation of pipe and 24 inches wider than pipe diameter.

E. For vaults and other structures, excavate to the depth necessary to install the structure and to a maximum of 18 inches beyond the outside walls of the vault or structure.

F. Remove excavated materials from site.

G. Correct unauthorized rock removal associated with structural excavations in accordance with backfilling and compacting requirements of Section 31 23 16, Excavation and as directed by Engineer.

H. Correct unauthorized rock removal associated with utility work in accordance with backfilling and compacting requirements of Section 31 23 17, Trenching and as directed by Engineer.

I. If material which would be classified as rock as defined herein is mechanically removed with equipment of a larger size than specified as Suitable Machinery herein, it shall be understood that any added costs for the removal of rock by this method shall be included in the unit price for common excavation and not paid for under this pay item. If material which would be classified as rock as defined herein is mechanically removed without [blasting,] hammering, breaking, or splitting, it will be considered common excavation and not paid for under this pay item. If equipment larger than the suitable machinery as defined herein is brought on the Project Site for the sole purpose of rock removal without hammering, breaking, or splitting, then such excavation will be considered rock removal.

3.4 ROCK REMOVAL BY EXPLOSIVE METHODS – NOT USED

3.5 FIELD QUALITY CONTROL

A. Request visual inspection of foundation bearing surfaces by Engineer before installing subsequent work.

END OF SECTION

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SECTION 31 23 19 – DEWATERING

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes temporary dewatering and surface water control systems for open excavations and utility trenches.

B. Section includes:

1. Dewatering systems.
2. Surface water control systems.
3. System operation and maintenance.
4. Water disposal.

C. Related Sections:

1. Section 02 30 00 - Subsurface Investigations
2. Section 31 05 16 - Aggregates for Earthwork
3. Section 31 23 16 - Excavation
4. Section 31 23 17 - Trenching

1.2 SUBMITTALS

A. Dewatering Plan:

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. Plan to be reviewed by the Engineer prior to the beginning of construction activities requiring dewatering. Review by the Engineer of the design shall not be construed as a detailed analysis of the adequacy of the dewatering system, nor shall any provisions of the above requirements be construed as relieving the Contractor of its overall responsibility and liability for the work.

1.3 DEFINITIONS

A. Dewatering includes the following:

1. Lowering of ground water table and intercepting horizontal water seepage to prevent ground water from entering excavations, trenches, tunnels, and /or shafts.

2. Reducing piezometric pressure within strata to prevent failure or heaving of excavations, trenches, tunnels, and /or shafts.

3. Disposing of removed water.

B. Surface Water Control: Removal of surface water within open excavations.

1.4 QUALITY CONTROL

A. All dewatering operations shall be adequate to assure the integrity of the finished project and shall be the responsibility of the Contractor.

B. Provide all labor, materials, and equipment necessary to dewater trench and structure excavations, in accordance with the requirements of the Contract Documents.

C. Secure all necessary permits to complete the requirements of this Section.

D. Control the rate and effect of the dewatering in such a manner as to avoid all objectionable settlement and subsidence.

E. Where the critical structures or facilities exist immediately adjacent to areas of proposed dewatering, reference points shall be established and observed at frequent intervals to detect any settlement which may develop.

1. The responsibility for conducting the dewatering operation in a manner which will protect adjacent structures and facilities rests solely with the Contractor.

2. The cost of repairing any damage to adjacent structures and restoration of facilities shall be the responsibility of the Contractor.

PART 2 PRODUCTS

2.1 EQUIPMENT

Dewatering, where required, may include the use of well points, sump pumps, temporary pipelines for water disposal, rock or gravel placement, and other means. Standby pumping equipment shall be maintained on the jobsite.

PART 3 EXECUTION

3.1 DEWATERING

A. Provide all equipment necessary for dewatering.

1. Have on hand, at all times, sufficient pumping equipment and machinery in good working condition.

2. Have available, at all times, competent workers for the operation of the pumping equipment.

3. Adequate standby equipment shall be kept available at all times to insure efficient dewatering and maintenance of dewatering operation during power failure.

B. Dewatering for structures and pipelines shall commence when groundwater is first encountered and shall be continuous until such times as water can be allowed to rise in accordance with the provisions of this Section or other requirements.

C. Site Grading:

1. At all times, site grading shall promote drainage.

2. Surface runoff shall be diverted from excavations.

3. Water entering the excavation from surface runoff shall be collected in shallow ditches around the perimeter of the excavation, drained to sumps, and be pumped or drained by gravity from the excavation to maintain a bottom free from standing water.

D. Dewatering shall at all times be conducted in such a manner as to preserve the undisturbed bearing capacity of the subgrade soils at proposed bottom of excavation.

E. If foundation soils are disturbed or loosened by the upward seepage of water or an uncontrolled flow of water, the affected areas shall be excavated and replaced with drain rock.

F. Maintain the water level below the bottom of excavation in all work areas where groundwater occurs during excavation construction, backfilling, and up to acceptance.

G. Flotation shall be prevented by maintaining a positive and continuous removal of water. The Contractor shall be fully responsible and liable for all damages which may result from failure to adequately keep excavations dewatered.

H. If well points or wells are used, they shall be adequately spaced to provide the necessary dewatering and shall be sandpacked and/or other means used to prevent pumping of fine sands or silts from the subsurface. A continual check shall be maintained to ensure that the subsurface soil is not being removed by the dewatering operation.

I. Dispose of water from the work in a suitable manner without damage to the environment or adjacent property. No water shall be drained into work built or under construction without prior consent of the Engineer. Water shall be filtered using an approved method to remove sand and fine sized soil particles before disposal into any drainage system.

J. The release of groundwater to its static level shall be performed in such a manner as to maintain the undisturbed state of the natural foundation soils, prevent disturbance of compacted backfill and prevent flotation or movement of structures, pipelines, and sewers.

K. Dewatering of trenches and other excavations shall be considered as incidental to the construction of the work and all costs thereof shall be included in the various contract prices in the bid forms.

END OF SECTION

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SECTION 31 23 23 – FILL

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes backfilling required at building perimeter and site structures to subgrade elevations, fill under interior and exterior slabs-on-grade or pavement, and fill under landscaped areas. Backfilling for utilities within building proper is included within this section; backfilling for utilities outside building is included in Section 31 23 17, Trenching.

B. Section includes:

1. Backfilling building perimeter to subgrade elevations.
2. Backfilling site structures to subgrade elevations.
3. Fill under slabs-on-grade.
4. Fill under paving.
5. Fill for over-excavation.

C. Related Sections:

1. Section 03 30 00 - Cast-In-Place Concrete
2. Section 31 05 13 - Soils for Earthwork
3. Section 31 05 16 - Aggregates for Earthwork
4. Section 31 22 13 - Rough Grading
5. Section 31 23 16 - Excavation
6. Section 31 23 17 - Trenching
7. Section 31 23 24 - Flowable Fill
8. Section 31 25 00 - Erosion and Sediment Controls
9. Section 31 37 00 - Riprap
10. Section 33 11 10 - Water Utility Distribution and Transmission Piping
11. Section 33 31 13 – Public Sanitary Utility Sewerage Piping
12. Section 33 41 10 - Storm Utility Drainage Piping
13. Supplementary Information: Geotechnical report; bore hole locations, and findings of subsurface materials. Contaminated Media Management Plan, Phase II Environmental Site Assessment

1.2 REFERENCES

A. American Association of State Highway and Transportation Officials:

1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.

B. ASTM International (ASTM):

1. ASTM C403 - Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance

2. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).

3. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

4. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

5. ASTM D4832 - Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.

1.3 DEFINITIONS

A. Controlled Low Strength Material (CLSM): Also referred to as Flowable Fill elsewhere in these Specifications. A self-compacted, cementitious material.

B. Imported Material: Materials obtained from sources offsite, suitable for specified use.

C. Lift: Loose (uncompacted) layer of material.

D. Optimum Moisture Content:

1. Determined in accordance with ASTM Standard specified to determine maximum dry density for relative compaction.

2. Determine field moisture content on basis of fraction passing 3/4-inch sieve.

1.4 SUBMITTALS

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

B. Imported Materials:

1. Materials Source: Submit name and location of imported fill materials suppliers.
2. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.
3. Submit results of aggregate sieve analysis and standard proctor test for granular material.

C. CLSM: Mix designs in accordance with Submittal requirements of Section 31 23 24, Flowable Fill.

1.5 QUALITY ASSURANCE

A. Subsoil and topsoil fill materials: In accordance with Quality Assurance requirements stated in Section 31 05 13, Soils for Earthwork.

B. Aggregate fill materials: In accordance with Quality Assurance requirements stated in Section 31 05 16, Aggregates for Earthwork.

C. CLSM:

1. In-place testing: In accordance with ASTM C403.
2. Compressive testing: In accordance with ASTM D4832.

D. Allowable Tolerances: Final grades shall be plus or minus 0.1-foot.

PART 2 PRODUCTS

2.1 FILL MATERIALS

A. Subsoil Fill: Type S2, Imported Fill Material, as specified in Section 31 05 13, Soils for Earthwork.

B. Imported Granular Fill: Coarse Aggregate Type A1, Dense-Graded Aggregate with gradation as shown in the Drawings and specified in Section 31 05 16, Aggregates for Earthwork.

C. Concrete:

1. Lean concrete as specified in Section 31 23 24, Flowable Fill, with compressive strength of 100 pounds per square inch (psi).

2. Structural concrete as specified in Section 03 30 00, Cast-in-Place Concrete. Compressive strength as required by the application or as noted in the Drawings.

D. Drain Rock: Coarse Aggregate Type A2, Granular Drain Backfill Material with gradation as shown in the Drawings and specified in Section 31 05 16, Aggregates for Earthwork.

E. Foundation Stabilization Material: Coarse Aggregate Type A1, Dense-Graded Aggregate, 2-1/2-inch - 0 gradation as specified in Section 31 05 16, Aggregates for Earthwork.

PART 3 EXECUTION

3.1 EXAMINATION

A. Prior to Work in this Section, become familiar with Site conditions. In the event discrepancies are found, notify Engineer as to the nature and extent of the differing conditions.

B. Verify sub-drainage, damp-proofing, or waterproofing installation has been inspected.

C. Verify underground tanks are anchored to their own foundations to avoid flotation after backfilling.

D. Verify structural ability of unsupported walls to support loads imposed by fill.

3.2 SITE CONDITIONS

A. Quantity Survey: The Contractor shall be responsible for calculations for quantities and volume of cut and fill from existing site grades to finish grades established under this contract as indicated in the Drawings or specified and shall include the cost for all earthwork in the total basic bid.

B. Dust Control: Must meet all federal, state, and local requirements. Protect persons and property from damage and discomfort caused by dust. Water surfaces as necessary and when directed by Engineer to quell dust.

C. Soil Control: Soil shall not be permitted to accumulate on surrounding streets or sidewalks nor to be washed into sewers.

D. See provisions for Work in Section 31 25 00, Erosion and Sediment Controls.

3.3 PREPARATION

A. Identify required lines, levels, contours, and datum locations.

B. Control of Water:

1. Excavated areas shall be kept free of water and frost.

2. Bearing surfaces which become softened by water or frost shall be re-excavated to solid bearing at Contractor's expense and backfilled with compacted crushed rock at Contractor's expense.

3. See Section 31 23 19, Dewatering for additional details.

C. Compact subgrade to density requirements for subsequent backfill materials.

D. Cut out soft areas of subgrade not capable of compaction in place and replace with specified granular fill material. See Article 3.5, Over-excavation for Unsuitable Foundation Conditions in Section 31 23 16, Excavation for additional details.

E. Proof roll to identify soft spots; fill and compact to density equal to or greater than requirements for subsequent fill material.

F. Subgrade to be approved by Engineer prior to placement of structures and commencement of backfill activities.

G. Do not allow or cause any work performed or installed to be covered up or enclosed prior to required tests and approvals. Should any Work be enclosed or covered up, uncover at Contractor's expense.

3.4 BACKFILLING

A. Backfill areas to contours and elevations shown in the Drawings with unfrozen materials.

B. Do not place materials when weather conditions and/or moisture content prevent attainment of specified density.

C. Maintain optimum moisture content of backfill materials to attain required compaction density.

D. Employ placement method that does not disturb or damage other work.

E. Mechanical tampers permitted in confined areas.

F. Systematically backfill to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen, or spongy subgrade surfaces.

G. Foundation Base for Structures:

1. Bring excavation to required subgrade elevation shown in the Drawings.

2. Place foundation base material to required grade shown in the Drawings.

3. Place foundation base material in 6-inch lifts and compact to 92 percent maximum dry density.

4. Water Quality Systems Building:

a. Concrete Footings: Place a 12-inch minimum layer of Coarse Aggregate Type A1, Dense-Graded Aggregate, 3/4-inch-0 gradation to required grade under all concrete footings, extending 12 inches horizontally outward from the edges of footings.

b. Concrete Slabs: Place a 12-inch minimum layer of Coarse Aggregate Type A1, Dense-Graded Aggregate, 3/4-inch-0 gradation under all concrete slabs.

H. Backfill for Structures:

1. Prior to placing backfill, remove forms, temporary construction, and debris below grade.

2. Backfill shall not be placed against poured concrete until 28 days have passed from completion of original concrete pour, unless otherwise approved by Engineer.

3. Heavy compactors and large pieces of construction equipment shall be kept away from any embedded wall a distance of a least 5 feet in order to avoid the build-up of excessive lateral pressures.

a. Over-compaction of fill near walls should be avoided.

4. Compaction within 5 feet of the walls shall be accomplished using hand-operated vibratory plate compactors or tamping units.

5. The maximum particle size of granular material placed against buried structures shall be limited to no greater than 1-1/2-inch diameter.

6. Structural fill backfill material shall be brought up on all sides of the walls and footings in such a manner as to avoid adverse differential lateral earth pressures on the vertical surfaces.

7. Appropriate lift thickness will depend on the type of compaction equipment used and the type of material being placed. All material shall be compacted to at least 95 percent of the maximum dry density.

    a. For moderate- to heavy-weight compactors, a maximum loose lift thickness of 8 inches shall be used.

    b. For hand-operated or small compactors, a maximum loose lift thickness of 8 inches shall be used.

8. Particular care must be taken to avoid damage to the pipe connections to the structure.

9. Utility trench backfill within 10 feet of all structural perimeters shall meet the requirements for structural fill.

I. For areas receiving surface structures or existing paved areas to be constructed or replaced, such as roadways, driveways, and sidewalks:

1. Place Coarse Aggregate Type A1, Dense-Graded Aggregate, 3/4-inch-0 gradation in 6-inch lifts.

2. Compact with vibratory equipment to 95 percent maximum density, unless otherwise specified or shown in the Drawings.

J. Permanent Embankment Fill:

1. On the sloping ground around the water quality systems building the new embankment fill shall be placed in horizontal lifts on a continuous series of minimum 6-foot-wide horizontal benches excavated into the surface of the existing slope.

2. Fill slopes shall be slightly overbuilt and then trimmed back to final grade using a track hoe with a smooth-edged bucket.

3. The Engineer shall review the proposed placement of any fill and evaluate the subgrade prior to fill placement.

4. The proposed compaction equipment shall be approved by the Engineer prior to fill placement to evaluate loads on embedded walls.

5. Permanent embankment fill placed beyond 5 feet of the embedded walls and beneath buildings, pavement, and other structures should be compacted to at least 95 percent of the maximum dry density.

6. Landscape fill shall be compacted to at least 90 percent of the maximum dry density as determined by ASTM D 698. Landscape fill should be no steeper then 3H:1V, unless shown otherwise.

K. Slope grade away from building minimum 3 percent slope for minimum distance of 10 feet, unless noted otherwise in the Drawings.

L. Make gradual grade changes. Blend slope into level areas.

M. Remove surplus backfill materials from Site in accordance with Section 31 23 16, Excavation.

3.5 FIELD QUALITY CONTROL

A. All testing and reporting shall be conducted and completed by an independent laboratory provided by the Owner. Initial testing will be paid for by the Owner. Subsequent testing after failure of initial acceptance testing shall be paid by the Contractor.

B. Perform laboratory material tests in accordance with ASTM D1557 (AASHTO T180).

C. In-place compaction testing for structural fill material shall be performed at 2-foot elevation increments in the fill material with at a minimum of one test per each 2,500 square feet of material placed. The Engineer shall be provided with the results of each compaction test at the time of testing.

D. Perform in place compaction tests in accordance with the following:

1. Density Tests: ASTM D2922.
2. Moisture Tests: ASTM D3017.

E. When tests indicate Work does not meet specified requirements, remove Work, replace, and retest at the sole expense of the Contractor.

F. When testing of subgrade is not possible or feasible as detailed above, proof roll compacted fill surfaces under slabs-on-grade, pavers, paving, and as may be otherwise required by the Engineer.

3.6 PROTECTION OF FINISHED WORK

A. Reshape and re-compact fills subjected to vehicular traffic.

3.7 SCHEDULE – NOT USED

END OF SECTION

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SECTION 31 23 23.33 - FLOWABLE FILL

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes flowable lean concrete mix used for structure backfill, utility bedding and backfill and other subgrade Site Work. Applications also include filling abandoned structures and utilities that remain in place.

B. Section Includes:

1. Structure backfill
2. Utility bedding
3. Utility backfill
4. Filling abandoned utilities

C. Related Sections:

1. Section 33 11 50 - Removal and Abandonment of Existing Pipe and Structures
2. Section 31 23 16 - Excavation
3. Section 31 23 17 - Trenching
4. Section 31 23 23 - Fill
5. Section 33 11 10 - Water Utility Distribution and Transmission Piping
6. Section 33 31 10 – Gravity Sanitary Utility Sewerage Piping
7. Section 33 41 10 - Storm Utility Drainage Piping

1.2 DEFINITIONS

A. Flowable Fill: Also referred to as Controlled Low Strength Material (CLSM) elsewhere in the Specifications. Lean cement concrete fill.

B. Utility: Any buried pipe, duct, conduit, manhole, tank, or cable.

1.3 REFERENCE STANDARDS

A. ASTM International (ASTM):

1. ASTM C33 - Standard Specification for Concrete Aggregates

2. ASTM C94 - Standard Specification for Ready-Mixed Concrete

3. ASTM C150 - Standard Specification for Portland Cement

4. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete

5. ASTM C403 - Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance

6. ASTM C494 - Standard Specification for Chemical Admixtures for Concrete

7. ASTM C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete

8. ASTM C1017 - Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete

9. ASTM C1040 - Standard Test Methods for Density of Unhardened and Hardened Concrete in Place by Nuclear Methods

10. ASTM D4832 - Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders

1.4 SUBMITTALS

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

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

C. Field Quality-Control Submittals:

1. Mix Design:

a. Furnish flowable fill mix design for each specified strength.

b. Furnish separate mix designs when admixtures are required for the following:

1) Flowable fill Work during hot and cold weather.
2) Air entrained flowable fill Work.

c. Identify design mix ingredients, proportions, properties, admixtures, and tests.

2. Furnish test results to certify flowable fill mix design properties meet or exceed specified requirements.

D. Delivery Tickets:

1. Furnish duplicate delivery tickets indicating actual materials delivered to Project Site.

2. Prepare delivery tickets containing the following information:

a. Project designation
b. Date
c. Time
d. Class and quantity of flowable fill
e. Actual batch proportions
f. Free moisture content of aggregate
g. Quantity of water withheld

1.5 QUALITY ASSURANCE

A. In-place testing of Flowable Fill: In accordance with ASTM C403.
B. Compressive testing of Flowable Fill: In accordance with ASTM D4832.

1.6 ENVIRONMENTAL REQUIREMENTS

A. Minimum Conditions: The following minimum conditions shall be met at time of flowable fill placement.

1. Do not install flowable fill during inclement weather.

2. Ambient temperature must be at least 34 degrees Fahrenheit (F) and rising.

3. Flowable fill shall be at 40 degrees F.

4. Subgrade on which flowable fill is to be placed shall be free of disturbed or soft material, debris, and water.

1.7 FIELD MEASUREMENTS

A. Verify field measurements before installing flowable fill to establish quantities required to complete the Work.

PART 2 PRODUCTS

2.1 FLOWABLE FILL

A. Flowable Fill:

1. Composed of cement, pozzolans, fine aggregate, water, and admixtures.

2. Low cement content.

3. Non-segregating, self-consolidating, free-flowing, and excavatable material which will result in a hardened, dense, non-settling fill.

4. Compressive strength at 28 days of 100 to 200 pounds per square inch (psi), if not otherwise shown in Drawings or specified.

2.2 MATERIALS

A. Portland Cement: ASTM C150, Type I.
B. Fine Aggregates: ASTM C33.
C. Water: Clean and not detrimental to concrete.

2.3 ADMIXTURES

A. Air Entrainment: ASTM C260.

B. Chemical Admixture: ASTM C494.

C. Fly Ash: ASTM C618 Class C or F, obtained from residue of electric generating plant using ground or powdered coal.

2.4 MIXES

A. Mix and deliver flowable fill according to ASTM C94, Option C.

B. Flowable Fill Design Mix:

ITEM	PROPERTIES
Cement Content	75 to 100 lb/cu yd
Fly Ash Content	[None]
Water Content	As specified
Air Entrainment	5 to 35 percent
28-Day Compressive Strength	Maximum 200 psi.
Unit Mass (Wet)	80 [100] to 110 [125] pcf
Temperature, Minimum at Point of Delivery	50 degrees F (10 degrees C)

C. Provide water content in design mix to produce self-leveling, flowable fill material at time of placement.

D. Design mix air entrainment and unit mass are for laboratory design mix and source quality control only.

2.5 SOURCE QUALITY CONTROL

A. Test and analyze properties of flowable fill design mix and certify results for the following:

1. Design mix proportions by weight of each material.

2. Aggregate: ASTM C33 for material properties and gradation.

3. Properties of plastic flowable fill design mix including:

   a. Temperature
   b. Slump
   c. Air entrainment
   d. Wet unit mass
   e. Yield
   f. Cement factor

4. Properties of hardened flowable fill design mix including:

   a. Compressive strength at 1-day, 7 days, and 28 days. Report compressive strength of each specimen and average specimen compressive strength.

   b. Unit mass for each specimen and average specimen unit mass at time of compressive strength testing.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify excavation specified in Section 31 23 16, Excavation and trenching specified in Section 31 23 17, Trenching is complete.

B. Verify utility installation as specified in elsewhere in the specifications is complete and tested before placing flowable fill.

C. Verify excavation is dry and dewatering system is operating, as may be required, prior to placement of flowable fill.

3.2 PREPARATION

A. Support and restrain utilities to prevent movement and flotation during installation of flowable fill.

B. Protect structures and utilities from damage caused by hydraulic pressure of flowable fill before fill hardens.

C. Protect utilities and foundation drains to prevent intrusion of flowable fill.

3.3 INSTALLATION – FILL, BEDDING, AND BACKFILL

A. Place flowable fill by chute, pumping, or other methods as approved by Engineer.

B. Place flowable fill in lifts to prevent lateral pressures from exceeding structural capacity of structures and utilities.

C. Place flowable fill evenly on both sides of utilities to maintain alignment.

D. Place flowable fill to elevations indicated on Drawings without vibration or other means of compaction.

3.4 INSTALLATION – FILLING ABANDONED UTILITIES

A. As specified in Section 33 11 50, Existing Pipe Abandonment.

3.5 FIELD QUALITY CONTROL

A. Perform inspection and testing according to ASTM C94.

1. Take samples for tests for every 100 cubic yards of flowable fill, or fraction thereof, installed each day.

2. Sample, prepare, and test four compressive strength test cylinders according to ASTM D4832. Test one specimen at 3 days, one at 7 days, and two at 28 days.

3. Measure temperature at point of delivery when samples are prepared.

B. Further construction proceeding upon placed flowable fill will be permitted only after initial set is attained, as measured by ASTM C 403.

1. Perform in place penetration (density) tests using handheld penetrometer to measure penetration resistance of hardened flowable fill.

2. Perform tests at locations as directed by Engineer.

C. Defective Flowable Fill: The Engineer reserves the right to reject all flowable fill failing to meet the following test requirements or flowable fill delivered without the following documentation.

1. Test Requirements:

a. Minimum temperature at point of delivery.
b. Compressive strength requirements for each type of fill.

2. Documentation: Duplicate delivery tickets.

D. No traffic or construction equipment shall be allowed on flowable fill for a least 24 hours after placement.

3.6 CLEANING

A. Remove spilled and excess flowable fill from Project Site.

B. Restore facilities and Site areas damaged or contaminated by flowable fill installation to existing condition before installation.

END OF SECTION

SECTION 31 23 33 – TRENCHING AND BACKFILLING

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes the requirements for excavation and backfill of all utilities, including installation of pipe bedding, pipe zone backfill, trench backfill, and related Work as shown on the Drawings and as specified.

B. Section includes:

1. Excavating trenches for pipe, utility vaults, and other utilities.
2. Compacted fill from top of utility bedding to final grades.
3. Trench and utility vault backfilling and compaction.

C. Related Sections:

1. Section 01 45 00 - Quality Control
2. Section 03 30 00 - Cast-In-Place Concrete
3. Section 31 05 13 - Soils for Earthwork
4. Section 31 05 16 - Aggregates for Earthwork
5. Section 31 10 00 - Site Clearing
6. Section 31 22 13 - Rough Grading
7. Section 31 23 16 - Excavation
8. Section 31 23 18 - Rock Removal
9. Section 31 23 23 - Fill
10. Section 31 23 24 - Flowable Fill
11. Section 31 37 00 - Riprap
12. Section 33 11 10 - Water Utility Distribution and Transmission Piping
13. Section 33 31 10 - Sanitary Utility Sewerage Piping: Sanitary Sewer Piping and Bedding
14. Section 33 41 10 - Storm Utility Drainage Piping
15. Supplementary Information: Geotechnical report; bore hole locations, and findings of subsurface materials. Contaminated Media Management Plan, Phase II Environmental Site Assessment

1.2 REFERENCES

A. American Association of State Highway and Transportation Officials:

1. AASHTO T99 - Standard Specification for Moisture-Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) Drop

2. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop ASTM International (ASTM)

B. ASTM International (ASTM):

1. ASTM C403 - Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance

2. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3))

3. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)

4. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)

5. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)

6. D4832, Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders

1.3 DEFINITIONS

A. Controlled Low Strength Material (CLSM): Also referred to as Flowable Fill. Lean cement concrete fill. A self-compacting, cementitious material.

B. Flexible Pipe: For the purposes of these Specifications, tubing between 1/2-inch and 4-inch diameter constructed of polyvinyl chloride (PVC) and high-density polyethylene (HDPE) are considered flexible pipes. HDPE piping 4 inches in diameter and larger is also considered flexible pipe.

C. Geosynthetics: Geotextiles, geogrids, geomembranes, and drainage composite materials.

D. Imported Material: Materials obtained from sources offsite, suitable for specified use.

E. Lift: Loose (uncompacted) layer of material.

F. Obstructions: Items which may be encountered during utility and vault trenching which do not require replacement.

G. Optimum Moisture Content:

1. Determined in accordance with ASTM Standard specified to determine maximum dry density for relative compaction.

2. Determine field moisture content on basis of fraction passing 3/4-inch sieve.

H. Pipe Bedding: Trench backfill zone for full trench width which extends from the bottom outside surface of the pipe to a minimum of 6 inches below the bottom outside surface of pipe, conduit, cable, or duct bank to the trench foundation so as to uniformly support the barrel of the pipe.

I. Pipe Zone: Trench backfill zone for full trench width which extends from the bottom outside surface of the pipe to a minimum of 12 inches above the top outside surface of pipe, conduit, cable, or duct bank.

J. Pipe Bedding, Pipe Zone, and Trench Backfill Classifications:

1. Class A: Backfill with suitable native or imported material that is approved to meet the characteristics required for the specific surface loading or other criteria of the backfill zone.

2. Class B: Backfill with imported granular material consisting of gravel or crushed rock meeting the requirements of this Section and Coarse Aggregate Type A1 as specified in Section 31 05 16, Aggregates for Earthwork; typical designated size shall be 3/4-inch-0.

3. Class C: Backfill with Fine Sand, as specified in Section 31 05 16, Aggregates for Earthwork.

4. Class D: Backfill with approved pit run or bar run material, well-graded from coarse to fine; maximum dimension shall be 3 inches.

5. Class E: Backfill with CLSM. See Section 31 23 23.33, Flowable Fill.

K. Pothole Excavations: Removal and replacement of all materials via coring, vacuum extraction, or similar method for the purposes of locating an underground utility and to investigate underground conditions.

L. Prepared Trench Bottom: The bottom of the trench on which the pipe bedding is to lie, and which provides support for the pipe.

M. Relative Compaction: Ratio, in percent, of as-compacted field dry density to laboratory maximum dry density as determined in accordance with ASTM Standards.

N. Rigid Pipe: For the purposes of these Specifications, pipe constructed of PVC, ductile iron, steel, concrete, and clay pipes are considered rigid pipes.

O. Sewer, Pipes, and Mains: Conduits of circular or other geometric shapes, used to convey liquids or gases, or other material.

P. Trench Backfill: Trench backfill zone for full trench width extending from the top of the pipe zone to pavement base rock, ground surface, or other surface material.

Q. Trench Stabilization: Removal of unsuitable material in the bottom of a trench and replacement with specified material for support of a pipe, main, conduit, structure, or appurtenances.

R. Utility: Any buried pipe, duct, conduit, or cable.

S. Well-Graded: A mixture of particle sizes with no specific concentration or lack thereof of one or more sizes that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids.

1.4 SUBMITTALS

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

B. Excavation Protection Plan: At a minimum, to include the following:

1. Methods and sequencing of mass excavation.
2. Proposed on-site and off-site spoil disposal locations.
3. Anticipated difficulties and proposed resolutions.
4. Proposed routes for Owner’s access to Owner’s facilities impacted by excavation Work.
5. Proposed haul routes.

C. Product Data:

1. Geotextile fabric, indicating fabric and construction

2. Marking tapes
3. Tracer wire
4. Connectors for tracer wire and/or marking tapes
5. Tracer wire locate boxes
6. Marker balls
7. Locator stations
8. Ground wires
9. Plastic or copper markers for service laterals.

D. Imported Materials:

1. Materials Source: Submit name and location of imported fill materials suppliers.
2. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.
3. Submit results of aggregate sieve analysis and standard proctor test for granular material.

E. CLSM: Mix designs in accordance with Submittal requirements of Section 31 23 23.33, Flowable Fill.

F. Concrete: Mix designs in accordance with Submittal requirements of Section 03 30 00, Cast-in-Place Concrete.

1.5 QUALITY ASSURANCE

A. Subsoil and topsoil fill materials: In accordance with Quality Assurance requirements stated in Section 31 05 13, Soils for Earthwork.

B. Aggregate fill materials: In accordance with Quality Assurance requirements stated in Section 31 05 16, Aggregates for Earthwork.

C. CLSM:

1. In-place testing: In accordance with ASTM C403.
2. Compressive testing: In accordance with ASTM D4832.

D. Allowable Tolerances: Final grades shall be plus or minus 0.1-foot.

1.6 QUALIFICATIONS – NOT USED

1.7 COORDINATION

A. Verify Work associated with lower elevation utilities is complete before placing higher elevation utilities.

B. Coordinate trenching and utility installation work with other work at utility construction location occurring near or adjacent to specified herein.

PART 2 PRODUCTS

2.1 FILL MATERIALS

A. Subsoil Fill: Type S1, Select Native Material as specified in Section 31 05 13, Soils for Earthwork.

B. Imported Granular Fill: Coarse Aggregate Type A1, Dense-Graded Aggregate with gradation as shown in the Drawings and specified in Section 31 05 16, Aggregates for Earthwork.

C. Concrete:

1. Lean concrete as specified in Section 31 23 24, Flowable Fill, with compressive strength of 100 pounds per square inch (psi).

2. Structural concrete as specified in Section 03 30 00, Cast-in-Place Concrete with compressive strength of 3,000 psi.

D. Drain Rock: Coarse Aggregate Type A2, Granular Drain Backfill Material with gradation as shown in the Drawings and specified in Section 31 05 16, Aggregates for Earthwork.

E. Sand: As specified in Section 31 05 16, Aggregates for Earthwork.

F. Trench Stabilization Material: Coarse Aggregate Type A1, Dense-Graded Aggregate, 2-1/2-inch - 0 gradation as specified in Section 31 05 16, Aggregates for Earthwork.

2.2 MARKING TAPE

A. Detectable:

1. Solid aluminum foil, visible on unprinted side, encased in protective high visibility, inert polyethylene plastic jacket.

2. Foil Thickness: Minimum 0.35 mils.

3. Laminate Thickness: Minimum 5 mils.

4. Width: 6 inches.

5. Identifying Lettering: Minimum 1-inch high, permanent black lettering imprinted continuously over entire length.

6. Joining Clips: Tin or nickel-coated furnished by Tape Manufacturer.

7. Manufacturers and Products:

a. Reef Industries; Terra Tape, Sentry Line Detectable
b. Mutual Industries; Detectable Tape
c. Presco; Detectable Tape

B. Color: In accordance with APWA Uniform Color Code for Temporary Marking of Underground Facilities and as specified in NEMA Z535.1, Safety Color Code.

Color	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	Potable water
Purple	Reclaimed water, irrigation, and slurry lines

2.3 ELECTRONIC LOCATING MATERIALS

A. Tracer Wire:

1. All pipe 12” and larger shall have direct burial tracer wire. Direct burial wire shall be copper-clad steel (CCS) high strength tracer wire.

2. Tensile Breaking Load: 380-pound average.

3. Jacket:

a. High molecular weight high-density polyethylene complying with ASTM D1248, 30-volt rating.

b. Color: Provide in colors per Article 2.03.B above.

4. Manufacturer and Product: Copperhead Industries; LLC, 12 CCS high strength reinforced tracer wire, or equal.

B. Tracer Wire Connectors:

1. Waterproof and corrosion proof.

2. Prefilled with silicone and suitable for use with low-voltage tracer lines of less than 50 volts.

3. Lug Connectors:

a. Waterproof plastic housing that encases the silicone prefilled lug terminals.
b. Manufacturer and Product: King Innovations; DryConnTM Direct Bury Lug or equal.

4. Twist Connectors:

a. Waterproof epoxy-filled packaging that encases the silicone prefilled twist connectors.

b. Manufacturer and Product: 3M Division; DBY Direct Bury Splice Kit 09053 connectors or equal.

C. Ground Wire: No. 12 AWG bare solid copper wire.

D. Locator Station:

1. Locater stations to be per SFWB.

2.4 VISUAL IDENTIFICATION MATERIALS

A. Tracer Wire Locate Boxes:

1. Material: Polyolefin.

2. Cover:

a. Color: Provide in colors per Article 2.03.B above.

b. Provide box cover identification marking for facility type such as “Sewer Locate Wire”, as approved by Owner.

c. Locking type with a nominal 6-inch opening.

3. Manufacturer and Product: Carson Industries LLC; L Series Model 708 or equal.

B. Service Lateral Plastic or Copper Markers:

1. Service Lateral Plastic or Copper Markers: Use markers of the type that requires installation to be recessed below grade.

a. Material: Plastic or copper. In new concrete, use “new construction” markers; in existing concrete use “retrofit” markers and use adhesive recommended by the Manufacturer.

b. Plastic Pavement Markers:

1) UV stabilized and fade resistant.

2) Material: Meet or exceed a tensile strength of 3,500 psi, and meet test requirements as outlined in ASTM G53, Standard Practice for Light and Water Exposure of Nonmetallic Material.

3) Color: Provide in color per Article 2.03 B above with the words, “WARNING, BURIED SEWER Call Before You Dig,” molded to the top of marker.

a) Provide wording for specific facility as approved by Owner.

4) Manufacturer and Product: Rhino Marking and Protective Systems; A-TAG pavement markers or equal.

c. Copper Pavement Markers:

1) Material: Copper material chosen by Manufacturer.

2) Diameter: 1-5/32-inch.

3) Wording: Provide facility identification wording stamped on the top such as “Sewer Lateral” as approved by Owner.

4) Manufacturer and Product: Berntsen Concrete Marker; BP2-U or equal.

C. Service Lateral 2-inch by 4-inch Markers:

1. S4S Douglas fir, pressure-treated 2-inch by 4-inch lumber, utility grade or better.
2. Grade stamped by an American Lumber Standards certified inspection agency.

PART 3 EXECUTION

3.1 PREPARATION

A. Call Local Utility Line Information service at 1-800-424-5555 not less than three working days before performing Work.

1. Request underground utilities to be located and marked within and surrounding construction areas.

2. Coordinate with and notify utility companies should it be necessary to remove or relocate facilities.

3. Maintain and protect above and below grade utilities indicated to remain.

B. Identify required lines, levels, contours, and datum locations.

C. Drawings and/or specifications cover and govern replacement and restoration of foreseeable damage.

D. The site of an open cut excavation shall be first cleared of all obstructions preparatory to excavation in accordance with Section 31 10 00, Site Clearing.

E. See Section 31 10 00, Site Clearing for additional requirements in protection of existing utilities, survey control, plant life, and landscaped areas in coordination with Work in this Section.

1. Intent of Drawings and Specifications is that all streets, structures, and utilities be left in condition equal to or better than original condition.

2. Where damage occurs, and cannot be repaired or replaced, the Contractor shall purchase and install new material, which is satisfactory to Owner.

F. Potholing / Exploratory Test Pits: Dig such exploratory test pits and perform potholing as may be necessary in advance of trenching to determine the exact location and elevation of subsurface structures, pipelines, duct banks, conduits, and other obstructions which are likely to be encountered or need to be connected to and shall make acceptable provision for their protection, support, and maintenance of their continued operation.

G. Paved or Surfaced Streets:

1. Wherever paved or surfaced streets are cut, saw wheel, or approved cutting devices shall be used.

2. Width of pavement cut shall be as shown in the Drawings.

3. Any cut or broken pavement shall be removed from site during excavation.

H. Traffic:

1. Maintain street traffic at all times as required by the Drawings and as specified herein.

2. Erect and maintain barricades, warning signs, traffic cones, and other safety devices during construction in accordance with the latest edition of Manual of Uniform Traffic Control Devices (MUTCD), Part 6, to protect the traveling public in any area applicable.

3. Provide flaggers as required during active work in roadway areas.

I. Operations shall be confined to rights-of-way and easements provided. Avoid encroachment on, or damage to, private property or existing utilities unless prior arrangements have been made with copy of said arrangement submitted to Engineer.

3.2 EASEMENTS

A. Where portions of the Work are located on private property, easements and permits will be obtained by the Owner. Easements shall provide for the use of property for construction purposes to the extent indicated on the easements.

B. Copies of these easements and permits will be available from the Owner for inspection by the Contractor. It shall be the Contractor's responsibility to determine the adequacy of the easement obtained in every case.

C. Confine construction operations to within the easement limits or street right-of-way limits or make special arrangements with the property owners for the additional area required and notify the Engineer with a copy of the written approval from property owners of any such conditions.

D. Any damage to private property, either inside or outside the limits of right-of-way or easements provided by the Owner, resulting from Work shall be the responsibility of the Contractor. Before the Engineer will authorize final payment, the Contractor will be required to furnish the Owner with written releases from property owners where the Contractor has obtained special agreements or easements or where the Contractor's operations, for any reason, have not been kept within the construction right-of-way obtained by the Owner.

3.3 PROTECTION

A. Existing Facilities:

1. It is the intent of these specifications that all streets, structure, and utilities be left in a condition equal to or better than original condition at the completion of the Project.

2. Where damage occurs, and cannot be repaired or replaced, the Contractor shall purchase and install new material to the satisfaction to the Engineer.

3. Drawings and/or specifications cover and govern replacement and restoration of foreseeable damage.

B. Removal of Water:

1. As specified in Section 31 23 19, Dewatering.

2. At all times during construction provide and maintain ample means and devices with which to remove promptly and dispose of properly all water entering the excavations or other parts of the Work.

3. Keep all excavations dry until the utilities or vaults to be placed therein are completed. In water bearing sand, well points and/or sheeting shall be supplied, together with pumps and other appurtenances of ample capacity to keep the excavation dry as specified.

4. Dispose of water from the Work in a suitable legal manner without damage to adjacent property or structures.

C. Trench Protection:

1. Provide the materials, labor, and equipment necessary to protect trenches at all times.

2. Trench protection shall provide safe working conditions in the trench and protect the Work, existing property, utilities, pavement, etc.

3. The method of protection shall be according to the Contractor's design.

4. The Contractor may elect to use a combination of shoring, overbreak, tunneling, boring, sliding trench shields, or other methods of accomplishing the work provided the method meets the approval of all applicable local, state, and federal safety codes.

5. Damages resulting from improper shoring, improper removal of shoring, or from failure to shore shall be the sole responsibility of the Contractor.

3.4 LINES AND GRADES

A. Trench excavation for piping, utility vaults, and other utilities shall be performed to the alignment and grade as indicated in the Drawings.

B. Where grades are not shown in the Drawings, utilities shall be laid to grade between control elevations shown.

C. Water mains shall be installed with a minimum cover of 36 inches.

D. The Engineer reserves right to make changes in lines, grades, and depths of utilities when changes are required for Project conditions.

E. Changes in the grade and horizontal alignment of the pipeline as shown in the Drawings or as provided elsewhere in the Specifications may be necessary due to unanticipated interferences or other reasons.

1. No additional compensation will be allowed the Contractor for changes in horizontal alignment.

2. No additional compensation will be allowed for changes in grade which require additional depth of trench excavation and backfill up to 2 feet from those shown in the Drawings.

F. Use laser-beam instrument with qualified operator to establish lines and grades.

3.5 OBSTRUCTIONS

A. Obstructions to the construction of the trench, such as tree roots, stumps, abandoned pilings, abandoned buildings and concrete structures, logs, rubbish, and debris of all types shall be removed without additional compensation from the Owner.

B. The Engineer may, if requested by the Contractor or Owner, make changes in the trench alignment to avoid major obstructions if such alignment changes can be made within the perpetual easement and right-of-way and without adversely affecting the intended function of the facility or increasing costs to the Owner.

3.6 INTERFERING ROADWAYS AND STRUCTURES

A. Remove, replace and/or repair any damage done during trenching activities to fences, buildings, cultivated fields, drainage crossings, and any other properties without additional compensation from the Owner.

1. Replace or repair these structures to a condition as good as or better than their pre-construction condition prior to commencing work in the area.

B. Paved Roadways:

1. Where paved roadways are cut as part of trenching activities, Class D trench backfill will be required to the bottom of pavement base.

2. New pavement shall be equal to or better than the existing paved surface.

3. New surface shall not deviate by more than 1/4-inch from the existing finish elevation.

C. Existing Structures:

1. If existing structures are encountered as part of trenching activities which will prevent construction and are not adequately shown in the Drawings, the Contractor shall notify the Engineer before continuing with the Work.

2. The Engineer may make such field revisions to the utility alignment as necessary to avoid conflict with the existing conditions.

3. The cost of waiting or "down time" during such field revisions shall be borne by the Contractor without additional cost to the Owner or liability to the Engineer.

4. If the Contactor fails to so notify the Engineer when a conflict of this nature is encountered, but proceeds with construction despite this interference, the Contractor shall do so at the Contractor's own risk with no additional payment.

3.7 TRENCHING

A. Excavate subsoil as required for construction of utilities to elevations shown in the Drawings.

B. Remove boulders and rock up to 1/2 cubic yard measured by volume per the requirements of this Section. Remove larger boulders and rock material as specified in Section 31 23 16.26, Rock Removal.

C. Open Trench Limit:

1. Do not advance open trench beyond the distance which will be backfilled and compacted the same day.

2. A maximum length of open trench shall not exceed 100 feet at any one time.

3. Temporary resurfacing shall be completed within 300 feet of the associated open trench limit for each main pipe laying operation.

4. Cover or backfill excavations at the end of each day.

5. If the trench is not backfilled at the end of each working day:

    a. Provide means to prevent caving of excavation sides, as necessary, during non-working hours.

    b. Cover the excavation with a system as needed to provide public safety and prevention of entry during non-working hours.

    c. Provide signed and stamped submittal of caving prevention system and cover system.

6. New trenching shall not be started when earlier trenches need backfilling, or the surfaces of streets or other areas need to be restored to a safe and proper condition.

D. Utility Crossings: Avoid horizontal and vertical conflicts with existing utilities.

1. Perform excavation within 24 inches of existing utility service in accordance with utility's requirements.

2. Vertical clearance between the new pipe and existing utilities shall be 12 inches minimum, unless otherwise noted on the Drawings.

3. Where existing utility lines are damaged or broken during trenching activities, the utility shall be repaired or replaced. For water or sewer bearing lines, care being taken to insure a smooth flow line and absolutely no leakage at the new joints.

4. All expenses involved in the repair or replacement of leaking or broken utility lines that have occurred due to the Contractor's operations shall be borne by the Contractor, and the amount thereof shall be absorbed in the unit prices of its bid.

E. Water Lines Crossing Sewer Lines: Whenever water lines cross sewer lines, the Contractor shall comply with local Health Department requirements.

1. Wherever possible, the bottom of the water line shall be 18 inches or more above the top of sewer pipe. One full length of the water line pipe shall be centered at the crossing.

2. For clearances less than 1-1/2 feet, the Contractor shall replace the existing sewer pipe with ductile iron or PVC of equal size, centered at the utility crossing, or shall encase existing sewer pipe with concrete for a minimum of 10 feet on both sides of crossing, as directed by the Engineer, at no additional cost to the Owner.

F. Excavate trenches to width and depth as indicated on Drawings. No additional payment will be provided for trenching activities beyond dimensions shown in the Drawings.

1. Excavation for trenches in which pipelines are to be installed shall provide adequate space for workers to place and joint the pipe properly and safely, but in every case the trench shall be kept to a minimum width.

2. The width of the pipe trench at and below the top of the pipe shall be such that the clear space between the barrel of the pipe and the trench shall not exceed 12 inch inches on either side of the pipe.

3. Excavation for utility vaults and other structures shall be wide enough to provide 18 inches between the structure surface and the sides of the excavation.

4. For pipe or utility vaults to have bedding material, excavate to a depth of 6 inches below the bottom of the pipe or utility vault. Care shall be taken not to excavate below depths required.

5. If over digging occurs, the trench bottom shall be filled to grade with compacted bedding material.

G. Remove water or materials that interfere with Work.

1. The trench at all times shall be kept free from water to facilitate fine grading, the proper laying and joining of pipe, and prevention of damage to completed joints.

2. Adequate pumping equipment shall be provided to handle and dispose of the water without damage to adjacent property.

3. Water in the trench shall not be allowed to flow through the pipe while construction work is in progress unless special permission to do so has been given by the Engineer.

4. An adequate screen shall be provided to prevent the entrance of objectionable material into the pipe.

5. Remove and dispose of existing abandoned sewer pipe, structures, and other facilities as necessary to construct the improvements.

a. Where the excavation activities require the removal of portions of an abandoned pipeline, masonry plugs shall be installed in the open ends of the pipe, unless otherwise noted in the Drawings or by the Engineer.

b. Coordinate with Engineer prior to plugging.

c. For plugs less than 36 inches in diameter, 8-inch-deep masonry units shall be used. For plugs in larger pipelines, 12-inch-deep masonry units shall be used.

6. The costs associated with the removal of water and materials noted above will be considered incidental to trench excavation and backfill.

H. Do not interfere with 45 degree bearing splay of foundations.

I. Over-excavation for Unsuitable Trench Foundation Conditions:

1. Cross-sectional dimensions and depths of excavations shown in the Drawings shall be subject to such changes as may be found necessary by the Engineer to secure foundations free from soft, weathered, shattered, and loose material or other objectionable materials.

2. Unsuitable materials shall be removed and replaced only as directed in writing by Engineer.

3. Unsuitable materials encountered shall be removed and replaced with Coarse Aggregate Type A1, 2-1/2-inch – 0 gradation, as specified in Table 31 05 16-A of Section 31 05 16, Aggregates for Earthwork. All material placed shall be compacted to 95 percent of maximum dry density.

4. Install nonwoven geotextile under trench stabilization material, over the soft or yielding excavated surface.

    a. Install the nonwoven geotextile ahead of placement of the trench stabilization material, continuously along the excavation bottom and centered on the pipe centerline.

    b. Use nonwoven geotextile width equal to the pipe diameter plus 2 feet.

    c. Place laps or splices in the geotextile in the direction of the pipe laying.

J. Trim excavation. Hand trim for bell and spigot pipe joints. Remove loose matter.

K. Excavated material shall be placed at locations and in such a manner that it does not create a hazard to pedestrian or vehicular traffic or interfere with the function of existing drainage facilities or system operation.

L. Remove excess subsoil not intended for reuse from site.

M. Stockpile excavated material in area designated on site in accordance with Section 31 05 13, Soils for Earthwork.

3.8 TUNNELING

A. In lieu of open cut trenching as specified above, the Contractor may utilize tunnel methods for installation of pipe where ground conditions are favorable and such methods will not disturb foundations under curbs, sidewalks, and other structures.

1. The Engineer must approve tunneling methods prior to utility installation.

2. Where tunneling is used, payment for the pipe installation will be made for the equivalent trench excavation and backfill as if the open cut method was used. Payment will not be made for surface restoration including pavement, curbs, sidewalks, and other surface improvements whose replacement is avoided by the tunneling method.

3.9 SHEETING AND SHORING

A. Sheet, shore, and brace excavations to prevent danger to persons, new and existing structures, and adjacent and neighboring properties and to prevent caving, erosion, settlement, and loss of surrounding subsoil.

B. Support trenches more than 5 feet deep excavated through unstable, loose, or soft material. Provide sheeting, shoring, bracing, or other protection to maintain stability of excavation.

C. Repair damage caused by failure of the sheeting, shoring, or bracing and for settlement of filled excavations or adjacent soil.

D. Repair damage to new and existing Work from settlement, water or earth pressure or other causes resulting from inadequate sheeting, shoring, or bracing.

E. Design sheeting and shoring to be removed at completion of excavation work, unless shown otherwise in the Drawings.

F. Construction Sheeting Left in Place:

1. Furnish, install, and leave in place construction sheeting and bracing when specified or when indicated or shown on the Drawings.

2. Construction sheeting and bracing originally intended for temporary installation, placed by the Contractor to protect adjacent and neighboring structures, may be left in place if desired by the Contractor and approved by the Engineer. All such sheeting and bracing left in place shall be included in the cost for excavation.

3. Any construction sheeting and bracing which the Contractor has placed to facilitate its work may be ordered in writing by the Engineer to be left in place. The right of the Engineer to order sheeting and bracing left in place shall not be construed as creating an obligation on its part to issue such orders. Failure of the Engineer to order sheeting and bracing left in place shall not relieve the Contractor of its responsibility under the contract.

4. For sheeting and shoring to be left in place as part of the completed Work, cut off minimum 18 inches below finished grade.

3.10 COMPACTION

A. Testing will be required to show specified densities of compacted backfill are being achieved by the Contractor's compaction methods.

B. Moisture Control:

1. Moisture condition backfill material to within 2 percent of optimum moisture content required for compaction throughout each lift of the fill.

2. Add moisture to granular backfill by sprinkling during compaction operation.

3. Compaction by ponding or jetting is not permitted.

C. Compact all materials and areas that are not accessible for in-place density testing, as determined by the Engineer, in place by whatever equipment and method is practicable or specified, and as approved by the Engineer.

1. Perform compaction at such moisture content as is required to produce well-filled, dense, and firm material in place that will show no appreciable deflection or reaction under the compacting equipment.

3.11 BEDDING

A. All utility vaults, potable water pipe 4-inch nominal diameter and over, all steel pipe, all concrete sewer pipe, all plastic pipe, all pipe under existing or future structures or roadways, and any and all utilities at a depth greater than 6 feet shall be laid in pipe bedding material.

B. Unless otherwise noted in the Drawings, pipe, or conduit of less than 4-inch diameter, outside structure lines and at a depth of less than 6 feet shall be bedded in native material properly shaped as specified below, all as detailed on the Drawings.

C. Compacted bedding material shall be placed the full width of the excavated trench to a depth as shown on the trench detail included in the Drawings.

1. In lieu of a detail, the depth shall be 6 inches.

D. Spread the bedding smoothly over entire width of trench to the proper grade so that the pipe is uniformly supported along the barrel.

E. Hand grade and compact each lift to provide a firm, unyielding surface along the entire pipe length. For rigid pipe, compact to at least 90 percent relative compaction.

F. Excavate bell holes at each joint to permit proper assembly and inspection of the joint.

G. Check grade and correct irregularities in bedding material.

H. Center pipes horizontally in trench width.

3.12 BACKFILLING

A. Backfill trenches to contours and elevations with unfrozen fill materials.

B. Systematically backfill to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen, or spongy subgrade surfaces.

C. Maintain optimum moisture content of fill materials to attain required compaction density.

D. Place fill material, with the exception of CLSM, in continuous layers and compact in 6- to 8-inch lifts.

1. Prevent pipe from moving either horizontally or vertically during placement and compaction of pipe zone material.

2. Where trenches are under existing or future structures, paved areas, road shoulders, driveways, or sidewalks, or where designated on the Drawings or specified elsewhere in these specifications, the trench backfill shall be Class B or Class E and pipe zone backfill shall be Class B or Class E. Class B backfill shall be compacted to 95 percent of maximum density at optimum moisture content.

3. Where trenches are outside existing or future structures, paved areas, road shoulders, driveways, or sidewalks, or where designated on plans or specified elsewhere, the trench backfill shall be Class A and pipe zone backfill in these areas shall be Class B. For these locations, compaction of Class B backfill shall be to not less than 85 percent of maximum density at optimum moisture content.

E. Employ placement method that does not disturb or damage nearby or adjacent foundation perimeter drainage or utilities in trench.

F. Do not use power-driven impact compactors to compact pipe zone material.

G. Backfill Immediately: All trenches and excavations shall be backfilled immediately after pipe or conduit is in approved condition to receive it and shall be carried to completion as rapidly as possible, unless otherwise directed by the Engineer.

H. Under no circumstances shall water be permitted to rise in open trenches after pipe has been placed.

I. Do not allow backfill material to free fall into the trench or allow heavy, sharp pieces of material to be placed as backfill until after at least 2 feet of backfill has been provided over the top of pipe.

J. Use hand compactors for compaction until at least 2 feet of backfill is placed over top of pipe. Thoroughly tamp each lift, including area under haunches, with handheld tamping bars supplemented by "walking in" and slicing material under haunches with a shovel to ensure that voids are completely filled before placing each succeeding lift.

K. Placement of Sand:

1. Place medium sand in lifts not exceeding 8 inches in uncompacted thickness.

2. Compact each lift to a minimum of 95 percent relative compaction prior to placing succeeding lifts.

L. Placement of CLSM:

1. Discharge from truck-mounted drum-type mixer into trench.

2. Place in lifts not exceeding 2 feet in thickness.

3. No compaction of CLSM is allowed.

4. Use steel plates to protect the CLSM from traffic a minimum of 24 hours. After 24 hours, the CLSM may be paved, or opened to traffic until permanent surface restoration is completed if it has hardened sufficiently to prevent rutting.

M. New trenching shall not be started when earlier trenches need backfilling, or the surfaces of streets or other areas need to be restored to a safe and proper condition.

N. Do not leave trench open at end of working day.

3.13 MARKING TAPE INSTALLATION

A. Continuously install marking tape along centerline of all buried piping, install 24 inches below finished grade. Coordinate with piping installation drawings.

3.14 ELECTRONIC LOCATING FACILITY INSTALLATION

A. Tracer Wire and Terminal Appurtenances:

1. Tracer Wire:

a. Install as shown or directed directly over the pipe centerline and on top of the pipe zone in all sewer trenches, including mainline sewers, service laterals and storm sewer inlet leads.

b. Connect mainline and service lateral tracer wires using either an approved direct-bury lug connector or direct-bury twist connector.

c. Extend tracer wire to locator stations in manholes, locator boxes, storm inlets, or other visually identifiable terminal appurtenances, allowing for access with electronic locating equipment, as shown or directed and according to the following requirements:

2. Locator Stations:

   a. Install locator stations as shown within manholes.

   b. Mount locator station to manhole wall within 18 inches of manhole rim with two stainless steel expansion anchors.

   c. Drill a minimum 3/8-inch diameter hole through the manhole wall within 18 inches of the finish grade of the manhole rim.

   d. Extend the tracer wire from the pipe trench in one continuous piece up the outside of the manhole and through the hole and into a locator station and attach to one of the lugs in the locator station.

   e. When multiple tracer wires are terminated in manhole install a multi-lead locator station.

   f. Extend a ground wire from the locator station through a minimum 3/8-inch diameter hole in the manhole wall.

   g. Install ground wire approximately 3 feet deep and extend from the outside manhole wall a minimum of 3 feet horizontally in any direction.

   h. Seal all holes drilled in manhole walls with silicone sealant.

3. Storm Inlet Tracer Wire Termination: Terminate tracer wire inside inlet and directly over storm outlet pipe by placing tracer wire as follows:

   a. Drill a minimum 3/8-inch diameter hole through inlet wall to pass tracer wire through to inside inlet wall.

   b. Seal hole with silicon sealer or material approved by Engineer.

   c. Leave 6 inches of coiled tracer wire along inside of inlet wall approximately 3 inches below the inlet frame and grate or as directed by Engineer.

4. Service Lateral Tracer Wire Termination: Terminate tracer wire at ends of service laterals as shown or directed, as follows:

   a. Termination in Tracer Wire Locate Boxes: Extend the tracer wire in one continuous piece up vertically from the pipe trench and into the bottom of the locate box. Leave 18 inches of coiled tracer wire inside locate box.

   b. Termination at 2-inch by 4-inch Markers: Extend tracer wire in one continuous piece directly up service lateral 2-inch by 4-inch markers and leave 18 inches of tracer wire wrapped around the exposed top end of 2-inch by 4-inch marker.

3.15 VISUAL IDENTIFICATION FACILITIES

A. Tracer Wire Locate Boxes: Install tracer wire locate boxes directly over service laterals at property line, service boundary, or other location as shown or directed by the Engineer.

B. Service Lateral Plastic or Copper Markers:

1. Install plastic or copper markers in the concrete curb directly over the centerline of the service lateral, as shown or directed by the Engineer.

2. Either plastic or copper markers may be used.

3. If there is not suitable concrete curb for marker placement, then install a lateral cleanout as close to property line as practical at location approved by Engineer.

C. Service Lateral 2-inch by 4-inch Markers:

1. Place a 2-inch by 4-inch marker at the end of each new service lateral not connected to a building sewer.

2. Omit markers only as approved.

3. Block the capped or plugged service lateral end with a wood block against undisturbed earth and install the marker.

4. Extend the marker from the blocked service lateral invert to at least 12 inches above the existing or proposed finish ground surface.

5. Install marker in one piece. No splicing will be accepted.

6. Paint the exposed portion of the marker after its installation with quality quick drying enamel white paint for a storm only sewer and green paint for a sanitary or combined sewer.

7. After the paint has dried, use black, quick drying enamel, and neatly indicate the distance from the ground surface to the top of the service lateral in feet and inches.

8. Do not disturb the position and location of the marker during the backfilling operation.

9. If the marker is broken, moved out of location, or vertical alignment is changed during the backfilling operation, reopen the trench, and replace the marker.

3.16 FIELD QUALITY CONTROL

A. All testing and reporting shall be conducted and completed by an independent laboratory provided by the Owner. Initial testing will be paid for by the Owner. Subsequent testing after failure of initial acceptance testing shall be paid by the

B. Perform laboratory material tests in accordance with AASHTO T99

C. In-place compaction testing of pipeline backfill materials shall be performed at 2-foot elevation increments, one test per 200 linear feet of pipeline trench as measured along pipe centerline.

1. The Engineer may reduce the frequency when satisfied with method of compaction.

2. The Engineer may direct testing at a higher frequency at no additional cost to the Owner upon failure to obtain specified densities or if the Contractor changes compaction equipment or methods of compaction.

3. The Engineer shall determine all test locations.

D. Perform in place compaction tests in accordance with the following:

1. Density Tests: ASTM D2922

2. Moisture Tests: ASTM D3017

E. When tests indicate Work does not meet specified requirements, remove Work, replace, and retest at the sole expense of the Contractor.

3.17 SURFACE RESTORATION AND CLEANUP

A. Open Trenches: At the end of each workday, all open trenches shall be backfilled and all trenches within streets shall be temporarily paved or covered to the satisfaction of the Engineer and the local permitting agency.

1. Temporary paving shall be replaced with permanent street paving at the completion of construction within street rights-of-way, or sooner, if deemed necessary by the Engineer.

2. No gravel-filled trenches shall be left open within the street right-of-way at the end of the workday.

B. Topsoil:

1. Where trenches cross lawns, garden areas, pastures, cultivated fields, or other areas on which reasonable topsoil conditions exist, remove the topsoil to the specified depth and place the material in a stockpile.

2. Topsoil shall not be mixed with other excavated material.

3. After the trench has been backfilled, the topsoil shall be replaced.

C. Clean up and remove all excess materials, construction materials, debris from construction, etc. Replace or repair any fences, mailboxes, signs, landscaping, or other facilities removed or damaged during construction. Replace all lawns, topsoil, shrubbery, flowers, etc., damaged or removed during construction. The Contractor shall be responsible for seeing that lawns, shrubs, etc. remain alive and leave premises in condition equal to original condition before construction.

3.18 SCHEDULE – NOT USED

END OF SECTION

SECTION 31 25 00 – EROSION AND SEDIMENT CONTROLS

PART 1 GENERAL

1.1 SCOPE

A. This section covers the requirements for temporary and permanent erosion and sedimentation control necessary to prevent migration of sediment and silt laden water to adjacent surface water bodies and drainage structures.

B. The Contractor shall provide all materials, labor, and equipment necessary to install adequate erosion and sedimentation controls.

1.2 QUALITY CONTROL

The Owner will apply to the Oregon Department of Environmental Quality (DEQ) and obtain a 1200-C Erosion Control Permit. All fees and permit costs will be borne by the Owner. If Contractor proposes to modify the approved erosion control plan, the Contractor shall work with DEQ to revise application/permit. Contractor shall obtain the final permit and shall be responsible for compliance with all permit provisions and shall accommodate all special inspections required thereof, all at no additional expense to the Owner beyond prices as bid.

1.3 SUBMITTALS

A. Following the Preconstruction Conference, the Contractor shall request City to transfer the name of the permit holder to the Contractor by submitting a completed 1200-C Name Change and Permit Transfer Application to DEQ. The 1200-C permit will be transferred to Contractor who will have sole responsibility for compliance with all of the permit requirements and the day-to-day implementation of the Erosion and Sediment Control Plan.

B. Upon completion of and acceptance of all Work, Contractor shall submit Notice of Termination Application for NPDES General Permit to Discharge Storm Water Associated with Construction Activity to DEQ.

1.4 SCHEDULE

A. Required temporary sedimentation control facilities must be constructed and in operation prior to land clearing and other construction to ensure that sediment laden water does not enter the natural drainage systems.

B. Temporary sediment facilities shall be maintained in a satisfactory condition until such time that permanent ESC facilities are in place or sufficient vegetation has been established and potential for on-site erosion has passed.

C. The implementation, maintenance, replacement, and additions to erosion/sedimentation control systems shall be the responsibility of the Contractor.

PART 2 PRODUCTS

2.1 CHECK DAM SAND OR GRAVEL BAGS

A. Bags to be either burlap or woven “Geotextile” fabric filled with gravel or sand.

2.2 JUTE MATTING

A. Be of a uniform open plain weave of unbleached, single jute yarn treated with a fire-retardant chemical.

B. The yarn shall be of a loosely twisted construction and shall not vary in thickness by more than one-half of its normal diameter.

C. Furnished in rolled strips 48 inches wide by approximately 50 yards long.

D. Average weight of 0.92 pounds per square yard with an allowable tolerance of plus or minus 1 inch in width and 5 percent in weight.

2.3 FILTER FABRIC FABRIC

A. Filter Fabric

1. Manufacturer:

a. Mirafi 140
b. Or equal.

B. Wire

1. Provide 2 by 2 mesh, 12-gauge galvanized wire.

C. Support Posts

1. Provide minimum 2-inch by 2-inch, Douglas Fir No. 1, or better wood posts.

2.4 CLEAR PLASTIC COVERING

A. Clear plastic covering for protection of slopes and cuts in accordance with ASTM D2103 for Polyethylene sheeting having a minimum thickness of 6 mil.

2.5 INLET PROTECTION

A. Protect new and existing stormwater inlets which collect stormwater runoff from a construction site from sediment by the use of filters.

2.6 STABILIZED CONSTRUCTION ENTRANCE

A. Wherever construction vehicles enter or leave a construction site, a Stabilized Construction Entrance is required.

PART 3 EXECUTION

3.1 EROSION CONTROL

A. Erosion control provisions shall meet or exceed the requirements of the local agency having jurisdiction.

B. When provisions are specified and shown on the drawings, they are the minimum requirements.

C. Contractor shall not permit sediment-laden waters to enter natural waterways.

D. As construction progresses and seasonal conditions dictate, more siltation control facilities may be required. It shall be the responsibility of the Contractor to address new conditions that may be created and to provide additional facilities over and above minimum requirements as may be required.

E. Provide temporary erosion control measures to prevent erosion from piles of topsoil or fill material. Before completing the Contract, any areas of bare soil shall be permanently seeded.

F. Additional measures may be necessary depending on construction activity and weather. Contractor will be responsible for carrying out the erosion control provisions of the approved ESC Plan.

1. Keep streets and paved surfaces clean of mud and debris. Install gravel construction entrances as shown on the Plans and maintain them for the duration of the construction period.

3.2 SILTATION CONTROL

A. Siltation control is required. Check dams or silt fences may be placed in streams or ditches receiving stormwater from areas disturbed by construction.

3.3 FILTER FABRIC FENCES

A. Filter fabric fence shall consist of filter fabric fastened to wire fabric with staples or wire rings.

B. Wire shall be fastened to posts set at 6 foot-maximum centers.

C. Fabric shall be buried into ground a minimum of 12 inches to prevent silt from washing under fabric.

D. Fence shall be located to catch silt and prevent discharge to drainage courses.

3.4 EROSION CONTROL CHECK DAM

A. Sand or gravel filled bags shall be installed in drainage way to catch silt.

B. Spillway shall be lower than outer edge of dam. Leave a one sandbag gap in top row to provide spillway.

3.5 PLACING JUTE MATTING

A. Seed and fertilizer shall be placed prior to placing of matting.

B. Jute matting shall be unrolled parallel to the flow of water. Where more than one strip of jute matting is required to cover the given area, it shall overlap the adjacent mat a minimum of 4 inches. The ends of matting shall overlap at least 6 inches with the upgrade section on top.

C. The up-slope end of each strip of matting shall be staked and buried in a 6-inch-deep trench with the soil firmly tamped against the mat. Three stakes per width of matting (one stake at each overlap) shall be driven below the finish ground line prior to backfilling of the trench.

D. Engineer may require that any other edge exposed to more than normal flow of water or strong prevailing winds be staked and buried in a similar manner.

E. Check-slots shall be laced between the ends of strips by placing a tight fold of the matting at least 6 inches vertically into the soil. These shall be tamped and stapled the same as up-slope ends. Check-slots must be placed so that one check-slot or one end occurs within each 50 feet of slope.

F. Edges of matting shall be buried around the edges of catch basins and other structures as herein described. Matting must be spread evenly and smoothly and in contact with the soil at all points.

G. Matting shall be held in place by approved wire staples, pins, spikes, or wooden stakes driven vertically into the soil. Matting shall be fastened at intervals not more than 3 feet apart in three rows for each strip of matting, with one row along each edge and one row alternately spaced in the middle. All ends of the matting and check-slots shall be fastened at 6-inch intervals across their width. Length of fastening devices shall be sufficient to securely anchor matting against the soil and driven flush with the finished grade.

3.6 PLACING CLEAR PLASTIC COVERING

A. Clear plastic covering shall be installed on erodible embankment slopes.

B. The clear plastic covering shall be installed immediately after completion of the application of roadside seeding. It is the intent of this specification that clear plastic covering will be in place before the fall rainfall begins.

C. Maintain the cover tightly in place by using sandbags or ties on slopes with a minimum of 10-foot grid spacing in all directions. All seams shall be taped or weighted down full length. There shall be at least a 12-inch overlap of all seams.

D. Immediately repair all damaged areas.

3.7 EXISTING DRAINAGE FACILITIES

A. Should a storm sewer or culvert become blocked or have its capacity restricted due to siltation from Contractor’s operations, the Contractor shall make arrangements with the jurisdictional agency for the cleaning of the facility at no additional expense to the Owner.

B. Contractor shall install catch basin inserts in existing catch basins in the vicinity of, or adjacent to, clearing or construction activities to prevent sediment from entering the on-site stormwater conveyance system.

3.8 DRAINAGE DIVERSION

A. Contractor may divert up-gradient surface runoff water around the site as required. Contractor will be responsible for routing diverted surface water to its original flow path downstream of the site and providing energy dissipation and/or dispersion as needed to mimic pre-diverted flow characteristics, as required by the Engineer.

B. Drainage shall be restored to condition existing prior to construction unless otherwise shown on the drawings.

END OF SECTION

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SECTION 31 37 00 - RIP RAP

PART 1 GENERAL

1.1 SCOPE

This Section consists of furnishing and placing an erosion-resistant cover material for protecting slopes and basins at locations shown or as directed.

A. Related Sections:

1. Section 03 60 00, Grouting
2. Section 31 22 13, Rough Grading
3. Section 31 23 18, Rock Removal

1.2 DEFINITIONS

A. Filter Blanket - A layer of graded granular material placed between the area prepared for it and the riprap.

B. Grouted Riprap - Loose riprap with all or part of the spaces filled with Portland cement mortar.

C. Keyed Riprap - Loose riprap placed on prepared slope, riprap geotextile, or filter blanket, as specified, and keyed in place by slapping the surface with a piece of armor plating.

D. Loose Riprap - Specified classes of graded rock placed on prepared slope, riprap geotextile, or filter blanket, as specified.

E. Riprap Backing - An option of using either riprap geotextile or a filter blanket placed between the area prepared for it and the riprap.

F. Riprap Basin - Energy dissipater consisting of loose riprap placed at pipe outlets as specified.

G. Riprap Geotextile - A geotextile placed between the area prepared for it and the riprap.

1.3 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.
B. Materials Source: Submit name of imported materials suppliers.
C. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

PART 2 MATERIALS

2.1 RIPRAP REQUIREMENTS

A. General - Furnish rock for loose riprap meeting the following requirements:

1. Meet the test requirements of provided herein.

2. Be angular in shape. Thickness of a single rock shall not be less than 1/3 its length. Rounded rock will not be accepted unless authorized by the Engineer.

3. Meet the gradation requirements for the class specified.

4. Be free from overburden, spoil, shale, and organic material. Non-durable rock, shale, or rock with shale seams is not acceptable.

B. Test Requirements - Furnish the rock meeting the following test requirements:

Material Test	Requirement
Apparent Specific Gravity (AASHTO T 85)	2.50 Min.
% Absorption (AASHTO T 85)	6.0 Max.
Degradation (ODOT TM 208A)	
Passing No. 20 Sieve	35.0% Max.
Sediment Height	8.0" Max.
Soundness (AASHTO T 104)	
Average Loss of 2 1/2" - 1 1/2" and 1 1/2" - 3/4" fraction after 5 alternations	16.0% Max.

C. Gradation Requirements - Grade loose riprap by class and weight of rock according to the following:

Class 50	Class 100	Class 200	Class 700	Class 2000	Percent (by Weight)
		Weight of Rock (pounds)			
50 - 30	100 - 60	200 -	700 -	2000 -	20.0
30 - 15	60 - 25	140	500	1400	30.0
15 - 2	25 - 2	140 - 80	500 -	1400 -	40.0
2 - 0	2 - 0	80 - 8	200	700	10.0 - 0
		8 - 0	200 - 20	700 - 40	
			20 - 0	40 - 0	

Uniformly grade each load of riprap from the smallest to the largest weight specified. Control of gradation will be by visual inspection.

1. Control Sample - If directed, provide, at a satisfactory location near the Project Site, a rock sample of at least 5 tons meeting the gradation for the class specified. This sample will be used as a frequent visual reference for judging the gradation of the riprap supplied.

2. Sampling and Testing Assistance - Any difference of opinion between the Engineer and the Contractor shall be resolved by dumping and checking the gradation of two random truckloads of rock. Mechanical equipment, a sorting site, and labor needed to assist in checking gradation shall be provided by the Contractor at no additional cost to the Owner.

D. Grouted Riprap

1. Furnish rock for grouted rip rap meeting the requirements of stated herein for class and size specified.

2. Furnish non-shrink Portland cement grout meeting the requirements of Section 03 60 00, Grouting.

E. Filter Blanket - Furnish filter blanket material meeting the following requirements according to riprap class:

Riprap Class	Filter Blanket
Class 2000	16-inch layer of Class 50 riprap conforming to the requirements of this section
Class 700	9-inch layer of 6-inch - 0 stone embankment meeting the test requirements of this section
Class 200	6-inch layer of 4-inch - 0 stone embankment meeting the test requirements of this section
Class 100	No filter blanket required
Class 50	No filter blanket required

PART 3 EXECUTION

3.1 PREPARATION

A. Remove brush, trees, stumps, and other organic material from slopes to be protected by riprap and dress to a smooth surface.

B. Remove all unsuitable material to the depth shown or directed and replace with approved material.

C. Compact filled areas as specified in Section 31 23 23, Fill.

D. Provide riprap protection as early as the structure foundation construction permits. Prepare the surfaces to be protected as shown.

E. Maintain the trench slopes, riprap geotextile, or filter blanket until the riprap is placed.

3.2 RIPRAP GEOTEXTILE

A. Install riprap geotextile as shown in the Drawings or as directed by the Engineer.

3.3 FILTER BLANKET CONSTRUCTION

A. If required, place the filter blanket on the prepared area to the full specified thickness in one operation, using methods which will not cause segregation.

B. The surface of the finished layer shall be reasonably even.

3.4 RIPRAP BACKING

A. When indicated on the Drawings, the Contractor shall have the option of placing either riprap geotextile or a filter blanket behind the riprap.

B. Install the backing per these specifications or as shown in the Drawings.

3.5 RIPRAP

A. General - Unless otherwise directed, place the riprap protection as the embankment is constructed. Its placement shall lag behind embankment construction only as necessary to allow proper embankment construction and prevent mixture of embankment and riprap material.

B. Loose Riprap - Place riprap on the prepared area:

1. With a clamshell, orange-peel bucket, skip, or similar approved device which will contain the riprap material to its final destination. Do not open the bucket until it has been lowered to the slope on which the material is being placed.

2. To its full course thickness in one operation.

3. According to the compaction requirements of Section 31 23 23, Fill if riprap is placed on geotextile

4. By methods that do not cause segregation of riprap or displace the underlying material.

5. To produce a compact riprap protection in which all sizes of material are placed in their proper proportion.

6. With some hand placing, or rearranging of individual stones by mechanical equipment, or some other approved means to provide a smooth finished surface.

Where filter material and/or riprap are placed under water, increase their thicknesses as shown or as directed.

C. Keyed Riprap - After placing loose riprap material, key the riprap into place by slapping the surface with a piece of armor plating (approximately 4 feet by 5 feet in size with a weight of approximately 5,000 pounds) or other approved means which will produce a nearly smooth surface.

D. Grouted Riprap - Place loose riprap material. If the depth specified for grouting is more than 12 inches, place the riprap in lifts of 12 inches or less and grout each lift before placing the next lift. Construct and grout the succeeding lifts before the grout in the previous lift has hardened.

Thoroughly moisten the stones and sluice any excess fines to the underside of the riprap before grouting. Deliver the grout to the place of final deposit by any means that will ensure uniformity and prevent segregation of the grout. Spade or rod the grout into the spaces to completely fill the voids in the riprap. Control pressure grouting and do not unseat the stones. Penetration of the grout shall be to the depth shown on the plans. If a rough surface is specified, brush the stone until 25 percent to 50 percent of the depth of surface stone is exposed. For a smooth surface, grout the crevices to within 5/8-inch of the surface.

Provide weep holes through the riprap as shown or as directed.

Place and cure grout according to 03 60 00, Grouting, except as provided above.

E. Riprap Basins - Excavate, backfill, and construct riprap basins, without a riprap geotextile or filter blanket, at pipe outlets with Class 50 riprap as shown or as directed.

3.6 MAINTENANCE

Maintain the riprap protection until accepted. Replace any material displaced by any cause at no additional cost to the owner.

END OF SECTION

SECTION 32 11 23 - AGGREGATE BASE COURSES

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes construction of an aggregate subbase and base course for placement under asphalt or concrete paving, unit paving, or placed and left exposed.

B. Section Includes:

1. Aggregate subbase
2. Aggregate base course

C. Related Sections:

1. Section 31 22 13 - Rough Grading
2. Section 31 23 17 - Trenching
3. Section 31 23 23 - Fill
4. Section 31 37 00 - Riprap
5. Section 31 05 16 - Aggregates for Earthwork
6. Section 32 12 16 - Asphalt Concrete Paving

1.2 REFERENCE STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO M288 - Standard Specification for Geotextile Specification for Highway Applications

2. T11, Standard Method of Test for Materials Finer Than 75µm (No. 200) Sieve in Mineral Aggregates by Washing

3. T27, Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates

4. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.

B. ASTM International (ASTM):

1. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).

2. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method

3. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)

4. ASTM D2940 - Standard Specification for Graded Aggregate Material for Bases or Subbases for Highways or Airports

5. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)

1.3 DEFINITIONS

A. Completed Course: Compacted, unyielding, free from irregularities and standing water, with smooth, tight, even surface, true to grade, line, and cross-section.

B. Completed Lift: Compacted with uniform cross-section thickness.

C. Keystone: Fine aggregate used to aid in binding of loose surface stone.

1.4 SUBMITTALS

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

B. Product Data:

1. Submit data for geotextile fabric and herbicide.

C. Materials Source: Submit name of aggregate materials suppliers.

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

1.5 QUALITY ASSURANCE

A. Furnish each aggregate material from single source throughout the Work.

PART 2 PRODUCTS

2.1 SHOULDER AGGREGATE

A. Of the size shown on the Plans.

B. Coarse Aggregate: Type A1, Dense-Graded Aggregate as specified in Section 32 05 16, Aggregates for Earthwork.

2.2 DENSE-GRADED BASE AGGREGATES

A. Of the size shown on the Plans.

B. Coarse Aggregate: Type A1, Dense-Graded Aggregate as specified in Section 32 05 16, Aggregates for Earthwork.

2.3 OPEN-GRADED BASE AGGREGATES

A. Of the size shown on the Plans.

B. Coarse Aggregate: Type A2, Granular Drain Backfill Material as specified in Section 32 05 16, Aggregates for Earthwork.

2.4 SOURCE QUALITY CONTROL

A. Perform tests necessary to locate acceptable source of materials meeting specified requirements.

B. Final approval of aggregate material will be based on test results of 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.

2.5 EQUIPMENT

A. Compaction Equipment: Adequate in design and number to provide compaction and to obtain specified density for each layer.

2.6 ACCESSORIES

A. Geotextile Fabric: AASHTO M288; non-woven, polypropylene.

PART 3 EXECUTION

3.1 SUBGRADE PREPARATION

A. Obtain Engineer's acceptance of subgrade before placing base course or surfacing material.

B. Verify compacted substrate is dry and ready to support paving and imposed loads.

1. Proof roll substrate with equipment approved by the Engineer in minimum two perpendicular passes to identify soft spots.

2. Remove soft substrate and replace with compacted fill as specified in Section 31 23 23.

3.2 PREPARATION

A. Correct irregularities in substrate gradient and elevation by scarifying, reshaping, and re-compacting.

B. Do not place base course or surfacing materials in snow or on soft, muddy, or frozen subgrade.

3.3 HAULING AND SPREADING

A. Hauling Materials:

1. Do not haul over surfacing in process of construction.

2. Loads: Of uniform capacity.

3. Maintain consistent gradation of material delivered; loads of widely varying gradations will 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 on prepared surface without segregation.

3. Should segregation of coarse from fine materials occur during placing, immediately change methods of handling materials to correct uniformity in grading.

4. Maintain consistent gradation of material. Widely varying gradation will be cause for rejection.

3.4 CONSTRUCTION OF COURSES

A. Untreated Aggregate Base Course:

1. If the required compacted depth of the base course exceeds 6 inches, construct it in two or more layers of nearly equal thickness. The maximum compacted thickness of any one layer shall not exceed 6 inches.

2. Completed Course Total Thickness: As shown on the Plans, 10-inch minimum.

3. Spread lift on preceding course to required cross-section. Place each layer in spreads as wide as practical and to the full width of the course before a succeeding layer is placed.

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, as follows:

a. Use 3/4-inch leveling course or surfacing material as keystone.

b. Spread evenly on top of base course, using spreader boxes or chip spreaders.

c. Roll surface until keystone is worked into interstices of base course without excessive displacement.

d. Continue operation until course has become thoroughly keyed, compacted, and will not creep or move under roller.

6. Blade or broom surface to maintain true line, grade, and cross-section.

B. Gravel Surfacing and Leveling Course:

1. Place shoulder aggregates in a single layer, or two or more layers of nearly equal thickness. The maximum compacted thickness of any one layer shall not exceed 9 inches.

2. Spread on preceding course in accordance with cross-section shown.

3. Blade lightly and roll surface until material is thoroughly compacted.

4. Complete Total Thickness: As shown on the Plans, 10-inch minimum.

3.5 ROLLING AND COMPACTION

A. Commence compaction of each layer of base immediately after spreading operations and continue until density of 95 percent of maximum density has been achieved as determined by AASHTO T180.

B. Roll each layer of material until there is no appreciable reaction or yielding under the compactor before succeeding layer is applied.

C. Shape and maintain the surface of each layer during compaction operations. Commence rolling at outer edges and continue toward center; do not roll center of road first.

D. Apply water as needed to obtain specified densities.

E. Place and compact each lift to the required density before succeeding lift is placed.

F. Surface Defects: Remedy by loosening and rerolling. Reroll entire area, including surrounding surface, until thoroughly compacted.

G. Finished surface shall be true to grade and crown before proceeding with surfacing.

3.6 SURFACE TOLERANCES

A. Blade or otherwise work surfacing as necessary to maintain grade and cross-section at all times, and to keep surface smooth and thoroughly compacted.

B. Finished Surface of Untreated Aggregate: Within plus or minus 0.04-foot of grade shown at any individual point.

C. Overall Average: Within plus or minus 0.04-foot from crown and grade specified.

3.7 FIELD QUALITY CONTROL

A. Quality control testing shall be performed by an independent testing laboratory provided by the Owner.

B. Refer to table below for minimum sampling and testing requirements for aggregate base course and surfacing. The Owner reserves the right to complete additional testing.

Property	Test Method	Frequency	Sampling Point
Gradation	AASHTO T11 and AASHTO T27	One sample every 500 tons but at least every 4 hours of production	Roadbed after processing
Moisture Density (Maximum Density)	AASHTO T180	One test for every aggregate grading produced	Production output or stockpile
In-Place Density and Moisture Content	AASHTO T310	One for each 500 ton but at least every 10,000 square feet of area	In-place completed, compacted area

3.8 CLEANING

A. Remove excess material from the Work area. Clean stockpile and staging areas of all excess aggregate. Restore per Specifications as applicable.

END OF SECTION

SECTION 32 12 16 - ASPHALT PAVING

PART 1 GENERAL

1.1 SCOPE

This section includes the construction of asphalt concrete pavement.

1.2 REFERENCE STANDARDS

A. References herein to "AASHTO" shall mean Association of American State Highway Transportation Officials.

B. Standard Specifications: Where the term "Standard Specifications" is used, such reference shall mean the current edition of the Oregon Department of Transportation (ODOT) Standard Specifications for Highway Construction. Where reference is made to a specific part of the Standard Specifications, such applicable part shall be considered as part of this section of the Specifications. In case of a conflict in the requirements of the Standard Specifications and the requirements stated herein, the requirements herein shall prevail.

1.3 DEFINITIONS

A. Maximum Density Test (MDT): Theoretical maximum density of the bituminous mixture determined by multiplying the theoretical maximum specific gravity, determined by ASTM D2041 and AASHTO T-209 (Rice), by 62.4 pounds per cubic foot.

1.4 SUBMITTALS

A. Aggregate Qualification Tests: In accordance with Standard Specifications **Section 00640** for aggregate used in aggregate base.

B. Aggregate Qualification Tests: In accordance with Standard Specifications **Section 00745** for aggregate used in asphalt concrete.

C. Job mix formula shall be an approved job mix formula. Submit formula, supplier, and product identification to the Engineer 30 days prior to start.

1. Definite percentage for:

   a. Each sieve fraction.
   b. New asphalt cement.
   c. Recycled asphalt pavement.

2. Temperature of completed mix when discharged from mixer.

3. Character and quantity of anti-strip and recycling agents.

1.5 QUALITY ASSURANCE

A. All testing to determine compliance with the specifications shall be performed by an independent testing laboratory contracted by the Contractor and approved by the Engineer. All testing costs shall be borne by the Contractor.

B. A minimum of five nuclear densometer readings shall be taken in random locations within every test area. Each test area shall not exceed 200 tons of asphalt; however, smaller areas may be designated by the Engineer.

C. The surface smoothness of the new asphalt concrete pavement shall be such that when a 10-foot straightedge is laid longitudinally across the paved area in any direction, the new pavement shall not deviate from the straightedge more than 1/8-inch. Surface drainage shall be maintained. Additionally, paving must conform to the design grade and crown and contain no abrupt edges, low or high areas or any other imperfections as determined by the Engineer. Pavement construction not meeting these requirements will be repaired by grinding the existing pavement to a 1-1/2-inch depth and replacing with Level 3, 1/2-inch dense graded Asphaltic Concrete the full width at no cost to Owner.

1.6 PRE-PAVING CONFERENCE

A. Any supervisory personnel of the Contractor and any subcontractors who are to be involved in the paving work shall meet with the Engineer, at a time mutually agreed upon, to discuss methods of accomplishing all phases of the paving work.

B. The Contractor shall be prepared to review the size and type of equipment to be used and the anticipated rate of placement to determine equipment needs.

PART 2 PRODUCTS

2.1 AGGREGATE MATERIAL

A. Aggregate Base for Dense Graded Asphalt Concrete: The aggregate material shall be a clean, well-graded crushed base aggregate conforming to the Standard Specifications. Base course shall be 1-1/2-inch minus aggregate and leveling course shall be 3/4-inch minus aggregate.

2.2 ASPHALT CONCRETE PAVEMENT

A. Dense Graded Hot Mix Asphalt Concrete

1. Use Level 3, 1/2-inch-dense graded, PG 70-22 HMAC. Conform to the requirements as specified in **Section 00745** of the Standard Specifications. Conform to the requirements as specified in **Section 00745** of the Standard Specification and match requirements of local jurisdiction roadway restoration requirements.

2. Asphaltic concrete pavement delivered to the site shall be accompanied by a ticket with the approved "job mix formula" number shown. Loads without tickets identifying the job mix formula will not be accepted.

3. Percent of recycled asphalt pavement used in new asphalt pavement shall not exceed 30 percent. Recycled asphalt pavement may not be used in top wearing course unless otherwise approved by the Engineer.

B. Tack Coat

In accordance with Standard Specifications. Use AR 4000, AC-20 asphalt, or CSS-1 emulsified asphalt C.

C. Seal and Cover Coat

Asphalt material shall be CRS-2 cationic emulsified asphalt. Cover stone shall conform to size 1/4-inch #10 aggregate in the Standard Specifications.

D. Subgrade Geotextile

1. Dense Graded AC Mix-For subgrade separation using dense graded asphalt concrete, use subgrade geotextile with Certification Level B as specified in **Section 02320** of the Standard Specifications.

E. Subgrade Stabilization

In the event that unstable materials are encountered during excavation, the additional excavation and installation of geotextile fabric and 12 inches of rock substructure will be required, as directed. Conform to the requirements as specified in **Section 00331** of the Standard Specifications. For subgrade separation, use subgrade geotextile with Certification Level B as specified in **Section 02320** of the Standard Specifications.

PART 3 EXECUTION

3.1 AGGREGATE PAVEMENT BASE

A. Place pavement base to the depth shown on the plans or as specified in all cases, pavement base shall be compacted to a minimum depth of 6 inches. Bring the top of the pavement base to a smooth, even grade at a distance below finished grade equivalent to the required pavement depth.

B. Compact the pavement base with mechanical vibratory or impact tampers to a density of not less than 95 percent of the maximum density, as determined by AASHTO T-180.

C. Obtain the Engineer’s acceptance of the subgrade before beginning construction of the aggregate base course.

D. When, in the judgment of the Engineer, the weather is such that satisfactory results cannot be secured, suspend operations. Place no aggregate base course in snow or in soft, muddy, or frozen subgrade.

E. If the required compacted depth of aggregate base course exceeds 6 inches, construct in two or more lifts of approximately equal thickness. Maximum compacted thickness of any one lift shall not exceed 6 inches. Compact each layer to the specified density before a succeeding lift is placed.

3.2 ASPHALT CONCRETE PAVEMENT

A. Construct asphalt concrete pavement in accordance with **Section 00745** of the Standard Specifications.

B. Conform to the requirements for prime coat and tack coat in the Standard Specifications. Tack coat all edges of existing pavement, manhole and clean out frames, inlet boxes, and like items. When rate is not specified, asphalt will be applied at the rate of 0.1-gallon per square yard.

C. Obtain the Engineer's acceptance of the aggregate base course before beginning construction of the asphalt concrete wearing course.

D. Hot mix asphalt shall be placed on dry, prepared surfaces, when air temperature in the shade of 40 degrees Fahrenheit (F) or warmer, unless otherwise authorized by the Engineer.

E. Placing asphalt pavement during rain or other adverse weather conditions will not be permitted unless otherwise authorized by the Engineer, except that asphalt mix in transit at the time these adverse conditions occur may be placed provided it is of proper temperature, the mix has been covered during transit, and it is placed on a foundation free from mud or free-standing water.

F. Correct any defects in material and workmanship, as directed, when determined detrimental by the Engineer. These include segregation of materials, non-uniform texture, and fouled surfaces preventing full bond between successive spreads of mixture. The corrections or replacement of defective material or workmanship shall be at the Contractor's expense.

G. Compact the bituminous mixture to at least 92 percent of the Theoretical Maximum Density.

H. The finished surface of each course of layer of mixture shall be of uniform texture, smooth, and free of defects and shall closely parallel that specified for the top surface finished grade. Remove and replace boils and slicks immediately with suitable materials.

I. The surface of each layer when tested with a Contractor-furnished 10-foot straightedge shall not vary from the testing edge by more than 0.02-foot for underlying courses of pavements and 0.015-foot for finished top courses or wearing courses of pavements. At no point shall the finished top of the wearing course vary more than 0.03-foot from the specified finished grade.

J. Lift thickness shall be as shown on the drawings or specified, but not to exceed 3 inches.

K. Do not place asphalt concrete pavement on emulsified asphalt (tack coat) until the asphalt separates from the water (breaks) but before it loses its tackiness.

L. Asphalt and sand seal edges where new asphalt concrete meets existing pavement.

3.3 FIELD QUALITY CONTROL

A. Job mix will be sampled immediately behind the paving machine.

B. Temperature of the mix will be measured immediately behind the paver.

C. The theoretical maximum specific gravity of the bituminous mixture will be determined in accordance with ASTM D2041.

D. Properties of the job mix will be measured using ASTM D2041.

E. Density of the compacted job mix will be measured in accordance with ASTM D2922.

3.4 ADJUSTMENT OF EXISTING MANHOLE COVERS AND VALVE BOXES

Prior to placing asphalt concrete pavement, the Contractor shall make all necessary adjustments to existing manhole frames and covers, and valve box covers to ensure that the tops of the manhole covers or valve box lids are flush with the finished grade of the adjoining pavement or ground surface, and that valve boxes and PVC pipes are centered and plumb over operating nut valve.

END OF SECTION

SECTION 32 31 13 - CHAIN LINK FENCING AND GATES

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes chain link steel fencing and gates as shown on the Drawings or specified elsewhere. All fences and gates shall be furnished with top rails and knuckled periphery edges, twisted barbed top and bottom of mesh.

B. American Iron and Steel (AIS) Compliance: Materials provided under work of this Section shall comply with the AIS requirements of the Water Infrastructure Finance and Innovation Act (WIFIA). All materials provided and incorporated into this Project shall meet the AIS requirements of P.L. 113-76, Consolidated Appropriations Act, 2014.

C. Section includes:

1. Chain link fabric
2. Posts
3. Rails
4. Tension wires
5. Braces
6. Fittings
7. Gates
8. Lock assemblies and gate stops

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Chain Link Fence Manufacturer's Institute:

1. Galvanized Steel Chain Link Fence Fabric
2. Industrial Steel Specifications for Fenceposts, Gates, and Accessories

B. ASTM International (ASTM):

1. A121, Standard Specification for Metallic-Coated Carbon Steel Barbed Wire

2. A313, Standard Specification for Stainless Steel Spring Wire

3. A392, Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric

4. A491, Standard Specification for Aluminum-Coated Steel Chain-Link Fence Fabric

5. A497, Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete

6. A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement

7. A780, Standard Specification for Repair of Damaged and Uncoated Areas of Hot-Dipped Galvanized Coatings

8. A824, Standard Specification for Metallic-Coated Steel Marcelled Tension Wire for Use with Chain Link Fence

9. A1011, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability

10. C94, Standard Specification for Ready-Mixed Concrete

11. C150, Standard Specification for Portland Cement

12. C387, Standard Specifications for Packaged, Dry, Combined Materials for Mortar and Concrete

13. F552, Standard Terminology Relating to Chain Link Fencing

14. F567, Standard Practice for Installation of Chain-Link Fence

15. F626, Standard Specification for Fence Fittings

16. F900, Standard Specification for Industrial and Commercial Swing Gates

17. F1043, Standard Specification for Strength and Protective Coatings on Metal Industrial Chain Link Fence Framework

18. F1083, Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures

19. F1183, Standard Specifications for Aluminum Alloy Chain Link Fence Fabric

20. F1184, Standard Specifications for Industrial and Commercial Horizontal Slide Gates

21. F1916, Standard Specification for Selecting Chain Link Barrier Systems with Coated Chain Link Fence Fabric and Round Posts for Detention Applications

C. Conflicts in requirements shall use this Section to take precedence.

1.3 SUBMITTALS

A. Section 01 30 00, Submittal Procedures: Requirements for submittals.

B. Shop Drawings:

1. Product Data: Include construction details, material descriptions, dimensions of individual components, and finishes for chain link fences and gates.

2. Fence, gate posts, rails, and fittings.

3. Chain link fabric.

4. Gates and hardware.

C. Manufacturer’s recommended installation instructions.

D. Evidence of Supplier and installer qualifications.

1.4 QUALITY ASSURANCE

A. Use skilled workers thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

B. Provide each type of steel fence and gate as a complete unit produced by a single manufacturer, including necessary erection accessories, fittings, and fastenings.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Site in undamaged condition.

B. Store materials off the ground to provide protection against oxidation caused by ground contact.

PART 2 PRODUCTS

2.1 MATERIALS

A. Fabric

1. Continuous chain link fence.

2. Height: As shown on the Drawings.

3. Mesh:

a. In areas shown on plans without privacy slats: 1-1/4-inch. All mesh shall have knuckled periphery to eliminate sharp appendages, with the exception of the top and bottom of mesh which shall have twisted barb finish.

b. In areas shown on plans with privacy slats: 2-inch. All mesh shall have knuckled periphery to eliminate sharp appendages, with the exception of the top and bottom of mesh which shall have twisted barb finish.

4. #9-gauge steel core wire.

5. Top and bottom selvage: twisted barb finish on top and bottom.

6. Galvanized after weaving.

7. Zinc coating shall not be less than 0.9 ounces per square foot.

8. Fabric shall be Black powder finish coated.

B. Line Posts

Line posts shall be hot dipped galvanized 2.375-inch outside diameter hot dipped galvanized pipe, weighing 3.12 pounds per lineal foot. All posts shall be black powder finish coated.

C. Terminal Posts

End, corner, and pull posts shall be hot dipped galvanized pipe 2.875 inches outside diameter and weighing not less than 4.64 pounds per lineal foot. All posts shall be black powder finish coated.

D. Top Rail

1. Top rail shall be hot dipped galvanized, black powder finish coated, 1.660-inch outside diameter pipe, weighing 1.83 pounds per lineal foot.

2. Furnish in random lengths of approximately 20 feet.

3. Jointed using a pressed steel or malleable sleeve, not only allowing for expansion and contraction, but also providing a continuous brace from end to end of each stretch of fence.

E. Tension Wire

Bottom tension wire shall be #7-gauge heavy galvanized high carbon steel coil spring wire, securely fixed to the fabric, line posts, and terminal posts.

F. Braces

1. All terminal posts shall be braced with 1.660-inch outside diameter. Provide horizontal pipe bracing of the same material as the top rail. Securely attached to the terminal and first line post with malleable iron fittings.

2. Braces shall be truss-braced from the first line post to the bottom of the terminal post, with a 3/8-inch galvanized truss rod assembly.

3. Corner posts shall be braced in both directions.

G. Fittings

1. Malleable, cast iron, or pressed steel.
2. Hot dip galvanized.

H. Fabric Ties

1. #11-gauge black wire ties shall be used to tie the fabric to the line posts and rails.

I. Privacy Slats

1. Privacy slats shall be black in color and included in submittal for Owner approval.

J. Chain Link Gates

1. Frames:

   a. Made of heavy galvanized 1.90-inch outside diameter pipe, weighing 2.28 pounds per lineal foot.

b. Welded or assembled with corner fittings.

2. Corner fittings, ball and socket hinges, catch stops, and center rest to be heavy galvanized malleable iron.

3. Hinges as required.

4. Provide diagonal cross-bracing.

5. Shall be black powder finish coated.

K. Gate Posts

Posts shall be hot dipped galvanized pipe 2.875-inch outside diameter weighing 4.64 pounds per lineal foot.

L. Framework Material

All posts, rails, and braces to be heavy galvanized and black powder coat finished.

M. Lock Assembly and Gate Stop

1. Provide for each gate one double-hasp drive gate drop rod lock assembly set in concrete and one gate stop set in concrete.

2. All lock assemblies and gate stops shall be fabricated from heavy galvanized malleable iron.

3. Provide one vandal-proof keyed lock and three keys for each gate assembly.

PART 3 EXECUTION

3.1 INSTALLATION

A. All materials and workmanship shall be first class in all respects and shall be done in a neat and workmanlike manner.

B. Installation shall be conducted in accordance with the requirements of the Chain Link Fence Manufacturers Institute and these Drawings and Specifications.

C. All line, terminal, gate stops, gate drop, and gate posts shall be fixed with a minimum of 3-foot embedment in concrete poured into a 1-foot diameter hole and plumb upon curing of the concrete unless otherwise shown on plans.

D. Line posts shall be spaced not further than 10-foot on-center.

E. Gates shall have 3-inch clearance above ground surface and sized for the application shown.

F. Space ties at 14 inches on center.

END OF SECTION

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SECTION 32 31 14 - ELECTRIC GATE OPERATORS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Electric Gate Operators:

1. LiftMaster 1.5 HP Swing Gate Operator Model HDSW24UL or approved equal.

1.2 RELATED SECTIONS

A. Section 03 30 00 - Cast-in-Place Concrete.
B. Section 26 05 00 - Common Work Results for Electrical.
C. Section 32 31 13 - Chain Link Fencing and Gates.

1.3 REFERENCE STANDARDS

A. National Electrical Manufacturers Association (NEMA): NEMA ICS 6 - Industrial Control and Systems: Enclosures.

B. Underwriters Laboratories (UL): UL 325 - Standard for Safety for Door, Drapery, Gate, Louver, and Window Operators and Systems.

C. Underwriters Laboratories (UL): UL 991 - Standard for Tests for Safety-Related Controls Employing Solid-State Devices.

D. International Organization for Standardization: ISO 9001 - Quality Management Systems.

1.4 SUBMITTALS

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

B. Product Data: Equipment list, system description, electrical wiring diagrams for installation, and manufacturer's data sheets on each product to be used, including:

1. Preparation instructions and recommendations.
2. Storage and handling requirements and recommendations.
3. Installation methods.

C. Shop Drawings: Submit shop drawings showing layout, profiles, and product components, including anchorage, edge conditions, and accessories.

1. Operation, installation, and maintenance manuals including wiring diagrams.
2. Risers, layouts, and special wiring diagrams showing any changes to standard drawings.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 Certified Manufacturer.

B. Installer Qualifications: Installation performed by factory authorized contractor specifically trained in gate operation systems of the type found within this section.

1. Provide documentation of maintenance and repair service availability for emergency conditions.

2. Provide quarterly maintenance for one year following Substantial Completion of the Project.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle materials and products in strict compliance with manufacturer's instructions and industry standards.

B. Store products indoors in manufacturer's original containers and packaging, with labels clearly identifying product name and manufacturer. Protect from damage.

1.7 WARRANTY

A. Manufacturer's Standard Limited Warranty:

1. Warranty Period: 5 years from certified installation date.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturer: LiftMaster Swing Gate Operator Model HDSW24UL; Or approved equal.

2.2 GATE HARDWARE AND OPERATORS

1. Operation: Gear driven.

2. Meet UL 325, UL 991, ASTM F2200, and CAS C22.2 No. 247.

3. Motor: 24 VDC, continuous duty type, sized to gate conditions.

4. Monitoring and controls:

a. Internet connectivity: Connect to SCADA as required.
b. Radio receiver: Security+ 2.0 technology.
c. Monitored retro reflective photo eye.

5. Accessories:

a. LiftMaster Transformer Kit Model 3PHCONV or approved equal.

b. Monitored safety devices: Through-beam photo eyes. Wireless edge with transmitter and receiver.

c. Wired monitored safety edges: Large profile edge.

d. Plug-in loop detector.

e. Internet gateway.

f. Wireless commercial keypad, mounted gooseneck style mount post, with location to be as shown on the drawing and field verified with the Owner, to be located no less than 6-foot from the gate at any point.

g. Emergency Vehicle Access.

PART 3 EXECUTION

3.1 EXAMINATION AND PREPARATION

A. Inspect and prepare substrates using the methods recommended by the manufacturer for achieving best result for the substrates under project conditions.

B. Do not proceed with installation until substrates have been prepared using the methods recommended by the manufacturer and deviations from manufacturer's recommended tolerances are corrected. Commencement of installation constitutes acceptance of conditions.

C. If preparation is the responsibility of another installer, notify Engineer in writing of deviations from manufacturer's recommended installation tolerances and conditions.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions. Test for proper operation and adjust until satisfactory results are obtained.

3.3 PROTECTION

A. Protect installed products until completion of project.
B. Touch-up, repair or replace damaged products before Substantial Completion

END OF SECTION

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SECTION 32 90 00 - PLANTING

PART 1 GENERAL

1.1 SCOPE

A. This Section includes the planting and establishment of plant materials, complete, including furnishing, delivery, planting, and maintenance of all trees, shrubs, and ground covers.

B. Section Includes:

1. Topsoil.
2. Imported topsoil.
3. Soil conditioners.
4. Fertilizer.
5. Mulch.
6. Anti-desiccant.
7. Fungi.
8. Tree staking and guying.
9. Standpipes.
10. Plant materials.
11. Plant guards.
12. Guarantee, maintenance and warranty.

1.2 RELATED SECTIONS

A. Section 31 05 13, Soils for Earthwork.
B. Section 32 91 21, Finish Grading and Seeding.

1.3 SUBMITTALS

A. The following submittals are required as part of this work:

1. Proof of procurement and contract for delivery of plant material.
2. Schedule for delivery of plant material for inspection prior to planting.
3. Sources of plant materials, and identification tags visible for each plant.
4. Color-coded tagging system for all plant material species. (Flag all plant materials prior to installation.)

B. Maintenance Plan: Provide a proposed method and schedule for performing watering of plant material and seeded areas for the duration of the two-year guarantee and maintenance period, or through two growing seasons. The watering contract shall provide for the following:

1. During dry spells, or generally between the months of June through October, water newly planted trees and shrubs with more frequency than established trees and shrubs. They should be watered at planting time followed by watering at the following intervals:

   a. Daily watering during 2 weeks after planting.
   b. Every 2-3 days watering during 3-12 weeks after planting.
   c. Once a week watering until establishment.

2. Trees and shrub beds to receive 1 inch of water per week.

3. Seeded areas to receive 2-inches of water per week.

4. Water sufficiently to maintain soil moisture depth between 6"-8" of the finish grade.

5. Watering operations shall not cause erosion or surface runoff onto paved areas.

PART 2 MATERIALS

2.1 TOPSOIL

A. Topsoil Type TS1, Select Native Topsoil Material, in accordance with Section 31 05 13, Soils for Earthwork.

2.2 IMPORTED TOPSOIL

A. Topsoil Type TS2, Imported Topsoil Material, in accordance with Section 31 05 13, Soils for Earthwork.

2.3 SOIL CONDITIONERS

A. Compost: Commercially manufactured material, made from dead plant material such as grass clippings, weeds, green and dead dry leaves, garden and vegetable material, and ground branches of trees and shrubs. Furnish a product that is composted under controlled aerobic decomposition, with the internal temperature reaching 135 °F for 15 days, without exceeding 155 °F. Ensure that it contains a maximum of 10% bacteria and 10% fungus. Additional certification may be required in areas having a certification program.

1. Mushroom Compost: Spent mushroom growing compost.

B. Sand

Clean, coarse, ungraded sand, meeting the requirements of ASTM C 33 for fine aggregate.

2.4 FERTILIZER

A. Commercial Fertilizer: A complete plant food containing 22% nitrogen, 16% phosphorous, 8% soluble potash, and a minimum 2% sulfur, conforming to applicable State fertilizer laws. Fertilizer shall be uniform in composition, dry, free-flowing, and delivered in original, unopened containers bearing manufacturer's guaranteed analysis.

B. Tea Bag Fertilizers

Plant fertilizer bags shall consist of compressed urea-formaldehyde containing added phosphorous and potassium to yield a 20:10:5 ratio of N-P-K plus 1.4 percent sulfur.

2.5 GARDEN MULCH

An approved, commercially manufactured, garden mulch made from composted yard debris and amended with inorganic materials. Mulch shall be free from noxious weed seed and all chemicals or materials harmful to plant life.

2.6 ANTI-DESICCANT

A transpiration retarding material to be used where any plant material is moved during the normal growing season. Anti-desiccant may be composed of an acrylic polymer or vinyl latex compound such as Foliguard and Wiltpruf, respectively.

2.7 FUNGI

Commercially produced ectomycorrhizal and endomycorrhizal fungi that improve plant root absorption of soil nutrients.

A. Furnish mycorrhizae inoculum in granular or concentrated powder form for areas to be seeded. The product shall have an OMRI Listed™ seal from the Organic Materials Review Institute.

B. The product shall contain a minimum of the following four (4) species of Endomycorrhizae fungi: *Glomus intraradices, G. mosseae, G. aggregatum,* and *G. etunicatum*. The product shall contain a minimum of the following seven (7) species of Ectomycorrhizae fungi: *Rhizopogon villosullus, R. luteolus, R. amylopogon, R. fulvigleba, Pisolithus tinctorius, Scleroderma Cepa*, and *S. citrinum*.

C. The product shall be MycoApply® Endo/Endo Plus by Mycorrhizal Applications, Inc., or EcoLive™ Organics by Sunmark Environmental Services, LLC, or an approved equivalent.

2.8 TREE STAKING AND GUYING

A. Staking Materials

1. Vertical stakes shall be 2" x 2" x 8' (minimum) or 2" round X 8' sound new fir, or hemlock, free of knots and other defects.

2. Tree ties shall be placed on the tree to allow natural movement in the wind. Tree ties shall be placed to allow for two years growth of the trunk.

B. Guying Material

1. Anchors shall be 2" x 4" x 3' sound new heart cedar, or redwood or treated fir or hemlock, free of knots or other defects.

2. Wires and tree ties shall be same as for staking with additional galvanized turnbuckle, centered in wire line with white industrial rubber hose, or manufactured product specific for this use.

2.9 PLANT MATERIALS

A. The Plant List is shown on the Drawings. Names of some species and varieties not included therein conform to names generally accepted in the native grown nursery trade. Information on sources for native plant material species can be obtained through the publication titled “Hortus Northwest.”

B. Nursery grown plant material shall be grown with a quality and habit of growth that is sound, healthy, vigorous, and free from insects, diseases, and injuries. Size shall be equal to or exceeding measurements indicated in the Plant List and measured before pruning with branches in normal position. Sizes and methods for handling shall be according to the American Standard for Nursery Stock recommended by the AAN.

C. Trees: Balled and burlapped trees shall be of height and caliper shown and with branching configuration recommended by ANSI Z60.1 for type and species required. Single stem trees shall be provided except where special forms are shown or listed. Container grown trees are subject to AAN specifications for container grown stock.

D. Shrubs: Shrubs shall be of the height shown or listed and with not less than minimum number of canes required by ANSI Z60.1 for type and height of shrubs and vines required. Shrubs are balled and burlapped (B&B) or container grown.

E. Ground cover shall be plants established and well rooted in removable containers, and with not less than a minimum number of and length of runners required by ANSI Z60.1 for the pot size indicated on the drawings.

PART 3 EXECUTION

3.1 INSPECTIONS AND REPORTS

All plant materials shall be inspected prior to installation. Notify the ENGINEER 10 days prior to delivery date for inspection at the site. Each individual species shall bear a tag indicating species and source. Material not inspected prior to planting will be rejected at the ENGINEER's sole discretion.

3.2 TIME OF PLANTING

Conduct planting operations under favorable weather conditions during seasons which are normal for such work, generally during the periods of March 1 to May 15 and from September 1 to October 31. Planting operations outside these time periods may be conducted with approval of the Landscape Architect.

3.3 EXAMINATION

A. Examine the site for conditions that might adversely affect execution, performance, quality of the Work, and survival of plantings.

B. Take field measurements of landscape areas to determine if differences exist between plans and actual ground dimensions. Notify ENGINEER prior to proceeding with Work.

C. Verify that grades and slopes of landscaped areas insure positive drainage and that they are acceptable to ENGINEER prior to commencing Work.

3.4 DELIVERY

Supply plants designated B&B (balled and burlapped) in the Plant List with firm, natural balls of earth, or diameter and depth sufficient to encompass the fibrous and feeding root system necessary for vital plant growth. Rootball shall be firmly wrapped with burlap and bound with twine, cord or wire

mesh. Manufactured rootballs or rootballs less than the diameter indicated the for the caliper or size of plant material (American Standard for Nursery Stock) will be rejected.

Furnish plants designated CG or "gallon" (container grown) in the Plant List with self-established root systems sufficient to hold earth together after removal from the container but not root-bound, in a container of specified size.

3.5 PROTECTION DURING DELIVERY

A. Small Plant Material

1. If plants are not in a dormant state, spray with anti-desiccant to cover foliage as recommended by manufacturer. During shipment, protect plants with a tarpaulin or other covering to prevent excessive drying from sun and wind.

2. Cover balls of B&B plants and containers of CG plants which cannot be planted immediately upon delivery with moist mulch to protect from drying.

B. Trees

Spray trees with anti-desiccant immediately prior to digging. Protect the top of the tree by wrapping with burlap. Pad all parts of the tree to be cabled or roped. Keep soil balls and exposed roots moist during all digging and transporting operations.

Transport trees during favorable weather conditions. Trees damaged by exposure during transport will be rejected at the site. Damaged trees, as a result of improper or haphazard moving or planting techniques, will be rejected. Right of rejection shall be at the sole discretion of the ENGINEER.

3.6 LOCATION OF PLANTS

A. Locate new planting where shown on the Drawings except where obstructions below ground are encountered or where changes have been made in the construction. Review necessary adjustments with the ENGINEER and begin planting only after approval from the ENGINEER.

B. All plant material species to be flagged prior to planting, (see Part 1, paragraph 1.03, item 4.)

C. Plant trees in locations shown. Plant shrubs and ground cover plants in random patterns within designated areas with the quantities indicated in the plant list.

3.7 PLANTING PROCEDURES

A. Planting Soil Mix: Prepare planting soil mix for plant pits and beds using stockpiled or imported topsoil, soil conditioners, and fertilizer. Thoroughly mix in the following proportions with rotary mixer or other method. Store and protect mixture from excessive leaching by covering with tarpaulin.

Material	Parts by Volume
Topsoil	2
Sand	1
Compost	1

B. Plant Pits: Excavate circular pits with vertical sides for all plants as shown in the details. Dispose of excavated subsoil. The diameter of the pits shall be a minimum of twice the diameter of the rootball. Compact planting soil mix at the bottom of plant pit.

C. Setting Small Plants

Remove the top 2/3 of burlap and all twine or cord from the top and sides of balled and burlapped plant material. Cut containers or water and lift plant material out of containers. Set base of all plants 2 inches above finish grade and backfill with planting soil mix and water to fill voids. When hole is 2/3 filled place planting tablets evenly around ball, (see below.) Form a shallow saucer around plant at the edge of the pit.

D. Setting Evergreen Trees

1. Prepare pits to receive trees prior to digging trees in situ. Break up side surfaces of tree pits with a pick or spade. Do not disturb the bottom of pit to ensure a solid base of support for the tree.

2. Lower tree into hole and stabilize in three locations before watering and backfilling with planting soil mix. All trees shall be properly aligned to be vertical after lowering rootball into hole. Take care when moving soil ball to avoid cracking and damaging roots.

3. Install standpipes for all trees over 10' in height as shown on the drawings. Backfill tree pit with planting soil mix. Use hand spades and work soil into the hole, watering to ensure all air pockets are eliminated. Tamp backfill after the tree pit is 1/2 full to stabilize the lower half of the rootball. Place plant tablets as indicated below.

4. Do not plant trees deeper than the level at which they originally grew. Do not plant in frozen ground or in freezing weather. All trees shall be planted in an upright, vertical position. Lopsided trees will be rejected.

E. Planting Fertilizer Bags: Planting fertilizer bags shall be placed according to manufacturer's instructions.

F. Install tree staking and guying as shown in the details. Submit alternative staking and guying products for review prior to installation.

G. Mulching: Mulch all tree pits and shrub layer areas with a 3-inch layer of bark mulch within 2 days of planting. Mulch to entirely cover area around saucer of trees.

3.8 GUARANTEE

A. Guarantee all trees, shrubs, and seeded areas for a minimum of 2 years to be alive and in vigorous growing condition at the end of the guarantee period or through two growing seasons.

B. Perform plant replacements and reseeding operations at the first opportunity during a season favorable for planting as defined herein and in Section 32 91 21, Finish Grading and Seeding.

C. Plant Materials:

1. Remove and replace any unsatisfactory plants and replace with plants of the same kind, quality and size as specified in the Plant List.

2. Furnish and plant replacements as specified herein.

3. Replacements shall be at the Contractor's sole expense.

D. Seeded Areas:

1. Repair any damage to seeded areas by filling with topsoil, fertilizing, and seeding as specified. Reseed as specified under Section 32 91 21, Finish Grading and Seeding.

2. Reseeding shall be at the Contractor's sole expense.

3.9 MAINTENANCE

A. The Contractor is responsible for watering all plant material and seeded areas for two years. Watering may be accomplished by installation of a temporary irrigation system.

1. Note water service and backflow prevention device provided for Contractor's use in developing a temporary irrigation system.

B. Perform the following maintenance operations during the two-year guarantee period:

1. Water as often as required to meet the requirements of the watering contract as stated above.

2. Remove all noxious weeds from plant beds and saucers by hand.

3. Mulch to maintain 3-inch garden mulch depth.

4. Reset plants to finish grade and restoration of plant saucers, as necessary

5. Repair damaged or washed out erosion control seeding.

C. Report any problems that may be a hindrance to completing and fulfilling the conditions of the plant guarantee within 7 days to the Owner.

3.10 INSPECTIONS

A. Start of the Maintenance and Guarantee Period:

1. Notify the Engineer two weeks in advance of anticipated substantial completion of planting and seeding operations.

2. Observations will be performed prior to the start of the formal guarantee and maintenance period.

B. Quarterly Inspections:

1. The Owner will make quarterly inspections of the site for compliance with the maintenance requirements.

2. Unsatisfactory conditions will be noted and forwarded in writing to the Contractor for correction. Respond and/or provide remedy for unsatisfactory conditions within two weeks of Owner notification.

C. Final Acceptance:

1. Notify the Owner within 15 days of the date for final inspection.

2. Before final acceptance, the terms of the plant/seeding guarantee must be met.

3. The duration of the guarantee and maintenance periods may be extended in order that the Contractor may fulfill obligations required under the guarantee.

END OF SECTION

SECTION 32 91 21 - FINISH GRADING AND SEEDING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Soil Preparation
2. Weed control
3. Fertilizing
4. Seeding
5. Mulching
6. Hydroseeding
7. Hydromulching
8. Maintenance and Establishment Period

B. Related Sections:

1. Section 31 22 13 - Rough Grading
2. Section 31 23 17 - Trenching
3. Section 32 05 13 - Soils for Earthwork
4. Section 32 90 00 – Plantings

1.2 UNIT PRICE – NOT USED

1.3 REFERENCES

A. ASTM International (ASTM):

1. ASTM C602 - Standard Specification for Agricultural Liming Materials.
2. 7 USC 1551-1611 - Federal Seed Act.

1.4 DEFINITIONS

A. Certified Seed: A grass or legume seed named variety that has been reviewed and accepted into the State Certified Seed program. Currently certified seed is individually sold in bags with a Certification Tag.

B. Pure Live Seed (PLS): Is a measure used to describe the percentage of a quantity of seed that will germinate. PLS is obtained by multiplying the purity percentage by the percentage of total viable seed, then dividing by 100.

C. Establishment Period: A period when planting work has been performed and initially accepted, and there is a contract requirement to care for the planted areas in some way until the period ends.

D. Sensitive Areas: Defined areas such as wetlands, natural water and riparian resources, special environmental zones, or where certain activities are restricted such as the use of chemicals.

E. Weeds: Vegetative species other than specified species to be established in given area.

F. Invasive Plants: Any species that appears on the State of Oregon Department of Agriculture standard. current noxious weed list, plus known problem species including phalaris arundinacea, mentha pulegium, holcus lanatus, anthoxanthum odoratum. The last crop plants (if listed as non-native on United States Department of Agriculture (USDA) Plants Database) are considered invasive if it comprises more than 15 percent in any newly established vegetation.

G. Weed Control: Removal and prevent regrowth of specified weeds, weed parts, and weed seeds from area within the Project limit.

1.5 SUBMITTALS

A. Product Data: Submit data for seed mix, mulch, tackifier, erosion control blanket, soil amendment materials, pesticides, herbicides, and other accessories. The product should meet or exceeds all product requirements specified herein.

B. Grass Seeds Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1. Certification of seed analysis, germination rate, and inoculation. Include the year of production and date of packaging. Certify that each lot of seed has been tested by a testing laboratory certified in seed testing within 12 months of delivery date. Also include:

a. Name and address of laboratory

b. Date of test

c. Lot number for each seed certified

d. Test Results: Name, percentages of purity and of germination, and weed content for each seed mix.

C. Operation and Maintenance Data: Include maintenance instructions and weed control.

1.6 QUALITY ASSURANCE

A. Provide seed mixture in containers showing percentage of seed mix, germination percentage, inert matter percentage, weed percentage, year of production, net weight, date of packaging, and location of packaging.

B. Pesticide shall not be used in this Project.

1.7 QUALIFICATIONS

A. Seed Supplier: Company specializing in manufacturing Products specified in this section with minimum 3 years documented experience.

B. Installer: Company specializing in performing work of this section with minimum 2 years documented experience.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver grass seed mixture in sealed containers. Seed in damaged packaging is not acceptable.

B. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer.

C. Deliver tackifier sealed containers showing weight, chemical analysis, and name of manufacturer.

1.9 MAINTENANCE SERVICE

A. Maintain seeded areas immediately after placement for 12 months from Date of Substantial Completion. Grass shall be well established and exhibits vigorous growing condition.

PART 2 PRODUCTS

2.1 SEED MIXTURE

A. Suppliers:

1. Sunmark Seeds, Portland, OR
2. PT Lawn Seed, Portland, OR
3. NaturesSeed.com
4. Or approved equal

B. SEED MIX

1. As shown in the Plant Schedule in the Drawings.

C. HYDRAULIC APPLIED EROSION CONTROL MULCH

1. As shown in the Plant Schedule in the Drawings.

2.2 ACCESSORIES

A. Wood and Bark Mulching Material: Chipped wood and bark, sawdust, and ground wood mulch should be free of growth or germination inhibiting ingredients.

B. Compost: Commercially manufactured fine and medium compost materials.

C. Fertilizer: Commercial grade; recommended for grass to eliminate deficiencies of topsoil and suitable for application with equipment designed for that purpose.

1. Deliver fertilizers in separate or mixture containers that have the percentage of total nitrogen, available phosphoric acid, and water-soluble potash (NPK) in the amounts specified. Label each container with a quality compliance certificate.

2. Application rate shall be determined by the soil conditions, as indicated in analysis to determine the proportions of Nitrogen percent, phosphoric acid percent, soluble potash percent.

D. Lime: ASTM C602, agricultural limestone containing a minimum 80 percent calcium carbonate equivalent.

E. Water: Clean, fresh, and free of substances or matter capable of inhibiting vigorous growth of grass.

F. Pesticides/Herbicide: Submit proposed pesticides and receive approval before using. Submit a copy of the Manufacturer's federal registered label and, if requested, a Material Safety Data Sheet. The Agency reserves the right to restrict chemicals from being used on sensitive areas.

1. Pesticide registered and approved by the Environmental Protection Agency (EPA), acceptable to authorities having jurisdiction, and of type recommended by Manufacturer for each specific problem and as required for Project conditions and application.

2. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

3. Pre-Emergent Herbicide (Selective and Non-Selective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the erosion control layer.

4. Post-Emergent Herbicide (Selective and Non-Selective): Effective for controlling weed growth that has already germinated.

2.3 SOURCE QUALITY CONTROL

A. Analyze soil to ascertain percentage of nitrogen, phosphorus, potash, soluble salt content, organic matter content, and pH value.

B. Provide recommendation for fertilizer and lime application rates for specified seed mix as result of soil testing.

C. Testing is not required when recent tests and certificates are available for imported topsoil. Submit these test results to testing laboratory. Indicate, by test results, information necessary to determine suitability.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Planting Season: Plant seeds when growing conditions are conducive to seed germination and quick but thorough establishment of seedlings.

1. Depending on latitude and elevation in the Pacific Northwest, these conditions occur either in mid-August through early October or mid-April to late May.

2. Avoid planting seed during the heat of summer or in late fall to avoid freezes that kill sprouting grass seeds.

C. Weed Control Coordinator - Submit certification at the preconstruction conference that the weed control coordinator meets the following minimum requirements:

1. Demonstrates ability to identify noxious and other weed species commonly seen in site location for at least 1 year conducting weed surveys.

2. Has successful weed control experience, with similar duties to those stated under typical duties below, on at least three construction or vegetation management projects. Certification of Pesticide Consultant License is preferred.

3. The weed control coordinator duties include:

   a. Identify Specified Weeds.
   b. Prepare and update the Weed Control Program.
   c. Coordinate Contractor's weed removal Work and records.
   d. Ensures the removed weeds are disposed of at an approved off-site facility.

D. Pesticide Applicator - Submit certification before application of pesticide Work begins, that when chemical weed control is used, that each applicator possesses a Commercial Pesticide Applicator's License held in the individual's name. Submit a certification each time a new applicator begins application Work on the Project.

E. Conduct soil analysis to determine soil fertility. The soil test should at least analyze the current nitrogen, phosphorus, potassium, and PH rates in the soil. Accordingly, the soil test result would suggest the proper soil amendment application including the rates of fertilizers and lime. Obtain the Engineer approval before applying soil amendment.

F. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Engineer and replace with new planting soil.

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

1. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.

2. Uniformly moisten excessively dry soil that is not workable, and which is too dusty.

3. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.

3.2 SOIL PREPARATION

A. Prepare area for seeding while generally considering the following:

1. Remove any matter detrimental or toxic to the growth of plants, including weeds, clods, rocks, or debris.

2. Application rates of fertilizer or lime shall be based on soil testing results.

3. Prepare a tilled, fine, but firm seedbed.

4. The soil shall have a pH range of 6.5 to 7.5.

3.3 WEED CONTROL

A. Do not harm or disturb any vegetation that was planted as proposed on the planting plans. Do not compact soil with heavy equipment.

B. Inspect the Project for new growth of specified weeds at least monthly during the plants growing season and apply weed control measures as appropriate.

1. Inspect the area at least every 30 days after growing season has begun or as directed for continuing control of all vegetation considered as weeds.

2. Provide schedule of weed control measures.

3. Request to use wheeled or tracked construction equipment in sensitive areas.

C. Remove and control weeds according to the following:

1. Verify the weed control methods before proceeding with weed control activities.

2. Remove all specified weeds and ensure that weed seeds or reproducing plant parts such as vines, runners, or rhizomes do not remain or become disbursed during control activities.

3. Place weeds and related materials in an approved container and transport to an approved offsite disposal facility according to applicable laws and regulations.

4. Keep the site weed free including weeds not initially documented.

D. Weed Control at Sensitive Areas - as determined by the Engineer:

1. Use only hand or light mechanical weed control methods within 50 feet of sensitive areas.

2. Hand methods include the use of hand tools. Light mechanical methods include the use of hand carried, motorized machinery.

E. Weed Control Corrective Work - If corrective work for areas identified as deficient by the Engineer, it should be completed within a 15 Calendar Day period,

3.4 SEEDING

A. Apply Seed mix at rate according to the plans.

3.5 HYDROSEEDING AND HYDROMULCHING

A. Mix seeds, fertilizers, mulch, and tackifier with water in specific tank as follows:

1. Hydraulic Equipment should continuously mix and agitates the slurry providing a continuous, non-fluctuating delivery.

2. Provide a uniform distribution of the slurry.

3. Place seed, fertilizer, mulch, and tackifier in the hydroseeder tank no more than 30 minutes prior to application.

B. Hydroseeding operation: Perform hydroseeding according to the following:

1. One-Step Operation - Apply materials in one step only for the following situations:

a. When seeding in conjunction with erosion control matting. Apply seed, fertilizer, and tracer before installing matting.

b. When treating small areas that are 1,500 square feet or less and totaling no more than 0.5 acre, double the amount of seed to compensate for seed suspended above Soil by the mulch.

2. Two-Step Operation – for areas over 0.5 acre, use the two-step method for all hydroseeding/hydromulching operations:

a. Step 1 - Apply seed and fertilizer.
b. Step 2 - Apply hydromulch.

C. Seed -Thoroughly mix seeds when more than one kind is to be used.

D. Mulch - Apply at the following rates based on dry fiber weight:

1. Slopes Flatter Than 1V:2H - Apply cellulose fiber that includes a tackifier at a rate of 2,000 pounds per acre.

2. Slopes 1V:2H or Steeper - Apply cellulose fiber that includes a tackifier at a rate of 3,000 pounds per acre.

3.6 SEEDING OVER MULCHED AREAS

A. If an area has been previously mulched for erosion control or temporary seed and mulch is present on the soil surface, double the pound rate for each seed type used. Apply seed and fertilizer hydraulically or mechanically and add a green dye to the mixture to visibly aid uniform application. Upon approval, fertilizer and seed may only be applied after mulching if one of the following conditions apply:

1. Mulch is punched into the soil by mechanized means. Avoid heavy equipment that may compact the soil. Roll seeded area with roller not exceeding 112 pounds/linear foot.

2. Mulch that is held down with netting or like material

3. Mulch is removed prior to seeding.

3.7 WORK QUALITY

A. After application, apply water with fine spray immediately after each area has been hydroseeded Apply water with fine spray immediately after each area has been mulched.

B. Drift - Prevent drift and displacement of seed and fertilizer regardless of equipment and methods used.

C. Displacement - Prevent seed, fertilizer, and mulch from falling or drifting onto other areas where grass is detrimental. Remove material that falls on plants, roadways, gravel shoulders, structures, and other surfaces where material is not specified.

D. Damage - Prevent damage to prepared areas and to completed fertilizer, seed, and mulch work. Replace all material that becomes displaced before acceptance of the work.

3.8 MAINTENANCE

A. Control growth of weeds. Remedy damage resulting from improper use of herbicides.

B. Weed Control - Remove specified weeds prior to plants going to seed and keep weed control and seeded areas "Weed Free" throughout the Establishment Period.

C. Immediately reseed areas showing bare spots.

D. Repair washouts or gullies.

E. Protect seeded areas with warning signs during maintenance period.

F. Ensure that each seeded area has a uniform, healthy and weed-free stand of grass or other seeded plants growing at the end of the Establishment Period. The minimum living plant coverage standards for acceptance of seeding in a planted area are as follows:

1. Temporary Seeding:

   a. West of the Cascades - 70 percent coverage of ground surface.
   b. East of the Cascades - 30 percent coverage of ground surface.

2. Permanent Seeding:

   a. West of the Cascades - 90 percent coverage of ground surface.
   b. East of the Cascades - 30 percent coverage of ground surface.

3. Wetland Seeding - 70 percent coverage of ground surface.

4. Water Quality Seeding - 100 percent of ground surface.

G. Protection - Protect seeded areas from trespass and other hazards of damage. Use protective fences and signs at no additional cost to the Agency. Obtain approval of protective methods used.

H. Fertilizing and Watering - Apply fertilizer according to grass and soil requirements. Apply water according to good horticultural practice under the prevailing conditions, as required to promote a healthy stand of plants. Obtain water at no additional cost to the Agency.

I. Mowing – If mowing is required, do the first mowing of grass when soil is firm enough to prevent rutting and grass is about 3 inches tall. After mowing, leave grass that is approximately 2 inches tall. At each subsequent mowing, leave about 1-1/2 inches of growth. After the second mowing, grass clippings may be left in place upon written approval.

J. Repair and Restore - Repair and restore soil grades and re-seed damaged, settled, or unproductive areas to the specified conditions of this Section at no additional cost to the Agency.

K. Finishing and Cleaning Up Cleanup - Remove weeds, trash, debris, stones, and other extraneous matter from seeded areas as directed and dispose of.

END OF SECTION

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SECTION 33 05 13 – MANHOLES

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes cast-in-place and precast concrete manholes and covers for access to subsurface drainage piping or utilities.

B. Section Includes:

1. Cast-in-place concrete manholes with transition to cover frame, covers, anchorage, and accessories.

2. Modular precast concrete manhole with tongue-and-groove joints with precast transition to cover frame, covers, anchorage, and accessories.

3. Bedding and cover materials.

C. American Iron and Steel (AIS) Compliance: Materials provided under work of this Section shall comply with the AIS requirements of the Water Infrastructure Finance and Innovation Act (WIFIA). All materials provided and incorporated into this Project shall meet the AIS requirements of P.L. 113-76, Consolidated Appropriations Act, 2014.

D. Related Sections:

1. Section 03 11 00 - Concrete Work
2. Section 03 21 00 - Reinforcing Steel
3. Section 31 05 13 - Soils for Earthwork
4. Section 31 05 16 - Aggregates for Earthwork
5. Section 31 23 16 - Excavation
6. Section 31 23 23 - Fill
7. Section 33 30 10.13 - Sewer and Manhole Testing
8. Section 33 41 10 - Storm Utility Drainage Piping

1.2 REFERENCE STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO M-198B – Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants

B. American Concrete Institute (ACI):

1. ACI 301 – Building Code Requirements for Structural Concrete
2. ACI 315 – Details and Detailing of Concrete Reinforcement
3. ACI 318 – Building Code Requirements for Structural Concrete

C. ASTM International (ASTM):

1. ASTM A48 - Standard Specification for Gray Iron Castings

2. ASTM A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

3. ASTM A615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

4. ASTM C55 - Standard Specification for Concrete Building Brick

5. ASTM C62 - Standard Specification for Building Brick (Solid Masonry Units Made from Clay or Shale)

6. ASTM C150 - Specifications for Portland Cement

7. ASTM C387 - Standard Specification for Packaged, Dry, Combined Materials for Concrete and High Strength Mortar

8. ASTM C443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets

9. ASTM C478 - Standard Specification for Precast Reinforced Concrete Manhole Sections

10. ASTM C497 - Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile

11. ASTM C827 – Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens of Cementitious Mixtures

12. ASTM C913 - Standard Specification for Precast Concrete Stormwater and Wastewater Structures

13. ASTM C923 - Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals

14. ASTM C990 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants

D. Federal Specifications:

1. SS-S-00210 (210-A) – Specification for Sealing Compound, Preformed Plastic, for Expansion Joints and Pipe Joints

E. US Army Corp of Engineers:

1. CRD-C 621 – Specifications for Non-Shrink Grout

1.3 SUBMITTALS

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

B. Product Data:

1. Pre-cast concrete manholes:

a. Design criteria and calculations.

b. Details of reinforcement.

2. Steps.

3. Cover and frame construction, features, configuration, dimensions, and material specifications.

4. Rubber gaskets.

5. Grout and mortar.

C. Shop Drawings:

1. Indicate manhole by location.

2. Provide dimensions, elevations, joints, location, and type of lifting inserts.

3. Indicate connecting piping material, piping size, piping connection angles and offsets, and sizes of penetrations.

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

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

F. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

1.4 DELIVERY, STORAGE, AND HANDLING

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

B. Comply with Precast Concrete Manufacturer's instructions and ASTM C913 for unloading, storing, and moving precast manholes and drainage structures.

C. Storage:

1. Store precast concrete manholes as to prevent damage to Owner's property or other public or private property.

2. Repair property damaged from materials storage.

PART 2 PRODUCTS

2.1 PERFORMANCE AND DESIGN CRITERIA FOR MANHOLES

A. Equivalent strength: Based on structural design of reinforced concrete as outlined in ACI 318.

B. Design of Lifting Devices for Precast Components: According to ASTM C913.

C. Design of Joints for Precast Components:

1. According to ASTM C913.

2. Lipped male/female joints.
3. Maximum Leakage: 0.025 gallons per hour per foot of joint at 3 feet of head.

D. Shaft Construction:

1. Reinforced concrete.
2. Concentric with eccentric cone top section
3. Sleeved to receive pipe connections.

E. Wall Thickness:

1. Minimum wall thickness shall be 5 inches.
2. Cones shall have the same wall thickness and reinforcement as riser sections.

F. Shape: Cylindrical.

G. Clear Inside Dimensions:

1. As indicated on Drawings.

2. Sections shall consist of circular sections in standard nominal inside diameters of 42, 48, 54, 60, 72, 84, 96, 108, 120, 132, or 144 inches.

H. Design Depth:

1. As indicated on Drawings.

I. Clear Cover Opening: As indicated on Drawings, minimum of 30 inches.

J. Pipe Entry: Furnish openings as required and as indicated on the Drawings.

K. Steps:

1. Rungs:

a. Material: Formed polypropylene with 1/2-inch diameter, Grade 60 reinforcing bar.
b. Comply with ASTM C478.
c. Reinforcing bar to comply with ASTM A615.

2. Formed integral with manhole sections.

3. Width: Minimum 12 inches.

4. Spacing: 12 inches on center vertically.

2.2 MANHOLES

A. Precast Concrete Manholes:

1. Sections:

a. Description: Reinforced precast concrete according to ASTM C478.
b. Gaskets: According to ASTM C923.

c. Heights: Multiples of 6 inches.

2. Bases:

a. Base slab integral with sidewalls.
b. Monolithic construction, conforming to ASTM C478.

B. Cast-in-Place Concrete Manholes:

1. Sections: Reinforced cast-in-place concrete as specified in Section 03 30 00 - Cast-in-Place Concrete.

2. Concrete forming in accordance with Section 03 10 00, Concrete Forming and Accessories.

C. Joint Materials:

1. Mortar:

a. Conform to ASTM C387.

b. Admixtures

1) Allowable, not exceeding the following percentages of weight of cement:

a) Hydrated lime, 10 percent
b) Diatomaceous earth or other inert materials, 5 percent

c. Consistency: Shall be such that it will readily adhere to the precast concrete if using the standard tongue and groove type joint.

d. Mortar not used within 30 minutes of initial mixing shall be discarded and not be used.

2. Non-Shrink Grout:

a. Description: Non-metallic, cementitious, commercial grout exhibiting zero shrinkage per ASTM C827 and CRD-C-621.

b. Manufacturers:

1) Preco-Patch
2) Sika 212
3) Euco N-S
4) Five-Star
5) Approved equal

3. Grout shall not be amended with water after initial mixing.

4. Grout not used within 20 minutes of initial mixing shall be discarded and not be used.

5. Commercial Concrete Bonding Agent:

    a. Non-shrink grout shall be placed or packed only with the use of an approved commercial concrete bonding agent applied to all cured concrete surfaces being grouted.

    b. Bonding agent shall be compatible with the brand of grout used.

    c. Water shall not be used as a substitute for the commercial bonding agent.

D. Preformed mastic gaskets for manhole joints shall meet Federal Specifications SS-S-00210 (210-A), AASHTO M-198B and ASTM C990.

E. Reinforcement:

1. Formed steel wire conforming to ASTM A1064.

2.3 FRAMES AND COVERS

A. Description:

1. Construction: ASTM A48, Class 30 gray cast iron.

2. Lid:

    a. Machined flat bearing surface.
    b. Removable.
    c. With grate lids at locations shown on the Drawings.

3. Cover Design: Per City of Oregon City standards unless shown other on plans.

4. Live Load Rating: AASHTO H20 loading.

5. Cover: Sanitary Sewer Manholes and Storm Manholes shall be molded with “S” cast in per City of Oregon City standards unless otherwise noted on the Drawings.

6. Coefficient of Friction on Outside Face: Minimum of 0.60.

2.4 GRADE RINGS

A. Description:

1. Four inches to 6 inches Thick:

    a. Material: Precast concrete.
    b. Comply with ASTM C478.

2. Less than 4 inches Thick:

    a. Material: Cast iron.
    b. Comply with AASHTO M306.

3. Rubber Seal Wraps:

    a. Wraps and Band Widths: Conform to ASTM C877, Type III.
    b. Cone/Riser Ring Joint: Minimum 3 inches overlap.
    c. Frame/Riser Ring Joint: 2 inches overlap.
    d. Additional Bands: Overlap upper band by 2 inches.

2.5 MATERIALS

A. Bedding and Cover:

1. Bedding: Coarse Aggregate Material Type A1, as specified in Section 31 05 16, Aggregates for Earthwork. Aggregate size as shown in the Drawings.

2. Backfill Around Structure: Coarse Aggregate Material Type A1, as specified in Section 31 05 16, Aggregates for Earthwork. Aggregate size as shown in the Drawings.

3. Soil Backfill from Above Pipe to Finish Grade:

    a. In existing or future roadways, right-of-way:

        1) Coarse Aggregate Material Type A1, as specified in Section 31 05 16, Aggregates for Earthwork. Aggregate size as shown in the Drawings.

    b. In non-paved areas outside of footprint of existing or future structures, outside of right-of-way:

        1) Soil Type S1, as specified in Section 31 05 13, Soils for Earthwork.
        2) Subsoil: No rocks over 6 inches in diameter, frozen earth, or foreign matter.

2.6 FINISHES

A. Steel:

1. Galvanizing:

    a. ASTM A123.
    b. Hot dipped galvanize after fabrication.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify items provided by other Sections of Work are properly sized and located.
B. Verify built-in items are in proper location and ready for roughing into Work.
C. Verify correct size of manhole excavation.

3.2 PREPARATION

A. Design the method of placement for all precast items and add all reinforcing steel, embeds, bracing, and other items necessary for placement. All portions of embeds which remain embedded in the concrete shall be made of stainless steel.

B. Mark each precast structure by indentation or waterproof paint showing date of manufacture, Manufacturer, and identifying symbols and numbers as indicated on Drawings to indicate its intended use.

C. Coordinate placement of inlet and outlet pipe or duct sleeves required by other Sections.

D. Do not install manholes where site conditions induce loads exceeding structural capacity of manhole components.

E. Inspect precast concrete structures immediately prior to placement in excavation to verify structures are internally clean and free from damage; remove and replace damaged units.

F. Subgrade

1. Subgrade shall be compacted to 95 percent of maximum density.

2. Compacted subgrade shall be covered with a minimum of 6 inches of aggregate base compacted to 95 percent of maximum density, extending a minimum of 6 inches beyond the outside limits of the manhole, unless otherwise indicated on Drawings.

3. Grade the aggregate base to a uniform, level surface which will fully support the structure and to an elevation that will ensure proper positioning of the top slab or lid.

3.3 INSTALLATION

A. Excavation and Backfill:

1. Excavate manholes as specified in Section 31 23 16, Excavation in location and to indicated depth.

2. Provide 12 inches of clearance around sidewalls of structure for construction operations.

3. When groundwater is encountered, prevent accumulation of water in excavations and place manholes in dry trench.

B. Where possibility exists of watertight structure becoming buoyant in flooded excavation, anchor structure to avoid flotation as approved by Engineer.

C. Base Pad:

1. Place base pad.
2. Trowel top surface level.

D. Backfill excavations for manholes as specified in Section 31 23 23, Fill.

E. Form and place manhole cylinder plumb and level and to correct dimensions and elevations.

F. Grout base of shaft sections to achieve slope to exit piping, trowel smooth, and contour to form continuous drainage channel.

G. Set cover frames and covers level without tipping and to correct elevations.

H. Coordinate with other Sections of Work to provide correct size, shape, and location.

I. Precast Concrete Manholes:

1. Assembly:

   a. Install precast structures in accordance with the Manufacturer's recommendations unless otherwise required by the Contract Documents.

   b. Verify installed manholes meet required alignment and grade.

   c. Lift precast components at lifting points designated by Manufacturer.

   d. When lowering manholes into excavations and joining pipe to units, take precautions to ensure that interior of pipeline and structure remains clean.

   e. Set precast structures bearing firmly and fully on crushed stone bedding, compacted as specified in Section 31 23 23, Fill or on other support system as indicated on Drawings.

   f. Assemble multi-section structures by lowering each section into excavation; set level and firmly position base section before placing additional sections.

   g. Place manhole sections plumb and level, trim to correct elevations, and anchor to base pad.

   h. Remove foreign materials from joint surfaces and verify sealing materials are placed properly.

   i. Maintain alignment between sections by using guide devices affixed to lower section.

2. Joints:

   a. Sealing materials may be installed onsite or at Manufacturer's plant.

   b. All joints shall be sealed watertight by the use of rubber gaskets or other approved preformed sealant.

   c. All joints shall then be filled with non-shrink grout on both the inside and outside surfaces to produce smooth interior and exterior surfaces.

3. Concrete Base Installation:

   a. Bases shall be set at the proper grade to allow pipe openings to match the grades for connecting pipes.

   b. Invert shall be constructed to a section identical with that of the sewer pipe.

   c. Where the size of sewer pipe is changed at the manhole, the invert shall be constructed to form a smooth transition without abrupt breaks or unevenness of the invert surfaces.

   d. Prevent sewage or water from contacting the new concrete or mortar surfaces to prevent damage to the fresh concrete or mortar until the initial set has been achieved.

e. Manhole bases shall be set level so base gravel fully and uniformly supports them in true alignment with uniform bearing throughout full circumference.

f. Do not level the base sections by wedging gravel, or other material, under the edges.

g. Flexible connectors shall be installed in the base section to form a permanently watertight seal.

4. Manhole Riser Sections:

a. Precast manhole components may be used to construct standard, drop and carry-through manholes. Manholes less than 4 feet in depth measured from the spring line of the pipe to the bottom of the lower riser ring shall be flat-top manholes.

b. Install manhole riser sections at the location shown on the plans. All sanitary sewer and pollution control manholes joints shall be watertight and shall use rubber gaskets or a preformed sealant. All joints shall then be filled with non-shrink grout inside and out so as to produce smooth interior and exterior surfaces. All manhole penetrations shall be watertight. Complete manholes shall be rigid. Compact backfill in accordance with the provisions stated elsewhere in this document.

c. All lift holes shall be thoroughly wetted, completely filled with mortar, and smoothed and pointed both inside and out to ensure watertightness.

d. The shortest length of riser section to be incorporated into the manhole shall be installed immediately below the flat slab top or cone.

e. Properly locate and plumb each manhole riser section.

f. Install manhole extensions and top slabs in accordance with Manufacturer's specifications and as shown on the plans. Lay section risers with the sides plumb and the tops level. Make joints and penetrations watertight.

g. Remove knockouts or cut structure to receive piping without creating openings larger than required to receive pipe; fill annular spaces with mortar.

5. Entrances/Exits:

a. Cut pipe flush with interior of structure.

b. Shape inverts through manhole as indicated on Drawings.

c. All rigid non-reinforced pipe entering or leaving the manhole (new or existing manhole) shall be provided with flexible joints within 1 foot of the structure and shall be placed on compacted bedding.

d. Ribbed HDPE pipe connections shall be grouted watertight with non-shrink grout.

e. PVC pipe shall be connected to manholes using an approved adapter specifically manufactured for the intended service.

1) Adapters shall be Fernco, Kor-N-Seal, or equal.

6. Grates, Frames, and Covers:

    a. Manhole frames, grates, and covers shall be installed in such a manner as to prevent infiltration of surface or groundwater between the frame and the concrete of the manhole section. Use preformed rubber ring to form a watertight seal.

    b. Manhole frames and covers shall be installed to grades shown on the drawings or as directed.

    c. Adjustment of manhole castings shall be made using specified precast grade rings and approved rubber ring joints.

    d. The maximum depth of adjustment below any manhole casting shall be 16 inches, and a minimum depth of adjustment shall be 4 inches.

J. Cast-in-Place Concrete Manholes:

1. Prepare crushed stone bedding or other support system as indicated on Drawings to receive base slab as specified for precast structures.

2. Erect and brace forms against movement as specified in Section 03 11 00, Concrete Work.

3. Install reinforcing steel as indicated on Drawings and as specified in Section 03 11 00, Concrete Work.

4. Place and cure concrete as specified in Section 03 11 00, Concrete Work.

5. Frames and Covers:

    a. Set frames using mortar and masonry.
    b. Install radially laid concrete brick with 1/4-inch-thick vertical joints at inside perimeter.
    c. Lay concrete brick in full bed of mortar and completely fill joints.
    d. If more than one course of concrete brick is required, stagger vertical joints.
    e. Set frame and cover as indicated on Drawings.

3.4 FIELD QUALITY CONTROL

A. Test concrete manhole and structure sections according to ASTM C497.

B. Perform manhole testing according to Section 33 30 10.13, Sewer and Manhole Testing.

C. Test cast-in-place concrete as specified in Section 03 11 00, Concrete Work.

D. Vertical Adjustment of Existing Manholes:

1. If required, adjust top elevation of existing manholes to finished grades as indicated on Drawings.

2. Reset existing frames, grates, and covers that were carefully removed and cleaned of mortar fragments to required elevation according to requirements specified for installation of castings.

3. When removal of existing concrete wall is required, remove concrete without damaging existing vertical reinforcing bars, clean concrete from vertical bars, and bend into new concrete top slab or splice to required vertical reinforcement as indicated on Drawings.

4. Clean and apply sand-cement bonding compound on existing concrete surfaces to receive cast-in-place concrete as specified in Section 03 11 00, Concrete Work.

END OF SECTION

SECTION 33 05 50 - REMOVAL AND ABANDONMENT OF EXISTING PIPE AND STRUCTURES

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes the removal of existing buried piping and abandonment in place of existing buried piping.

B. Section includes:

1. Pipe removal.
2. In-place abandonment of pipe.

C. Related Sections:

1. Section 03 60 00, Grouting.
2. Section 31 23 16, Excavation.
3. Section 31 23 17, Trenching.
4. Section 31 23 19, Dewatering.
5. Section 31 23 23, Fill.
6. Section 31 23 24, Flowable Fill.

1.2 SUBMITTALS

A. Provide all submittals in accordance with Section 01 33 00, Submittal Procedures.

B. Piping Abandonment Plan:

1. Identify locations specified for pipe abandonment.

2. Provide method to be utilized to abandon the pipe, including whether the pipe will be left in place or removed in its entirety.

C. Non-Shrink Grout: Product data in accordance with Section 03 60 00, Grouting.

D. CLSM: Mix designs in accordance with Submittal requirements of Section 31 23 24, Flowable Fill.

1.3 REQUIREMENTS OF REGULATORY AGENCIES

A. Permits: The Contractor is responsible for obtaining all necessary permits required for completion of the work described herein.

B. Protection of Persons and Property: Meet all federal, state, and local safety requirements for the protection of workmen, other persons, and property in the vicinity of the work and requirements of the General Provisions.

1.4 PROTECTION OF EXISTING WORK

A. Carefully examine the Contract Documents to determine the extent of the work of this Section.

B. Carefully coordinate the work of this Section with all other work and construction.

C. Take all necessary precautions to prevent damage to existing facilities or utilities which are to remain in place and be responsible for any damages to existing facilities or utilities, which are caused by the operations.

1.5 REPAIR OF DAMAGE

A. Work procedures shall provide for safe conduct of the work; careful removal and disposition of materials and equipment; protection of facilities, utilities and property which are to remain undisturbed; coordination with existing facilities and utilities to remain in service.

B. Any damage to existing facilities or utilities to remain as caused by the Contractor's operations shall be repaired to acceptance of Engineer.

C. Damaged items shall be repaired or replaced with new materials as required to restore damaged items or surfaces to a condition equal to and matching that existing prior to damage or start of work of this contract.

1.6 EXISTING CONDITIONS

A. If the pipe material contains any hazardous materials, such as asbestos, requiring special handling upon removal, it is the responsibility of the Contractor to remove and dispose of the material in accordance with all applicable federal, state, and local regulations.

PART 2 PRODUCTS

2.1 OWNERSHIP OF EXISTING MATERIALS

A. All materials, equipment, miscellaneous items, and debris involved, occurring, or resulting from pipe removal work shall become the property of the Contractor at the place of origin, unless otherwise specified in the Drawings or by the Engineer.

2.2 CONTROLLED LOW STRENGTH MATERIAL

A. As specified in Section 31 23 24, Flowable Fill.

PART 3 EXECUTION

3.1 PIPE REMOVAL

A. Where identified on the Drawings, remove, and dispose of all pipe material and associated appurtenances.

1. All fire hydrants, air release valves service lines and appurtenances being abandoned shall be removed to 36 inches below finished grade.

2. Existing service line appurtenances, including valve and meter boxes, shall be removed to 36 inches below finished grade.

B. All exposed ends of pipes and fittings to remain in service shall be capped or plugged with an appropriate ductile iron blind flange, cap or plug and restrained.

1. A pipe shall be considered in service if it is possible to flood the pipe with water by opening valves in the water system.

C. All excavation and backfilling associated with pipe removal shall be performed in accordance with 31 23 17, Trenching.

3.2 IN-PLACE ABANDONMENT OF PIPING

A. Where identified on the Drawings, abandon pipe in place.

B. Cut and Plug exposed ends of pipes being abandoned in place with a minimum of two (2) feet of non-shrink grout.

1. Prior to placing grout, roughen interior pipe surface and apply epoxy bonding agent.

3.3 FILLING PIPE WITH CLSM

A. Where pipes are identified in the Drawings to be abandoned-in-place, fill pipes greater than 12 inches in diameter with CLSM.

B. CLSM shall be placed in a manner to ensure complete filling of the pipe, leaving no cavities or voids.

C. Install hot taps, saddles, fill lines and appurtenances as necessary for pumping CLSM from the surface into the pipe being filled.

D. CLSM shall be pumped up grade from fill lines rigidly connected to the pipes being filled.

E. Placement of CLSM by free flowing (non-pumped) methods will not be acceptable.

F. Fill lines shall be located at elevations lower than the pipe being filled.

G. As the CLSM is being placed, use other fill lines as view ports to ensure complete filling of the pipes.

H. Relocate pumping equipment as necessary to complete filling of the pipes.

I. Excavate and cut access holes in the pipes as necessary to complete filling operations.

J. Perform pipe filling operations in a manner to eliminate all air pockets.

K. Submit volume calculations for CLSM placed in each filled segment of piping to verify that pipelines have been completely filled.

3.4 IN-PLACE ABANDONMENT FOR SEWER AND OTHER MISCELLANEOUS DRAINAGE FACILITIES

A. General:

1. Remove structures to a minimum of 3 feet below subgrade, unless otherwise noted.

2. Cover top surface of abandoned structures with two sheets of nonwoven geotextile, extended at least 1-foot beyond the outside walls of the abandoned manhole, sump, or basin.

B. Sumps:

1. Remove existing sediment, soil, and water. Properly dispose of these materials in accordance with the requirements of these specifications.

2. Remove top cone and first solid concrete section to a depth of approximately 8 to 10 feet below ground.

3. Fill sump with flowable fill as specified in Section 31 23 24, Fill.

4. Backfill remaining voids for facilities within existing or proposed roadways with approved materials as specified in Section 32 11 23, Aggregate Base Courses.

3.5 SALVAGING MANHOLE FRAMES, COVERS, AND GRATES:

A. Remove manhole frames, covers, and grates scheduled for salvage and store in approved location.

B. Frames, grates, and covers meeting Specifications may be salvaged from structures to be adjusted and may be reused in the Work if of suitable size and condition.

C. Clean salvaged components to be reused of foreign material by methods that will not harm the components.

D. Manhole frames and covers removed by the Contractor are the property of the Owner. Notify the Engineer a minimum of 48 hours before removal to arrange for pickup of the removed frames and covers, if not reused.

3.6 CLEANUP

A. During and upon completion of work of this Section, promptly remove all unused tools and equipment, surplus materials, and debris.

B. Adjacent areas shall be returned to their existing condition prior to the start of work.

END OF SECTION

SECTION 33 05 64 - PRECAST CONCRETE VALVE VAULTS AND METER BOXES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Precast concrete valve vaults.
2. Precast concrete meter boxes.

B. American Iron and Steel (AIS) Compliance: Materials provided under work of this Section shall comply with the AIS requirements of the Water Infrastructure Finance and Innovation Act (WIFIA). All materials provided and incorporated into this Project shall meet the AIS requirements of P.L. 113-76, Consolidated Appropriations Act, 2014.

C. Related Section:

1. Section 05 50 00, Metal Fabrications
2. Section 31 05 16, Aggregates for Earthwork
3. Section 31 23 16, Excavation
4. Section 31 23 23.33, Flowable Fill.
5. Section 33 11 10, Water Utility Distribution and Transmission Piping

1.2 REFERENCE STANDARDS

A. ASTM International (ASTM):

1. ASTM A48 - Standard Specification for Gray Iron Castings.
2. ASTM A185 - Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
3. ASTM A536 - Standard Specification for Ductile Iron Castings.
4. ASTM A615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
5. ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
6. ASTM C33 - Standard Specification for Concrete Aggregates.
7. ASTM C150 - Standard Specification for Portland Cement.
8. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
9. ASTM C478 - Standard Specification for Precast Reinforced Concrete Manhole Sections.
10. ASTM C497 - Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile.
11. ASTM C890 - Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures.

12. ASTM C913 - Standard Specification for Precast Concrete Water and Wastewater Structures.

13. ASTM C990 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.

14. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft3 (600 kN-m/m3)).

15. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).

16. ASTM D4104 - Standard Test Method (Analytical Procedure) for Determining Transmissivity of Nonleaky Confined Aquifers by Overdamped Well Response to Instantaneous Change in Head (Slug Tests).

17. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.3 COORDINATION

A. Coordinate Work with utilities within construction area.

B. The drawings identify precast vaults and meter boxes by Manufacturer and model number. This information is provided for dimensional information only. Provide precast items in accordance with the requirements of this Section.

1.4 PREINSTALLATION MEETINGS - NOT USED

1.5 SUBMITTALS

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

B. Product Data: Submit data on valve vaults and meter boxes.

C. Shop Drawings for Precast Concrete Valve Vaults:

1. Indicate plan, location, and inverts of connecting piping.
2. All interior and exterior dimensions.
3. Location and type of lifting inserts, connection embeds, and joints.
4. Details of reinforcement.
5. Covers or hatches.
6. Ladders and grating.

D. Manufacturer's Certificate: Certify that precast concrete valve vaults and meter boxes meet or exceed ASTM standards and specified requirements.

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

1.6 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations and inverts of buried pipe, components, and connections.

1.7 QUALITY ASSURANCE

A. Perform Work according to standards identified in Article 1.2 herein.

1.8 DELIVERY, STORAGE, AND HANDLING

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

B. Transport and handle precast concrete units with equipment designed to protect units from damage.

C. Storage:

1. Store precast concrete valve vaults and meter boxes according to Manufacturer instructions.

2. Do not place concrete units in position to cause overstress, warping, or twisting.

PART 2 PRODUCTS

2.1 DESIGN REQUIREMENTS

A. Performance and Design Criteria:

1. Watertight, Precast, Reinforced, Air-Entrained Concrete Structures:

a. Manufactured to conform to ASTM C913.

2. Loading:

a. Design to ASTM C890-A16 / AASHTO HS20 live loading and installation conditions.

b. Where vaults are below grade, a dead load of 125 pounds per cubic foot shall be added for the soil.

c. Lateral loads:

1) Static: 105 x Depth of fill per square foot (psf) triangular equivalent fluid pressure plus a surcharge of an additional 3 feet of soil depth in areas subject to vehicular traffic (assume traffic load in all areas, unless indicated otherwise by the Contract Documents).

2) Seismic acceleration: UBC Zone 3 requirements (I = 1.25) where I = importance factor, I = 1.25, but not less than 0.20 grams (g) acting on structure mass. Seismic loading need not be considered simultaneously with traffic surcharge.

3. Minimum 28-Day Compressive Strength: 3,000 pounds per square inch (psi).

4. Honeycombed or re-tempered concrete is not permitted.

5. No knockouts shall be cast into vault walls. All pipe penetrations shall be pre-formed or core-drilled at the required locations.

6. Accessories: Accessories such as ladders, floor grates at sumps, and other features shall be provided as shown on the Drawings.

7. Size: Vault dimensions shall be as required by the Drawings.

2.2 PRECAST CONCRETE VALVES AND METER BOXES

A. Manufacturers:

1. Furnish materials according to City of Oregon City standards as shown in the details of the Drawings.

B. Valve Vault and Meter Box Frames and Covers:

1. Cast Iron Castings:

a. ASTM A48, Class 30 or better.
b. Free of bubbles, sand, air holes, and other imperfections.

C. Access Steps:

1. Steel reinforced formed polypropylene:

a. ASTM C478
b. Reinforced rod: ASTM A615, Grade 60, 1/2-inch diameter

2. Aluminum: ASTM B221, Alloy 6061-T6

3. Width: Minimum 12 inches

4. Spacing: 12 inches on center vertically.

2.3 ACCESS HATCHES AND LIDS

A. Unless noted otherwise elsewhere in the Contract Documents, vaults shall have concrete top slabs with access openings as shown on the Drawings.

B. Vault Manufacturer shall provide the access hatches per the requirements of Section 05 50 00, Metal Fabrications.

C. Lids shall have lifting holes.

D. When leveling bolts are used to set the vault top sections, ensure the load from the top slab is transferred through grout to the vault walls so that the load is not carried by the leveling bolts.

2.4 MATERIALS

A. Portland Cement:

1. ASTM C150, Type II

B. Coarse Aggregates:

1. ASTM C33
2. Graded 1 inch to No. 4 sieve

C. Sand:

1. ASTM C33
2. Fineness Modulus: 2.35

D. Water:

1. Potable.
2. Clean and free of injurious amounts of acids, alkalis, salts, organic materials, and substances incompatible with concrete or steel.

E. Air-Entraining Admixtures: ASTM C260

F. Reinforcing Steel:

1. Deformed Bars: ASTM A615, Grade 40 minimum
2. Welded Wire Fabric: ASTM A185

G. Gaskets:

1. Rubber gaskets: ASTM C443

H. Joint Sealant:

1. ASTM C990

I. Bedding:

1. Aggregate Bedding Material: Fill Type A1 as specified in Section 31 05 16, Aggregates for Earthwork. Size as shown in the Drawings.

2.5 FABRICATION

A. Fabricate precast reinforced concrete structures according to ASTM C913, to dimensions indicated on Drawings, and to specified design criteria.

B. Vaults may be formed with separate top and bottom slabs.

C. Walls shall be cast so that all sides are continuous at corners and their full length with no block-outs or knockouts.

D. Horizontal joints may be provided so that walls can be placed in horizontal segments.

E. All horizontal joints shall be keyed to prevent offsets and shall be provided with a watertight gasket.

F. Finish:

1. Formed surfaces shall be smooth and uniform with no fins, bulges, or other irregularities.

2. Any void greater in width than 1/2-inch or deeper than 3/8-inch shall be repaired.
3. Unformed interior slab surfaces shall have a smooth steel trowel finish.
4. Unformed exterior slab surfaces shall have a light broom finish applied to a steel trowel finish.

2.6 MIXES

A. Design concrete mix to produce required concrete strength, air-entrainment, watertight properties, and loading requirements.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that piping connections, sizes, locations, and inverts are as indicated on Drawings.

3.2 PREPARATION

A. Ream pipe ends and remove burrs.

B. Remove scale and dirt from components before assembly.

C. Establish invert elevations for each component in system.

D. Hand trim excavation to suit valve vaults and meter boxes; remove stones, roots, and other obstructions.

3.3 INSTALLATION

A. Vaults/Meter and Bedding:

1. Excavate as specified in Section 31 23 16, Excavation for Work of this Section.

2. Hand trim excavation for accurate placement of vaults and meter boxes to elevations indicated.

3. Place bedding material level in one continuous layer to a minimum compacted depth of 12 inches.

4. Compact bedding material to 95 percent maximum density.

5. Bases for precast concrete structures shall be set level so that bedding material fully and uniformly supports them in true alignment with uniform bearing throughout full perimeter. Do not level bases by wedging gravel under the edges.

6. Backfill around sides of vaults and meter boxes as required by the Drawings.

B. Connect piping.

3.4 FIELD QUALITY CONTROL

A. Request examination of subgrade by Engineer prior to placing aggregate base under precast materials.

B. Compaction Testing: In accordance with Field Quality Control requirements of Section 31 23 23, Fill.

C. When tests indicate Work does not meet specified requirements, remove Work, replace, and retest.

D. Frequency of Compaction Tests: In accordance with Section 01 45 00, Quality Control.

END OF SECTION

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SECTION 33 11 10 - WATER UTILITY DISTRIBUTION AND TRANSMISSION PIPING

PART 1 GENERAL

1.1 SUMMARY

A. Work under this Section applies to furnishing and installation of pipe materials, fittings, and appurtenances normally encountered with water distribution and transmission systems including potable water and fire water systems.

B. American Iron and Steel (AIS) Compliance: Materials provided under work of this Section shall comply with the AIS requirements of the Water Infrastructure Finance and Innovation Act (WIFIA). All materials provided and incorporated into this Project shall meet the AIS requirements of P.L. 113-76, Consolidated Appropriations Act, 2014.

C. Section includes:

1. Pipe and fittings
2. Flexible couplings
3. Flanged coupling adapters
4. Insulating flanged joints
5. Tapping sleeves and valves
6. Flexible expansion joints
7. Bedding and cover materials
8. Geomembrane for gas line crossings

D. Related Requirements:

1. General

a. Furnish and install all piping systems shown and specified in accordance with the requirements of the Contract Documents.

b. Each buried piping system shall be complete, with all necessary fittings, valves, accessories, lining and coating, testing, excavation, backfill and encasement, to provide a functional installation.

c. Piping layouts shown in the Drawings are intended to define the general layout, configuration, and routing for pipe, as well as the size and type of piping to be installed. The piping plans are not pipe construction or fabrication drawings.

d. The Contractor shall cause the Supplier of pipes, valves, fittings, and appurtenances to coordinate piping installation such that all equipment is compatible and is capable of achieving the performance requirements specified in the Contract Documents.

e. It is the Contractor's responsibility to develop the details necessary to construct all piping systems, to accommodate the specific equipment provided, and to provide and install all spools, spacers, adapters, connectors, valves, gaskets, fittings, appurtenances etc., for a complete and functional system.

E. Related Sections:

1. Section 03 11 00 - Concrete Work
2. Section 13 47 13 – Cathodic Protection
3. Section 31 05 13 - Soils for Earthwork
4. Section 31 05 16 - Aggregates for Earthwork
5. Section 31 23 16 - Excavation
6. Section 31 23 17 - Trenching
7. Section 31 23 23 - Fill
8. Section 31 23 24 - Flowable Fill
9. Section 33 05 17 - Precast Concrete Valve Vaults and Meter Boxes
10. Section 33 12 13 - Water Service Connections
11. Section 33 12 16 - Water Utility Distribution and Transmission Valves
12. Section 33 12 19 - Fire Hydrants
13. Section 33 13 00 - Testing and Disinfecting of Water Utility Piping

1.2 REFERENCE STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO T99 - Standard Specification for Moisture-Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) Drop

B. American Society of Mechanical Engineers (ASME):

1. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250
2. ASME B16.5 - Pipe Flanges and Flanged Fittings, Steel Nickel Alloy, and other Special Alloys
3. ASME B16.21 - Nonmetallic Flat Gaskets for Pipe Flanges
4. ASME B31.10 - Standards of Pressure Piping

C. ASTM International (ASTM):

1. ASTM A36 - Standard Specification for Carbon Structural Steel

2. ASTM A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

3. ASTM A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications

4. ASTM A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength

5. ASTM A536, Standard Specification for Ductile Iron Castings.

6. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3))

7. ASTM D1598 - Standard Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure

8. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds

9. ASTM D1785 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120

10. ASTM D2241 - Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)

11. ASTM D3139 - Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals

12. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

13. ASTM F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

D. American Water Works Association (AWWA):

1. AWWA C104 - Cement-Mortar Lining for Ductile-Iron Pipe and Fittings

2. AWWA C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems

3. AWWA C110 - Ductile-Iron and Gray-Iron Fittings

4. AWWA C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings

5. AWWA C115 - Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges

6. AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast

7. AWWA C153 - Ductile-Iron Compact Fittings

8. AWWA C219 - Bolted, Sleeve-Type Couplings for Plain-End Pipe

9. AWWA C600 - Installation of Ductile-Iron Mains and Their Appurtenances

10. AWWA C605 - Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water

11. AWWA C606 - Grooved and Shouldered Joints

12. AWWA C900 - Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. Through 60 In. (100 mm Through 1,500 mm), for Water Transmission and Distribution

E. Manufacturers Standardization Society of the Valve and Fittings Industry:

1. MSS SP-60 - Connecting Flange Joints between Tapping Sleeves and Tapping Valves

F. NSF International (NSF):

1. NSF Standard 61 - Drinking Water System Components – Health Effects
2. NSF Standard 372 - Drinking Water System Components – Lead Content

3. NSF 600 – Health Effects Evaluation and Criteria for Chemicals in Drinking Water

1.3 SUBMITTALS

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

B. Product Data: Submit data on pipe materials, pipe fittings, restrained joint systems, and accessories.

C. Shop Drawings: Indicate piping layout, including piping specialties.

1. Layout Schedule for applicable segments of proposed transmission main alignment. Schedule shall include layout plan and dimensions, schedule of pipe fittings and specials, materials and class for each size and type of pipe, joint details, pipe supports, and any special provisions required for assembly.

D. Lining and coating data.

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

F. Manufacturer’s handling, delivery, storage, and installation requirements.

G. Field Quality-Control Submittals:

1. Pipeline hydrostatic testing plan.
2. Indicate results of Contractor-furnished tests and inspections.

H. Preconstruction Photographs:

1. Submit digital files of colored photographs of Work areas and material storage areas.

1.4 CLOSEOUT SUBMITTALS

A. As-Built Drawings:

1. Record actual locations of piping mains, valves, connections, thrust restraints, and invert elevations.
2. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.5 QUALITY ASSURANCE

A. Materials:

1. Unless otherwise noted, all water works materials provided for the Project shall be new, of first-class quality and shall be made by reputable manufacturers.

2. All material of a like kind shall be provided from a single manufacturer unless otherwise approved by the Owner’s Representative.

3. All material shall be carefully handled and installed in good working order free from defect in manufacture, storage, and handling.

4. All pipe and fittings shall be manufactured in the United States of America, unless otherwise approved by the Owner.

B. Markings:

1. Pipes and Fittings: Mark each pipe and fitting at plant. Include date of manufacture, Manufacturer's identification, specification standard, inside diameter of pipe, dimension ratio as applicable, pipe class as applicable, pipe number for laying purposes as applicable, and other information required for type of pipe.

2. Bolting materials (washers, nuts, and bolts) shall be marked with material type.

C. Testing:

1. Except where otherwise specified, all materials used in the manufacture of the pipe shall be tested in accordance with the applicable Specifications and Standards.

1.6 MATERIAL DELIVERY, STORAGE, AND HANDLING

A. In accordance with Manufacturer's written recommendations and as specified in these Contract Documents.

B. Pipe, specials, and fittings delivered to Project Site in damaged condition will not be accepted.

C. Storage:

1. Store and support pipe securely to prevent accidental rolling and to avoid contact with mud, water, or other deleterious materials.

2. Pipe and fittings shall not be stored on rocks, gravel, or other hard material that might damage pipe. This includes storage area and along pipe trench.

3. Do not store materials in direct sunlight.

4. Gaskets: Do not allow contact with oils, fuels, petroleum, or solvents.

D. Handling:

1. Pipe and appurtenances shall be handled in accordance with Manufacturer's recommendations or requirements contained in this section or subsequent sections dealing with the specific pipe material, whichever is more stringent.

2. Pipe shall be handled with proper equipment in a manner to prevent distortion or damage. Use of hooks, chains, wire ropes, or clamps that could damage pipe, damage coating or lining, or kink and bend pipe ends is not permitted.

3. Use heavy canvas, or nylon slings of suitable strength for lifting and supporting materials.

4. Lifting pipe during unloading or lifting into trench shall be done using two slings placed at quarter point of pipe section. Pipe may be lifted using one sling near center of pipe, provided pipe is guided to prevent uncontrolled swinging and no damage will result to pipe or harm to workers. Slings shall bear uniformly against pipe.

E. Pipe Plugs:

Provide and install a cap or plug on each end of pipe during transportation and onsite storage to protect linings and coatings from debris. Install watertight plug-in end of installed pipe at the end of the workday. Under no circumstances shall materials be dropped or dumped into the trench.

PART 2 PRODUCTS

2.1 WATER PIPING

A. General

1. All piping materials and specials shall meet the specifications of this Section and of the appropriate AWWA Standard Specifications. In the case of conflict, the more stringent specifications shall apply.

2. All coatings and materials specified herein which may come in contact with potable water shall conform to National Sanitation Foundation (NSF) Standard 61, 372 and 600.

3. Minimum Pressure Ratings: Unless otherwise specified herein or shown in the Drawings, the minimum working pressure rating of all water works materials specified herein shall be 1-1/2 times the operating pressure or 150 pounds per square inch (psi) minimum.

4. Gaskets:

a. Material: Styrene Butadiene Rubber (SBR) composition.

B. Ductile Iron Pipe:

1. Centrifugally cast, conforming to AWWA Standard C151.

2. Coating: Zinc exterior coating in accordance with AWWA/ ANSI C105/ A21.5, zinc coating per ISO 8179-1.

3. Pipe Mortar Lining: Shop-applied NSF 61 cement mortar lining, smoothed finish, complying with AWWA C104.

4. Pipe Thickness Class:

a. Comply with AWWA C151.

b. Class 52, unless shown to be greater in the Plans.

1) The Contractor shall be aware ductile iron piping with thickness class greater than Class 52 may have long fabrication and supplier lead times. The Contractor shall be responsible for coordinating product submittal and delivery times accordingly such as not to delay construction.

5. Polyethylene Encasement:

a. Where buried pipe is shown on the Drawings.

b. Comply with AWWA C105.

c. Polyethylene film shall be minimum 8-mil thick virgin linear low-density polyethylene (LLDPE).

d. Secure in place with 2-inch wide, 10-mil polyethylene tape.

e. V-BIO Enhance Polyethylene or approved equal film shall be minimum 9-mil thick, with Dialectric strength of 800V/MIL, and tensile Strength (MD) of min 4300 psi and provided where specified or shown on plans.

6. Joints:

a. Joint types shall be provided as identified in the Drawings and as required for the application.

b. Mechanical Joints:

1) Comply with AWWA C111.

c. Push-on Joints:

1) Comply with AWWA C111.

2) Manufacturers, without exception:

a) Tyton Joint by U.S. Pipe Company and McWane.
b) Fastite Joint by AMERICAN (American Cast Iron Pipe Company).
c) Or equal.

d. Restrained Joints:

1) Joint restraint for pipe shall be accomplished with an integral lock mechanism, except as may be otherwise specified.

a) Any such system shall be a manufacturer's standard proprietary design, shall be as recommended by the Manufacturer for the application, and shall be performance proven.

2) Restraining components:

a) Ductile iron complying with AWWA C110 and/or C153, with the exception of a manufacturer’s proprietary design dimensions.

b) Push-on joints for such fittings shall comply with AWWA C111.

3) Deflection:

a) The maximum pipe deflection shall not exceed one-half of the Manufacturer’s stated joint deflection allowance.

4) Manufacturers:

a) For pipe larger than 12”

(1) “TR Flex”, United States Pipe and Foundry Company.
(2) “Flex-Ring”, American Cast Iron Pipe Company.
(3) “HDSS”, U.S. Pipe Company.
(4) Or equal.

b) For pipe 12” and smaller

(1) ““Field-Lok”, U.S. Pipe Company.
(2) “Fast Grip”, AMERICAN (American Cast Iron Pipe Company).
(3) “TR Flex”, McWane and U.S. Pipe Company.
(4) “Flex-Ring”, AMERICAN (American Cast Iron Pipe Company).
(5) “HDSS”, U.S. Pipe Company.
(6) Or equal.

c) For all pipe sizes

(1) Wedge-type Restraint System – “MEGALUG”, EBBA Iron, Inc. or equal.

(a) Where any restrained joint system requires the use of a wedge-type mechanical restraint gland for restraint, the glands shall be provided in quantities as may be required and shall be considered incidental to the joint restraint system.

(b) Wedge-type mechanical restraining glands shall not be used to restrain the plain end of plain end ductile iron or cast-iron fittings.

5) “Foster Adaptor”, Infact Corporation

a) Where specified, mechanical joint (MJ) valves and fittings shall be connected using a bolt-through positive restraint mechanism manufactured of ductile iron conforming to ASTM A536, 65-45-12.

b) The positive restraint device shall connect the valves and/or fittings at a linear distance not to exceed three (3) inches and without attachment to pipe.

c) The device shall come complete with all accessories, including standard styrene butadiene rubber (SBR) MJ gaskets conforming to the latest revision of AWWA C111/ASTM F-477 and weathering steel (Corten) bolts conforming to AWWA C111/A21.11 and ASTM A242.

d) Nuts for 3 through 12-inch sizes shall be SAE Grade 5 steel with black oxide coating. Nuts for 14-inch and larger adaptors shall be heavy hex Corten steel conforming to ASTM A242.

e) MJ positive restraining device shall be supplied with NSF 61, 7-mil. fusion bonded epoxy conforming to AWWA C116/A21.16-09 as well as the coating, surface preparation and application requirements of ANSI/AWWA C550.

f) The device shall be used with standard mechanical joint fittings (AWWA C110 or C153) and valves and shall be Infact Corporation FOSTER ADAPTOR or equal.

e. Flanged Joints:

1) Flat faced, complying with AWWA C111 and C115, unless otherwise specified.

2) Bolt hole drilling according to ASME/ANSI B16.1, Class 125, or ASME/ANSI B16.1, Class 250, where specified. Flanges shall be attached with bolt holes straddling the vertical axis of the pipe unless otherwise shown.

3) The Contractor shall coordinate with pipe, valve, and fitting suppliers to make certain mating pipe, valve, and fitting flanges match in bolt pattern.

4) Pressure rating of flange joints shall not exceed the rating of the pipe or fitting of which they are a part, and the maximum pressure rating of the joint shall be 250 psi.

5) Flange joint connections shall not be exposed to test pressures greater than 1-1/2 times their rated working pressure.

6) Threaded flanges:

a) Ductile iron pipe spools with threaded flanges shall conform to AWWA C115.
b) Installed only on pipe with a minimum Class 53 wall thickness.

7) Buried flanges:

a) Flanged connections shall not be buried unless shown as such on the Drawings.
b) Buried flanges shall be wrapped with 2 layers of 10-mil tape along edges of flanges.

8) Gaskets:

a) Full faced, composed of synthetic rubber and 1/8-inch-thick conforming to ASME B21.1 and AWWA C111.

b) Ring gaskets will be permitted only where specifically noted in the Drawings and Specifications.

c) Gaskets for flanged joints shall be as follows:

(1) Pipe sizes between 2-inch and 24-inch diameter, shall be Toruseal, Flange-Tyte or equal.

(a) See Section 13 57 13.13 for cathodic protection requirements.

2.2 FITTINGS

A. Material: Ductile iron, complying with AWWA Standard C110.

1. Fittings conforming to AWWA C153 may be substituted in lieu of AWWA C110 fittings.

B. Fittings used for joining ductile iron and PVC pipe shall be of the type, size, and strength designated on the Plans, elsewhere in the specifications.

1. Fittings shall be mechanical joint, push-on type, flanged or plain-end as required and shown on the Drawings.

2. All restraint systems and flanged fittings shall be provided with bolts and gaskets as specified herein.

C. Pressure ratings: As specified for joining pipe above and as shown on the Drawings.

D. Coating and Lining:

1. Zinc exterior coating in accordance with AWWA/ ANSI C105/ A21.5, zinc coating per ISO 8179-1.

2. Cement Mortar Lining: Comply with AWWA C104.

3. Wax Tape Coating System (Field Coating): Petrolatum wax tape coating system where specified or shown on drawings:

a. General: Apply a wax tape coating system generally per AWWA C217 and consists of three parts: surface primer, wax-tape, and outer covering. All three parts shall be the product of the same manufacturer.

b. The primer shall be a blend of petrolatum, plasticizer, and corrosion inhibitors having a paste like consistency. It shall have a pour point of 100-degrees F to 110-degrees F and a flash point of 350-degrees. Use Trenton Wax-Tape Primer or approved equal.

c. The wax-tape shall consist of a synthetic-fiber felt, saturated with a blend of high melt microcrystalline wax, solvents, and corrosion inhibitors, forming a tape coating that is easily formable over irregular surfaces and which firms up after application. The tape shall have a saturant pour point between 125-degrees F and 130-degrees F and a dielectric strength equal to a minimum of 100-volts per mil. Tape thickness shall be 50-mils to 90-mils in 6-inch-wide rolls. Use Trenton No. 1 wax-tape or equal.

d. The outer covering shall consist of two layers of a plastic wrapper at total of one 150 gauge or three 50 gauge wound together as a single sheet. The plastic wrapper material shall consist of clear polyvinylidene chloride, high cling membranes wound together as a single sheet. Use Trenton Poly-Ply or approved equal.

E. Following information cast upon fittings:

1. Manufacturer's identification.
2. Country of manufacture.
3. Pressure rating.
4. For bends, number of degrees and/or fractions of a circle.

F. Owner may require additional metallurgical documentation or other certifications.

2.3 NUTS, BOLTS, AND WASHERS

A. All bolts shall have heavy hex head with heavy hex nuts.

B. For operating pressures greater than 150 psi:

1. Bolts: Steel alloy composition. Comply with ASTM A193.
2. Nuts: Comply with ASTM A194, Grade 2H.
3. Washers: Comply with ASTM F436.

C. For operation pressures of 150 psi or less:

1. Bolts: Low-carbon steel composition. Comply with ASTM A307, Grade B.
2. Nuts: Comply with ASTM A563A, Heavy Hex.
3. Washers: Comply with ASTM F844.

D. Higher-strength bolts with higher torque values as specified above for operation pressures greater than 150 psi shall not be used for assembly of flange joints including gray-iron flanges.

2.4 FLEXIBLE COUPLINGS

A. General

1. All flexible couplings shall be constructed to inside diameters that properly fit the connecting pipes.

2. The Contractor shall be responsible for selecting sleeve lengths appropriate to the application, subject to review and approval of the Engineer, recognizing that longer sleeves allow for larger deflections and may ease installation.

B. Flexible Couplings:

1. Description:

a. Comply with AWWA C219.

b. Type: Bolted, sleeved.

c. Configuration: Straight, transition, or reducing as shown in the Drawings.

d. Center rings and end rings: Ductile iron. Comply with ASTM A536.

e. Gaskets: Virgin styrene butadiene rubber (SBR) compounded for water service. Comply with ASTM D2000.

f. Bolts and nuts: High strength low alloy steel. Comply with AWWA C111.

g. Lining and coating: Factory-applied fusion bonded epoxy.

h. Working pressure: Up to 260 psi.

2. Manufacturers:

    a. For 2-inch to 24-inch diameter:

        1) Romac Industries, Inc. – Style 501 or equal.

    b. For 12-inch diameter and larger:

        1) Romac Industries, Inc. – 400 Series or equal.

C. Insulating Flexible Couplings:

1. The Contractor shall be responsible for selecting couplings appropriate to the application, subject to review and approval of the Engineer, recognizing that different pipe materials will require specific sizing and material selection for couplings.

2. Description:

    a. Comply with Flexible Coupling specifications above.

    b. Insulating Boot: Ethylene propylene diene monomer (EPDM) compounded for water service. Comply with ASTM D2000.

3. Manufacturers:

    a. For 4-inch to 14-inch diameter:

        1) Romac Industries, Inc. – Style IC501 or equal.

    b. For 12-inch to 96-inch diameter:

        1) Romac Industries, Inc. – Style IC400 or equal.

D. Restrained Flexible Couplings:

1. Description:

    a. Body: Steel. Comply with ASTM A36.

    b. Restrained gland: Ductile iron. Comply with ASTM A536, Grade 65-45-12.

    c. Gaskets: Virgin styrene butadiene rubber (SBR) compounded for water service. Comply with ASTM D2000.

    d. Bolts and nuts: All-thread rod, at a minimum complying with ASTM A193 Grade B7. Nuts per ASTM A194 Grade 2H.

    e. Lining and coating: Factory-applied fusion bonded epoxy.

    f. Working pressure: **250** psi. Test pressure: **400** psi.

2. Manufacturers:

    a. Romac Industries, Inc. – Style 400RG

b. EBAA Iron – 3800 MEGA-COUPLING

2.5 FLANGED COUPLING ADAPTERS

A. Flanged Coupling Adapters:

1. All flanged coupling adapters shall be constructed to diameters that properly fit the connecting plain end pipe and the flanged fitting.

2. Description:

a. Comply with AWWA C219.

b. Flange: AWWA Class D Steel Ring Flange, compatible with ANSI Class 125 and 150 bolt circles.

c. End ring and body:

1) Steel. Comply with ASTM A36.
2) Ductile iron. Comply with ASTM A536, Grade 65-45-12.

d. Flange: Compatible with ANSI Class 125 and 150 bolt circles.

e. Gaskets: Virgin styrene butadiene rubber (SBR) compounded for water service. Comply with ASTM D2000.

f. Bolts and nuts: High strength low alloy steel bolts and nuts. Comply with AWWA C111 composition requirements.

g. Lining and coating: Factory-applied fusion bonded epoxy.

h. Working pressure rating: Equal to the maximum rating of the flange.

3. Manufacturers:

a. Romac Industries, Inc.

1) Style FCA501

a) For 3-inch to 16-inch diameter.

2) Style FC400.

b. For 12-inch to 96-inch diameter.

B. Restrained Flanged Coupling Adapters:

1. Description:

a. Gland and flange body: Ductile iron. Comply with ASTM A536.

b. Flange: Compatible with ANSI Class 125 and 150 bolt circles.

c. Gaskets: Virgin styrene butadiene rubber (SBR) compounded for water service. Comply with ASTM D2000.

d. Restraining bolts and lugs: Ductile iron. Comply with ASTM A536.

e. T-bolts, Bolts, and nuts: High strength low alloy steel. Comply with AWWA C111 composition requirements.

f. Lining and coating: Factory-applied fusion bonded epoxy.

2. Manufacturers:

a. Romac Industries, Inc. – RFCA Restrained Flanged Coupling Adapters.
b. EBAA Iron – MEGAFLANGE Restrained Flange Adapter.

2.6 TAPPING SLEEVES AND VALUES

A. Tapping Sleeves:

1. Description:

a. Type: Dual compression.

b. Material:

1) Body: Stainless steel, Type 304.
2) Flanged outlet: Stainless steel, Type 304.

c. Outlet Flange Dimensions and Drilling: Comply with ASME B16.1, Class 150, and MSS SP-60.

d. Outlet Gasket:

e. Provide with Type 304 stainless steel test plug.

f. Nuts, bolts, and washers: Stainless steel, Type 304.

2. Manufacturers:

a. Romac Industries, Inc. – Model STS 420
b. JMC Industries, Inc.
c. Or approved equal.

B. Tapping Valves:

1. Resilient wedge gate valves specified in Section 40 05 51.15, Gate Valves.

2.7 FLEXIBLE EXPANSION JOINTS

A. Description

1. Installed at locations indicated in the Drawings.

2. End connections: As shown in the Drawings.

3. Material: Ductile iron, AWWA C153.

4. Working pressure: 350 psi, minimum.

5. Construction:

   a. An expansion joint designed and cast as an integral part of a double ball and socket type flexible joint.

   b. Manufactured of ductile iron, conforming to requirements of AWWA C153 and ASTM A536.

   c. Deflection: Minimum of 15 degrees deflection per ball.

   d. Expansion:

      1) 12-inch diameter and under: 8-inch.
      2) Greater than 12-inch diameter: 16 inches.

   e. Each flexible expansion joint shall be hydrostatically tested to the Manufacturer's published pressure rating prior to shipment.

   f. Lining: All interior "wetted" parts shall be shop-lined with a minimum of 15 mils of fusion bonded epoxy conforming to the applicable requirements of AWWA C213 and shall be holiday tested with a 1500-volt spark test conforming to said specification.

   g. Coating: Minimum 6 mils fusion bonded epoxy conforming to ANSI/AWWA C116/A21.16.

6. Quality Assurance: Hydrostatically tested to Manufacturer's published pressure rating prior to shipment.

7. Appropriately sized polyethylene sleeves, meeting AWWA C105 requirements, shall be included for direct bury applications.

B. Manufacturers

1. EBAA Iron, Inc. – Flex-Tend or equal. Force Balanced Flex-Tend where specified or shown on plans.

2.8 UNDERGROUND PIPE MARKERS

A. As specified in Section 31 23 17, Trenching.

2.9 CONCRETE ENCASEMENT AND CRADLES

A. Concrete:

1. As specified in Section 03 30 00 - Cast-in-Place Concrete.
2. Type: reinforced, air entrained as shown in the Drawings.
3. Compressive Strength: Minimum 3,000 psi at 28 days.
4. Finish: Rough troweled.

B. Concrete Reinforcement: As specified in Section 03 20 00 - Concrete Reinforcing.

2.10 BEDDING AND COVER MATERIALS

A. Bedding and Cover:

1. Pipe Bedding: Coarse Aggregate Material Type A1, as specified in Section 31 05 16, Aggregates for Earthwork. Aggregate size as shown in the Drawings.

2. Pipe Zone Backfill: Coarse Aggregate Material Type A1, as specified in Section 31 05 16, Aggregates for Earthwork. Aggregate size as shown in the Drawings.

3. Trench Backfill from Pipe Zone to Finish Grade:

a. Material type varies by location, as shown in the Drawings.

b. Coarse Aggregate Material Type A1, as specified in Section 31 05 16, Aggregates for Earthwork. Aggregate size as shown in the Drawings. See local requirements for soil classifications.

c. Subsoil Type S1 and S2 as specified in Section 31 05 13, Soils for Earthwork and as shown in Drawings . See local or State DOT requirements for soil classifications.

2.11 GEOMEMBRANE FOR GAS LINE CROSSINGS

A. Furnish 40 mil reinforced geomembrane with 300V/mil dielectric strength and minimum 150# puncture resistance and 150# tensile strength. Geomembrane shall be XR-5 as manufactured by Seaman Corporation or equal.

2.12 ACCESSORIES

A. Concrete for Thrust Restraints: As specified in Section 03 30 00 - Cast-in-Place Concrete.

B. Manhole and Cover: As specified in Section 33 05 13- Manholes.

C. Miscellaneous Steel Rods, Bolt, Lugs, and Brackets:

1. Comply with ASTM A36 or ASTM A307.
2. Grade A carbon steel.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that existing utility water main size, location, and invert are as indicated on Drawings.

3.2 PREPARATION

A. Preconstruction Site Photos:

1. Take photographs along centerline of proposed pipe trench; minimum one photograph for each 50 feet of pipe trench.

2. Show mailboxes, curbing, lawns, driveways, signs, culverts, and other existing Site features.

3. Include Project name, date taken, and sequential number of each photograph in physical log or CD.

B. Inspection:

1. All pipe sections, specials, and jointing materials shall be carefully examined for defects.

2. No piping or related materials shall be laid that is known to be defective. Any defective piece installed shall be removed and replaced with a new pipe section in a manner satisfactory to the Engineer at the Contractor's expense.

3. Defective material shall be marked and removed from the job site before the end of the day.

C. Pipe Cutting:

1. Cut pipe ends square, ream pipe and tube ends to full pipe diameter, and remove burrs.

2. Use only equipment specifically designed for pipe cutting; use of chisels or hand saws is not permitted.

3. Grind edges smooth with beveled end for push-on connections.

4. Prior to assembly of field cut pipe, the reference mark shall be re-established with a pencil or crayon. The location of the reference mark at the proper distance from the bevel end shall be in accordance with the Manufacturer's recommendations.

D. Remove scale and dirt on inside and outside before assembly. Cleaning of each pipe or fitting shall be accomplished by swabbing out, brushing out, blowing out with compressed air, or washing to remove all foreign matter.

E. Prepare pipe connections to equipment with flanges or unions.

3.3 INSTALLATION

A. Bedding:

1. Excavation:

a. Excavate pipe trench as specified in Section 31 23 17, Trenching for Work of this Section.

b. All pipe trenches shall be excavated below the proposed pipe invert as required to accommodate the depths of pipe bedding material as scheduled on the Drawings.

c. Remove large stones or other hard matter which could damage pipe or impede consistent pipe bedding backfilling or compaction.

d. Trench base shall be inspected prior to placement of pipe.

e. Hand trim excavation for accurate placement of pipe to elevations as indicated on Drawings.

2. Dewater excavation as specified in Section 31 23 19, Dewatering to maintain dry conditions and to preserve final grades at bottom of excavation.

3. Provide sheeting and shoring as specified in Section 31 23 17, Trenching.

4. Place bedding material at trench bottom, level fill materials in one continuous layer not exceeding 6 inches compacted depth and compact to 95 percent of maximum density.

B. Piping:

1. Install pipe according to AWWA C600.

2. Handle and assemble pipe according to Manufacturer instructions and as indicated on Drawings.

3. Lift or roll pipe into position. Do not drop or drag pipe over prepared bedding.

4. Steel Rods, Bolt, Lugs, and Brackets: Coat buried steel with one coat of coal tar coating before backfilling.

5. Sanitary Sewer Separation:

a. Install new water lines and appurtenances in compliance with local and state regulations governing the horizontal and vertical separations between water and sewer facilities.

b. Variance:

1) If a variance is proposed due to requested design revisions or if an existing facility has been installed at a different location or elevation than indicated on the Plans, submit written proposal for review and approval by the Engineer.

2) Include the reason for the variance, type of material and condition of the sewer line, location of the water and sewer facilities, horizontal and vertical skin-to-skin clearances and corrective measures proposed.

3) Each variance will be considered on a case-by-case basis.

4) Review Time: Allow a minimum of 5 working days review and response to each proposal.

6. Install ductile iron fittings according to AWWA C600.

7. Joints:

a. Pipe jointing surfaces shall be clean and dry when preparing surfaces for joining.

b. Lubricants, primers, adhesives, etc. shall be used as recommended by the Pipe or Joint Manufacturer's specifications.

c. The jointing materials or factory-fabricated joints shall then be placed, fitted, joined, and adjusted in such a manner as to obtain a watertight joint.

d. Trenches shall be kept water-free and as dry as possible during bedding, laying, and jointing.

e. As soon as possible after the joint is made, sufficient backfill material shall be placed along each side of the pipe to prevent movement of the pipe from any cause.

8. Flanged Joints: Not to be used in underground installations except within structures, unless shown otherwise in the Drawings.

9. Deflection:

   a. Gasket-joined PVC pressure pipe may be deflected both horizontally and vertically at the joints after assembly for all nominal pipe sizes.

      1) Longitudinal bending of pipe barrel to accomplish deflections is limited to nominal sizes 4-inch and 6-inch diameter gasket-joined piping.

   b. The maximum pipe deflection must not exceed one half of Manufacturer's stated allowance for the longitudinal bending and joint deflection.

   c. Set a laser, string line, or other approved alignment guide along the centerline of previously installed pipe to the point where pipe joint deflection is required. Extend the approved alignment guide to the end of the proposed subsequent pipe length. A measurement will be taken from the alignment guide to the centerline of the subsequent pipe length to determine the amount of pipe joint deflection proposed. The measured deflection must not exceed the specified allowable deflection for the purpose of aligning the pipe.

10. Install pipe and fittings to the line and grade specified on the Drawings, with joints centered, pipe properly supported and restrained against movement, and all valve stems plumb. Re-lay pipe that is out of alignment or grade.

11. High Points:

    a. Install pipe with no high points, unless otherwise shown in the Drawings.

    b. If unforeseen field conditions arise that necessitate high points, install air release valves as directed by Engineer.

12. Bearing:

    a. Install pipe to have bearing along entire length of pipe.
    b. Excavate bell holes to permit proper joint installation where necessary or as directed by Engineer.
    c. Do not lay pipe in wet or frozen trench.

13. Prevent foreign material from entering pipe during placement.

14. Install pipe to allow for expansion and contraction without stressing pipe or joints.

15. Close pipe openings with watertight plugs during Work stoppages.

16. All pipe ends which are to be permanently closed shall be plugged or capped and restrained against internal pressure.

17. Install access fittings to permit disinfection of water system performed under Section 33 13 00, Testing and Disinfecting of Water Utility Piping.

18. Cover:

    a. Establish elevations of buried piping with not less than 36 inches of cover.
    b. Measure depth of cover from final surface grade to top of pipe barrel.

C. Tapping Sleeves and Valves:

1. As indicated on Drawings and according to Manufacturer instructions.

D. Wax tape Coating for DI Fittings, Valves and Appurtenances:

1. Coat all buried DI fittings and valves, mechanical joints and restraints, and pipe flanges with wax tape coating system in accordance with AWWA C217 and in accordance with manufacturer's recommendations. Extend the wax tape coating system over the adjacent piping past the fitting, restraint, flange, etc. by a minimum 6-inches.

2. Clean the surfaces to receive the wax tape coating free from dirt, grease, and other foreign materials.

    a. Apply primer as recommended by tape manufacturer or cut strips of wax tape and apply them around bolts, nuts, mechanical joint restraints, and other irregular shapes so that there are no voids or spaces under the tape. Apply enough tape to completely encapsulate exposed steel surfaces.

    b. 70 mils is the minimum wax tape thickness.

    c. Apply over smooth surfaces and 140 mils over sharp and irregular surfaces, or of a thickness required to fill voids. Apply two layers of polyvinylidene chloride, high cling membrane sheet over the wax tape coating by tightly wrapping it around the pipe such that it adheres and conforms to the wax tape. Secure the plastic wrap to the pipe with adhesive tape.

E. Polyethylene Encasement:

1. Encase piping in polyethylene as directed in Section 13 47 13, Cathodic Protection to prevent contact with surrounding backfill material.

2. Comply with AWWA C105.

3. Encasement shall be two (2) layers of 8 mil polyethylene encasement, V-bio, by US Pipe.

F. Thrust Restraints:

1. Provide valves, tees, bends, caps, and plugs with concrete thrust blocks at locations shown in the Drawings and as required to facilitate testing of lines.

2. Pour concrete thrust blocks against undisturbed earth.

3. Locate thrust blocks to ensure that pipe and fitting joints will be accessible for repair.

4. Provide thrust restraint bearing area on subsoil as shown in details within the Drawings.

5. Install tie rods, clamps, setscrew retainer glands, or restrained joints.

6. Protect metal-restrained joint components against corrosion with polyethylene film or wax tape as specified herein.

7. Avoid encasing mechanical and flanged joints in concrete. Provide clearance between concrete and mechanical and flange joints to allow future bolt removal.

G. Backfilling:

1. Backfill of piping systems shall be as specified in Section 31 23 17, Trenching.

H. Testing and Disinfection of Potable Water Piping System:

1. In accordance with AWWA C600 AWWA C651 and as specified in Section 33 13 00, Testing and Disinfecting of Water Utility Piping.

2. All chlorinated water used in disinfection of the water main shall either be discharged through an approved connection to a public sanitary sewer system or shall be dechlorinated to limits acceptable by the Oregon State Department of Environmental Quality (DEQ) prior to discharge into any storm drainage system or open drainage way.

3. No chlorinated water shall be discharged into a storm drainage system or open drainage way without a dechlorination under a plan meeting DEQ's requirements.

3.4 FIELD QUALITY CONTROL

A. Compaction Testing: See Section 31 23 17, Trenching for Compaction Testing requirements for piping trenches.

END OF SECTION

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SECTION 33 12 16 - WATER UTILITY DISTRIBUTION AND TRANSMISSION VALVES

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes valves and valve boxes for installation with buried water distribution and transmission main, including fire hydrants and tapping sleeves.

B. Section Includes:

1. Valves.
2. Valve boxes.
3. Valve operator extensions.

C. American Iron and Steel (AIS) Compliance: Materials provided under work of this Section shall comply with the AIS requirements of the Water Infrastructure Finance and Innovation Act (WIFIA). All materials provided and incorporated into this Project shall meet the AIS requirements of P.L. 113-76, Consolidated Appropriations Act, 2014.

D. Related Sections:

1. Section 03 30 00 - Cast-in-Place Concrete: Concrete for thrust restraints

2. Section 33 11 10 - Water Utility Distribution and Transmission Piping: Piping trenching, backfilling, and compaction requirements.

3. Section 33 12 13 - Water Service Connections: Pipe materials, fittings, and service connection appurtenances and installation requirements.

4. Section 33 12 19 - Fire Hydrants: Execution requirements for fire hydrants.

5. Section 33 13 00 - Testing and Disinfecting of Water Utility Piping: Flushing and disinfection requirements.

1.2 REFERENCE STANDARDS

A. American Society of Mechanical Engineers (ASME):

1. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250
2. ASME B16.5 - Pipe Flanges and Flanged Fittings, Steel Nickel Alloy, and other Special Alloys
3. ASME 1.20.1 - General Purpose Pipe Threads (Inch)

B. American Water Works Association (AWWA):

1. AWWA C504 - Rubber-Seated Butterfly Valves, 3 In. Through 72 In.

2. AWWA C509 - Resilient-Seated Gate Valves for Water Supply Service

3. AWWA C550 - Protecting Interior Coatings for Valves and Hydrants

4. AWWA C600 - Installation of Ductile-Iron Mains and Their Appurtenances

5. AWWA C605 - Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe and Fittings

C. ASTM International (ASTM):

1. ASTM B62 - Standard Specification for Composition Bronze or Ounce Metal Castings
2. ASTM B584 - Standard Specification for Copper Alloy Sand Castings for General Applications

D. NSF International (NSF):

1. NSF 61 - Drinking Water System Components - Health Effects
2. NSF 372 - Drinking Water System Components - Lead Content

1.3 COORDINATION

A. The Contractor shall cause the Supplier of valves to coordinate installation such that all pipes, valves, fittings, appurtenances, and equipment are compatible and capable of achieving the performance requirements specified in the Contract Documents.

B. Coordinate Work of this Section with South Fork Water Board standards and utilities within construction area.

1.4 SUBMITTALS

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

B. Product Data: Submit Manufacturer's latest published literature. Include illustrations, installation and maintenance instructions, and parts lists.

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

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

E. Lining and coating data.

F. Valve Labeling: Schedule of valves to be labeled indicating in each case the valve location and the proposed labeling for the valve.

G. Certification of Valves Larger than 12 inches: Furnish certified copies of hydrostatic factory tests, indicating compliance with applicable standards.

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

I. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

1.5 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of valves.
B. Operation and Maintenance Data: Submit information for valves.

1.6 MAINTENANCE MATERIAL SUBMITTALS – NOT USED

1.7 QUALITY ASSURANCE

A. Cast Manufacturer's name, maximum working pressure, size of valve, and year of fabrication into valve body.

B. Valve Testing: Each valve body shall be tested under a test pressure equal to twice its design water-working pressure.

C. Certification: Prior to shipment, submit for all valves over 12 inches in diameter, certified, notarized copies of the hydrostatic factory tests, showing compliance with the applicable standards of AWWA, American National Standards Institute (ANSI), ASTM, etc. Valves tested and supplied shall be trackable and traceable by serial number, tagged or otherwise noted on valve, upon arrival to Site.

D. Unless otherwise noted, all water works materials provided for the Project shall be new, of first-class quality and shall be made by reputable manufacturers.

E. All material of a like kind shall be provided from a single manufacturer, unless otherwise approved by the Engineer.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves and accessories for shipment according to applicable AWWA standards.

B. Seal valve and ends to prevent entry of foreign matter.

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

D. Storage:

1. Store materials in areas protected from weather, moisture, or other potential damage.
2. Do not store materials directly on ground.

E. Handle products carefully to prevent damage to interior or exterior surfaces.

F. All defective or damaged materials shall be replaced with new materials at no cost to the Owner.

PART 2 PRODUCTS

2.1 GENERAL

A. All materials in contact with potable water shall conform to ANSI/NSF Standard 61 and meet the “lead free” requirements of the Safe Drinking Water Act amendment, effective January 4, 2014, as per the lead content evaluation procedures outlined in NSF/ANSI Standard 372.1.

1. All fittings shall either be cast or permanently stamped with markings identifying the item as complying with NSF 61 per the requirements of NSF 372 for “lead free”.

2. All brass in contact with potable water shall comply with ASTM B584.

2.2 RESILIENT WEDGE GATE VALVES

A. As specified in Section 40 05 51.16, Gate Valves.

B. Connecting Hardware:

1. As specified in Article 2.3, Nuts, Bolts and Washers of Section 33 11 10, Water Utility Distribution and Transmission Piping.

C. Gaskets:

1. As required for the end connection types specified in Section 33 11 10, Water Utility Distribution and Transmission Piping.

2.3 DOUBLE-DISC GATE VALVES – NOT USED

A. Gaskets:

1. As required for the end connection types specified in Section 33 11 10, Water Utility Distribution and Transmission Piping.

2.4 SOLID WEDGE, METAL SEATED GATE VALVES – NOT USED

2.5 RUBBER-SEATED BUTTERFLY VALVES

A. As specified in Section 40 05 51.18, Butterfly Valves.

B. Operation:

1. All buried valves shall be provided with 2-inch square operating nuts.

C. Connecting Hardware:

1. As specified in Article 2.3, Nuts, Bolts and Washers of Section 33 11 10, Water Utility Distribution and Transmission Piping.

D. Gaskets:

1. As required for the end connection types specified in Section 33 11 10, Water Utility Distribution and Transmission Piping.

2.6 ACTUATORS

A. Unless otherwise indicated, all valves shall be furnished with manual actuators.

B. Actuators shall be sized for the valve design pressure in accordance with AWWA C504.

C. All gear-assisted valves that are buried and submerged shall have the actuators hermetically sealed and grease-packed.

D. All valves 6 inches to 30 inches in diameter may have traveling-nut actuators, worm-gear actuators, spur- or bevel-gear actuators, as appropriate for each valve.

2.7 VALVE BOXES

A. Valve Boxes:

1. Materials: Cast iron.

2. Construction:

a. Walls not less than 3/16-inch thick at any point.
b. Internal diameter not less than 5 inches.

3. Type: Two-piece extension.

4. Manufacturers:

a. East Jordan (EJCO)
b. Approved Equal

B. Covers:

1. Construction:

a. Prevents dislodging and rotation from traffic.
b. Allows a hand-held pry bar to be applied for easy removal.

2. Materials: Cast iron.

3. Lid Inscription: **W**

4. Manufacturers: Matching that of valve box.

C. Riser:

1. Polyvinyl Chloride (PVC) Pipe:

a. ASTM D3034, SDR 35 PVC.
b. White, Schedule 40, 8-inch diameter.
c. Length as shown on details in the Drawings.

2.8 VALVE OPERATOR EXTENSIONS

A. As shown in the Drawings.

B. Provide operator extensions to a maximum of 12 inches below grade where depth to valve exceeds 36 inches.

2.9 ACCESSORIES

A. Concrete for Thrust Restraints: Concrete type as specified in Section 03 30 00 - Cast-in-Place Concrete.

PART 3 EXECUTION

3.1 PREPARATION

A. Conduct operations to not interfere with, interrupt, damage, destroy, or endanger integrity of surface or subsurface structures, utilities, and landscape in immediate or adjacent areas.

B. Identify required lines, levels, contours, and datum locations.

C. Locate, identify, and protect from damage utilities to remain.

D. Access:

1. All valves shall be installed to provide easy access for operation, removal, and maintenance.

2. Avoid conflicts between valve operators and above grade construction such as structural members or handrails.

E. Valve Accessories:

1. Where combinations of valves, sensors, switches, and controls are specified, it shall be the responsibility of the Contractor to properly assemble and install these various items so that all systems are compatible and operating properly.

2. The relationship between interrelated items shall be clearly noted on shop drawing submittals.

3.2 INSTALLATION

A. General:

1. All valves, operating units, stem extensions, valve boxes, and accessories shall be installed in accordance with the Manufacturer's written instructions and as shown in the Drawings and as specified herein.

2. Valves shall be firmly supported to avoid undue stresses on the pipe.

3. Stem extensions shall be braced at no greater than 10 feet intervals and be provided with double universal joints to allow for misalignment, where applicable.

B. Perform trench excavation, backfilling, and compaction as specified in Section 33 11 10, Water Utility Distribution and Transmission Piping.

C. Install valves in conjunction with pipe laying.

D. Set valves plumb.

E. Provide buried valves with valve boxes installed flush with finished grade.

1. Valves installed out of paved or otherwise hard-surfaced areas shall be set in a concrete pad at finished grade.

2. Concrete valve box pads shall be 18 inches square and be not less than 6 inches thick.

F. Disinfection of Water Piping System:

1. Flush and disinfect system as specified in Section 33 13 00, Testing and Disinfection of Water Utility Piping.

3.3 FIELD QUALITY CONTROL

A. Pressure test valving for water distribution system according to AWWA C600 and in accordance with Section 33 13 00, Testing and Disinfection of Water Utility Piping.

B. Field Testing of Valves:

1. All valves 24-inch diameter or larger, and all in-line transmission main valves, shall be pressure and leakage tested at the Site and shall pass the field testing prior to installation.

2. Valves shall be tested at 1.5 times normal operating pressure, 150 pounds per square inch (psi) minimum.

3. No valve shall be accepted for installation that fails to pass the field pressure test. Any valves failing field pressure tests shall be replaced by the Contractor at no additional cost to the Owner.

4. Engineer shall witness field testing.

END OF SECTION

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SECTION 33 12 19 - FIRE HYDRANTS

PART 1 GENERAL

1.1 SUMMARY

A. This Section addresses dry-barrel fire hydrants used in water supply service.

B. Section includes:

1. Fire hydrants used in water main installations.

C. American Iron and Steel (AIS) Compliance: Materials provided under work of this Section shall comply with the AIS requirements of the Water Infrastructure Finance and Innovation Act (WIFIA). All materials provided and incorporated into this Project shall meet the AIS requirements of P.L. 113-76, Consolidated Appropriations Act, 2014.

D. Related Sections:

1. Section 03 11 00 – Concrete Work
2. Section 31 05 16 - Aggregates for Earthwork
3. Section 31 23 17 - Trenching
4. Section 33 13 00 – Testing and Disinfection of Water Utility Piping

1.2 REFERENCE STANDARDS

A. American Water Works Association (AWWA):

1. AWWA C502 - Dry-Barrel Fire Hydrants
2. AWWA C550 - Protective Interior Coatings for Valves and Hydrants
3. AWWA C600 - Installation of Ductile-Iron Mains and Their Appurtenances

B. National Fire Protection Association (NFPA):

1. NFPA 291 - Recommended Practice for Fire Flow Testing and Marking of Hydrants

1.3 COORDINATION

A. All hydrants supplied for the Project shall be of like kind from a single manufacturer.

1.4 SUBMITTALS

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

B. Product Data: Submit Manufacturer's latest published literature, including illustrations, installation and maintenance instructions, and parts lists.

C. Shop Drawings: Submit description of proposed installation.

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

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

F. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

1.5 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of fire hydrants and service valves.
B. Operation and Maintenance Data: Submit data for hydrants.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare hydrants and accessories for shipment according to AWWA standards.

B. Seal hydrant and ends to prevent entry of foreign matter.

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

D. Storage:

1. Store materials in areas protected from weather, moisture, or potential damage.
2. Do not store materials directly on ground.

E. Handle materials in a way that prevents damage to interior and exterior surfaces.

PART 2 PRODUCTS

2.1 FIRE HYDRANTS

A. Manufacturers:

1. See City of Oregon City Standards and water construction notes for acceptable manufacturers and models.

B. Dry-Barrel Type:

1. Comply with AWWA C502.

2. Body: Cast iron.

3. Valve: Cast Iron, compression type.

4. Drain Valve: Stainless Steel.

5. Burial Depth: As indicated on Drawings.

6. Inlet Connection Size: 6 inches (150 millimeters).

7. Valve Opening: 5-1/4 inches (133 millimeters) in diameter.

8. End Connections: Mechanical joint or bell end.

9. Bolts and Nuts: Galvanized steel.

10. Operating Nut: Bronze.

11. Interior Coating: Comply with AWWA C550.

12. Direction of Opening: Counterclockwise and clearly marked on operating nut or hydrant top, unless otherwise indicated.

C. Hose Connections:

1. One 4-1/2-inch diameter pumper, two 2-1/2-inch diameter hose nozzles.
2. Obtain thread type and size from local fire department.
3. Attach nozzle caps by separate chains.

D. Finishes:

1. Primer and two coats of enamel.

2. Color: Rodda All-Purpose Equipment Enamel (1625 Safety Orange), Miller Paint Safety Orange (#D18756), or Oregon City approved equal.

2.2 NSF INTERNATIONAL (NSF) REQUIREMENTS

A. All fire hydrants must be NSF/ANSI Standard 61 certified and meet the "lead free" requirements of the Safe Drinking Water Act amendment, effective January 4, 2014, as per the lead content evaluation procedures outlined in NSF/ANSI Standard 372.

2.3 ACCESSORIES

A. Concrete for Thrust Restraints: Concrete type as specified in Section 03 11 00, Concrete Work.

B. Aggregate: Aggregate for hydrant drainage as specified in Section 31 05 16, Aggregates for Earthwork.

2.4 OUT OF SERVICE COVERS/OUT OF SERVICE RINGS

A. Provide orange plastic bag with reflective tape, or red plastic hydrant out of service rings.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify location and size of hydrants from Drawings. Final location of hydrants to be determined by Engineer in the field.

B. Obtain clarification and directions from Engineer prior to execution of Work.

C. If installing a hydrant on an existing water system, verify invert elevation of existing piping is as indicated on Drawings prior to excavation and installation of fire hydrant.

3.2 PREPARATION

A. Conduct operations not to interfere with, interrupt, damage, destroy, or endanger integrity of surface or subsurface structures, utilities, and landscape in immediate or adjacent areas.

B. Identify required lines, levels, contours, and datum locations.

C. Locate, identify, and protect from damage utilities to remain.

D. Do not interrupt existing utilities without permission and without making arrangements to provide temporary utility services.

1. Notify Owner and Engineer not less than 48 hours in advance of proposed utility interruption.

2. Do not proceed without written permission from Engineer.

3. Only District staff shall operate valves in existing system.

3.3 INSTALLATION

A. Perform trench excavation, backfilling, and compaction as specified in Section 31 23 17, Trenching.

B. Install pier support block and drainage gravel for fire hydrants; do not block drain hole.

1. Place drainage gravel around the pier block and bottom of hydrant to 6 inches above the hydrant drain opening.

2. Place textile fabric to cover drain rock prior to placement of backfill.

3. Setting shall allow the hydrant barrel to drain into drainage gravel at base of hydrant.

C. Set fire hydrants plumb with pumper nozzle facing roadway.

D. Set fire hydrants with centerline of pumper nozzle 18 inches (450 millimeters) above finished grade, and with safety flange not more than 8 inches (203 millimeters) nor less than 2 inches (50 millimeters) above grade. Install hydrant extensions where required and as approved.

E. Paint hydrants according to color scheme of local authorities having jurisdiction. Touch up paint after hydrant installation and testing.

F. After hydrostatic testing, flush hydrants, and check for proper drainage.

G. Disinfection of Water Piping System:

1. Flush and disinfect system as specified in Section 33 13 00, Testing and Disinfection of Water Utility Piping.

3.4 FIELD QUALITY CONTROL

A. Pressure test water distribution system according to AWWA C600 and Section 33 11 10, Water Utility Distribution and Transmission Piping, Field Quality Control.

3.5 CONCRETE HYDRANT PADS

A. When hydrant is place within sidewalks, form and pour-in-place 36-inch by 36-inch by 6-inch, 4,000 pounds per square inch (psi) concrete pad around the hydrant after the hydrant has been installed and set to grade.

B. Center hydrant pad on the hydrant. Set hydrant pad so top of pad is flush with surrounding surface, or as directed by the Engineer.

C. Hydrant pads may be adjusted to reach the back of curb if the hydrant pad is no less than 1-foot in any one direction.

3.6 OUT-OF-SERVICE HYDRANTS

A. To indicate that the fire hydrant is NOT operational, secure reflective tape, an orange plastic bag over the entire hydrant assembly or an approved out-of-service cover.

B. An out-of-service ring may also be used in addition to the bag or cover in case of removal of the cover.

C. Maintain the plastic bag up until the waterline is accepted by the Owner.

END OF SECTION

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SECTION 33 13 00 - TESTING AND DISINFECTION OF WATER UTILITY PIPING

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes hydrostatic pressure testing, disinfection, and purity testing of potable water systems piping, fittings, valves, and domestic water services.

B. Section Includes:

1. Pressure testing and disinfection of potable water distribution and transmission piping systems and appurtenances.

2. Testing and reporting of results.

C. Related Sections:

1. Section 33 11 10 - Water Utility Distribution and Transmission Piping
2. Section 33 12 16 - Water Utility Distribution and Transmission Valves
3. Section 33 12 19 - Fire Hydrants
4. Section 33 12 13 - Water Service Connections

1.2 REFERENCE STANDARDS

A. American Water Works Association (AWWA):

1. AWWA B300 - Hypochlorites
2. AWWA B301 - Liquid Chlorine
3. AWWA C600 - Installation of Ductile-Iron Mains and Their Appurtenances
4. AWWA C605 - Underground Installation of PVC and PVCO Pressure Pipe and Fittings
5. AWWA C651 - Disinfecting Water Mains
6. AWWA C655 - Field Dechlorination

1.3 SUBMITTALS

A. Section 01 33 00 –Submittals Procedures: Requirements for submittals.

B. Product Data: Submit procedures, proposed chemicals, and treatment levels.

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

D. Pipeline Testing and Disinfection Plan: To be submitted for review and approval by the Engineer a minimum of 1 month before testing is to start. As a minimum, the plan shall include the following:

1. Testing schedule.

2. Hydrostatic Testing Plan:

a. Narrative of the proposed process.
b. Proposed equipment to be used.
c. Disposal location for excess water used to fill mains.

3. Disinfection Plan:

    a. Narrative of the proposed process.

    b. Proposed chemicals and equipment (including list of all pumps and meters) to be used.

    c. Calculations for the amount of chlorine required to achieve required chlorine residual levels.

    d. Proposed method of mixing, injecting, and distributing of chlorine solution throughout all portions of the new water system facilities.

    e. Proposed plan for testing chlorine levels throughout the length of pipeline.

4. Proposed testing locations.

5. Proposed plan for water conveyance, including flow rates.

6. Proposed plan for water control.

7. Proposed plan for water disposal, including flow rates. Include proposed plan for dechlorination of disinfection water, including discharge points.

8. Proposed measures to be incorporated in the Project to minimize erosion while discharging water from the pipeline.

1.4 CLOSEOUT SUBMITTALS

A. Disinfection Report:

1. Type and form of disinfectant used.

2. Date and time of disinfectant injection start and time of completion.

3. Test locations.

4. Name of person collecting samples.

5. Initial and 24-hour disinfectant residuals in treated water in parts-per million (ppm) for each outlet tested.

6. Date and time of flushing start and completion.

7. Disinfectant residual after flushing in ppm for each outlet tested.

1.5 QUALITY ASSURANCE

A. Perform Work according to AWWA C651.

PART 2 PRODUCTS

2.1 EQUIPMENT

A. All test equipment, chemicals for chlorination, temporary valves, bulkheads, or other water control equipment and materials shall be determined and furnished by the Contractor subject

to the Engineer's review. No materials shall be used which would be injurious to the construction or its future functions.

B. All temporary thrust restraint and equipment and facilities required for hydrostatic testing will be considered incidental.

C. As a minimum, furnish the following equipment and materials for the testing:

Amount	Description
2	Graduated containers approved by the Engineer.
1	Hydraulic pump approved by the Engineer with hoses, valves, and fittings as needed and required for the testing and disinfection of the facilities.
1	High range chlorine test kit, as approved by Engineer, with digital readout. Range of detection shall be between 5 and 200 ppm. Accuracy of 3 percent.
2	Pressure gauges with pressure range at least 120 percent greater than the required maximum test pressure with graduations in 2 pounds per square inch (psi) increments. Gauges shall have been calibrated with 90 days of pressure testing.

2.2 DISINFECTION CHEMICALS

A. Chemicals:

1. Hypochlorite: Comply with AWWA B300.
2. Liquid chlorine: Comply with AWWA B301.

2.3 DECHLORINATION CHEMICALS

A. Chemicals:

1. Comply with AWWA C655.

PART 3 EXECUTION

3.1 HYDROSTATIC TESTING OF WATER PIPING

A. Make all necessary provisions for conveying water to the points of use and for the disposal of test water.

B. Furnish and operate pumps, gauges, plugs, saddles, corporation stops, miscellaneous hose and piping, and measuring equipment necessary for performing the test.

1. Testing materials and equipment required to perform testing are incidental and included in the cost of the pipe.

C. No section of the pipeline shall be hydrostatically tested until backfill has been placed, compacted, and passed required density testing and all field-placed concrete or mortar has attained full strength.

1. At the Contractor's option, early strength concrete may be used when the full-strength requirements conflict with schedule requirements.

2. All such substitutions and installations shall be approved by the Engineer prior to installation.

D. Provide 72-hour notification to the Engineer and Owner prior to conducting hydrostatic testing.

1. Provide coordination and scheduling required for the Owner and Engineer to witness and provide necessary labor for operating Owner's existing system during hydrostatic testing and disinfecting procedures.

2. The Contractor shall not operate any part of the existing water systems.

E. Pipe Filling:

1. Fill pipes slowly, in an approved method, from the lowest elevation to highest point along test section with potable water.

2. Take all required precautions to prevent entrapping air in the pipes.

3. Allow for natural absorption of water by the lining of the pipe to occur.

4. Apply specified test pressure by pumping.

F. Testing of Mains:

1. Ductile Iron: In accordance with AWWA C600.

2. Polyvinyl chloride (PVC): In accordance with AWWA C605.

3. General:

a. Tests shall be conducted under a hydrostatic test pressure not less than 1.25 times the stated anticipated maximum sustained working pressure of the pipeline measured at the highest elevation along the test section and not less than 1.5 times the stated working pressure at the lowest elevation of the test section, minimum 150 psi, unless otherwise shown in the Drawings.

b. In no case shall the test pressure exceed the rated working pressure for any joint, thrust restraint, valve, fitting, or other connected appurtenance of the test section.

c. Testing shall be performed by applying the specified test pressure by pumping.

d. Once the test pressure has been attained, the pump shall be valved off.

e. The test will be conducted for a 2-hour period with the allowable leakage not to exceed the value as calculated per the Allowable Leakage formula below.

f. During the test period, there shall be no appreciable or abrupt loss in pressure.

4. Allowable Leakage:

a. Flanged Joints: Pipe, fittings, and valves with flanged joints shall be completely watertight. No leakage allowed.

b. Mechanical or Push-on Joints: Pipe, fittings, and valves with rubber gasketed joints shall have a measured loss not to exceed the rate given in the following Allowable Leakage formula:

$$AL = \frac{LD(P)^{1/2}}{148{,}000}$$

In the above formula:

AL = Allowable leakage, in gallons per hour
L = Length of pipe tested, in feet
D = Nominal diameter of pipe, in inches
P = Average test pressure during the leakage test, in pounds per square inch.

5. Maintaining Pressure:

a. During the test period, operate the pump as required to maintain pressure in the pipe within 5 psi of the specified test pressure at all times.

b. At the end of test period, operate the pump until the specified test pressure is again obtained.

1) The pump suction shall be in a clean, graduated barrel, or similar device or metered so that the amount of water required to restore the test pressure may be accurately measured.

2) Sterilize this makeup water by adding chlorine to a concentration of 25 milligrams per liter (mg/L).

c. The Engineer will determine the quantity of water required to maintain and restore the required pressure at the end of the test period.

d. Each hour's loss stands on its own and will not be averaged.

6. Defects, Leakage, Failure:

a. If the test reveals any defects, leakage in excess of the allowable, or failure, furnish all labor, equipment, and materials required to locate and make necessary repairs.

b. Correct any visible leakage regardless of the allowable leakage specified above.

c. All leaks shall be repaired in a manner acceptable to the Engineer.

d. The testing of the line shall be repeated until a test satisfactory to the Engineer has been achieved.

3.2 DISINFECTION OF WATER PIPING

A. Disinfection shall be in accordance with the latest version of AWWA C651 following Engineer's acceptance of hydrostatic testing.

B. Chlorination by means of tablets or powders (calcium hypochlorite) placed in each length of pipe during installation is specifically prohibited.

C. Flush all foreign matter from the pipeline, branches, and services.

1. Provide at no additional cost to the Owner, hoses, temporary pipes, ditches, etc., as required to dispose of flushing water without damage to adjacent properties.

2. Flushing velocities shall be at least 2.5 feet per second (fps).

3. For large diameter pipe where it is impractical or impossible to flush the pipe at 2.5 fps velocity, clean the pipe in place from the inside by brushing and sweeping, then flush the line at a lower velocity.

4. Minimum flushing discharge of 2 times the volume contained in section of pipe being flushed.

D. Chlorine Application:

1. Fill the test section of main from the lowest elevation and maintain a steady flow rate while injecting the water main with chlorinated water.

2. Flow (bleed) a blow-off, standpipe or hydrant at the water main's high point(s) to allow air to escape and ensure all interior pipe surfaces are wetted.

E. Chlorine Residual:

1. Measure chlorine residual with a high-range chlorine test kit at a point near to the injection point while filling the main.

2. Adjust the dose rate as necessary to maintain the target dose rate.

F. Potable water piping shall be disinfected with a solution containing a minimum 25 ppm and a maximum 50 ppm chlorine.

1. Once the main is completely filled with super-chlorinated water, measure the chlorine residual a minimum of once every 200 feet of main and once for each main branch, 2-inch service, or as directed by the Engineer.

2. The chlorine solution shall remain in the piping system for a period of 24 hours, after which time the sterilizing mixture shall have a strength of at least 10 ppm of chlorine.

3. If check samples fail to produce acceptable results, the disinfection procedure shall be repeated at the expense of the Contractor until satisfactory results are obtained.

G. Flush piping, branches, and services with municipal potable water until the chlorine residual is below 1.5 ppm and approximately the same as the source water.

1. There is no minimum flushing velocity for this step.

H. Disposal of any water containing chlorine shall be performed in accordance with the latest edition of AWWA C651 and C655, and all state or local requirements.

1. Disposal may be made into existing sanitary sewer systems providing approvals are obtained from the respective system owners.

2. Any chlorinated water discharged to open stream channels must be dechlorinated prior to discharge to levels acceptable by Oregon State Department of Environmental Quality (DEQ).

3.3 DISINFECTION AND TESTING OF WATER MAIN END CONNECTIONS AND TIE-INS

A. Disinfection of potable water piping and appurtenances at end connections and tie-ins to the existing system which are required to remain in service due to restrictions in allowable shutdown time shall be disinfected as described below.

B. Prior to connecting new potable water piping and appurtenances with existing piping and appurtenances, the interior of all new pipe, fittings, valves, and appurtenances shall be swabbed or sprayed with a 1 percent to 5 percent calcium hypochlorite solution.

C. In accordance with AWWA C651, swabbing or spraying of connection piping is allowed only if the total length of piping is equal to or less than one pipe length (18 feet). All runs of new piping over 18 feet in total length will require hydrostatic pressure testing, flushing and disinfection as detailed elsewhere in this Section.

D. Following the disinfection procedures described above, connection of the new piping and appurtenances to the existing water system shall be made.

1. During the system startup, the Engineer and Contractor shall visually inspect all new fittings, piping, valves, and appurtenances for evidence of leakage.

2. Any leakage observed during this period shall be promptly repaired by the Contractor, at Contractor's expense, as required by the Engineer.

3.4 FIELD QUALITY CONTROL

A. Bacteriological Sampling and Testing:

1. The Owner will collect samples after the line is flushed in accordance with the latest edition of AWWA C651.

a. The locations for sample collection shall be at the sole discretion of the Owner and Engineer.

b. The chlorine residual must be below 1.5 ppm or restored to the level maintained in the Owner's distribution system, when the sample is taken.

2. Bacterial Testing: After completing the chlorination procedure, test the main according to the following:

a. Bacterial Sampling

1) Sampling:

a) Allow main to sit for a minimum of 24 hours without any water use.

b) Using sampling site procedures outlined herein, collect two sets of samples a minimum of 15 minutes apart while the sampling taps are left running.

c) Both sets of samples must pass for the main to be approved for service.

2) Allow 24 hours for the test results for each sample set.

b. Sampling Locations

1) The Owner will take one bacteriological sample from the end of the main and on each branch.

2) For long runs of main, at least one sample will be taken for every 1,200 feet of new main and as directed.

c. Sample Testing

1) The Owner will test the sample set for coliform bacteria and publish the test results within 24 hours.

d. Evaluating the Test Results

1) If one or more of the sample set tests positive for coliforms (fails), repeat chlorination and sampling processes specified herein after correcting the cause of the failure and as directed by the Engineer.

2) When two consecutive sample sets test negative (passing)for coliform bacteria, the bacterial testing is complete.

e. Completion of Bacterial Testing

1) Upon completion of bacterial testing, notify the Owner shall notify the Engineer and Contractor in writing that the testing is complete and the main is ready for tie-in.

f. Multiple Positive (Failing) Test Results

1) If sample sets continue to test positive for coliforms, the Engineer will determine how to proceed, up to and including repeating the chlorination procedure or rejecting the pipe.

3. Results of the bacteriological testing shall be satisfactory with the Oregon Health Authority (OHA) and/or other appropriate regulatory agencies, or disinfection shall be repeated by the Contractor.

B. Optional Sampling and Testing

1. If a pipeline is not promptly returned to service, the situation will be evaluated by the Owner to determine if the water quality may have been impacted and if additional testing as specified herein is warranted.

END OF SECTION

SECTION 33 30 10.13 - SEWER AND MANHOLE TESTING

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes methods for testing of gravity sewer piping, pressure sewer piping, and manholes.

B. Section includes:

1. Testing of Gravity Sewer Piping:

   a. Mandrel
   b. Low pressure air testing (Sanitary Only).
   c. Video inspection of gravity pipe.

2. Testing of pressure piping.

3. Deflection testing of plastic sewer piping.

4. Testing of Manholes:

   a. Vacuum testing.
   b. Exfiltration testing.

C. Related Sections:

1. Section 33 05 13 - Manholes.
2. Section 33 13 00 - Testing and Disinfection of Water Utility Piping.
3. Section 33 41 10 - Storm Utility Drainage Piping.

1.2 REFERENCE STANDARDS

A. ASTM International:

1. ASTM C1244 - Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill.

2. ASTM D2122 - Standard Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings.

B. American Water Works Association:

1. AWWA C600 - Installation of Ductile Iron Mains and Their Appurtenances.

2. AWWA C605 - Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe and Fittings.

1.3 SUBMITTALS

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

B. Submit following items prior to start of testing:

1. Testing procedures.
2. List of test equipment.
3. Testing sequence schedule.
4. Provisions for disposal of flushing and test water.
5. Certification of test gauge calibration.
6. Deflection mandrel drawings and calculations.

C. Test and Evaluation Reports: Indicate results of manhole and piping tests.

PART 2 PRODUCTS

2.1 VACUUM TESTING

A. Equipment:

1. Vacuum pump.

2. Vacuum line.

3. Vacuum Tester Base:

a. Compression band seal.
b. Outlet port.

4. Shutoff valve.

5. Stopwatch.

6. Plugs.

7. Vacuum Gauge: Calibrated to 0.1 in. Hg (0.34 kPa).

2.2 EXFILTRATION TESTING

A. Equipment:

1. Plugs.
2. Pump.
3. Measuring device.

2.3 AIR TESTING

A. Equipment:

1. Air compressor.
2. Air supply line.
3. Shutoff valves.
4. Pressure regulator.
5. Pressure relief valve.
6. Stopwatch.

7. Plugs.
8. Pressure Gauge: Calibrated to 0.1 psi.

2.4 HYDROSTATIC TESTING

A. Equipment:

1. Hydro pump.
2. Pressure hose.
3. Water meter.
4. Test connections.
5. Pressure relief valve.
6. Pressure Gauge: Calibrated to 0.1 psi.

2.5 DEFLECTION TESTING

A. Equipment:

1. "Go, no go" mandrels.
2. Pull/retrieval ropes.

2.6 VIDEO TESTING

A. Equipment:

1. Camera
2. 1-inch target ball

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify manholes and piping are ready for testing.
B. Verify trenches are backfilled.
C. Verify pressure piping thrust restraint system is installed, as may be required.

3.2 PREPARATION

A. Obstructions:

1. After backfilling and restoration of surfaces, gravity pipelines shall be inspected for obstructions and shall be cleaned.

2. Pipes less than 24 inches in diameter shall be cleaned using the sewer ball method.

3. Lines larger than 36 inches in diameter may be cleaned by flushing as long as they are first visually inspected to assure that no physical obstructions exist.

a. Flushing shall be such that velocities are at least 2.5 feet per second.

B. Lamping:

1. Lamp gravity piping after flushing and cleaning of lines, checking manholes for unfinished work.

2. Perform lamping operation by shining light at one end of each pipe section between manholes.

3. Observe light at other end.

4. Pipe not installed with uniform line and grade will be rejected.

5. Remove and reinstall rejected pipe sections.

6. Reclean and lamp until pipe section is installed to uniform line and grade.

C. Plugs:

1. Plug outlets, wye branches, and laterals.
2. Brace plugs to resist test pressures.

3.3 FIELD QUALITY CONTROL

A. Testing of Gravity Sewer Piping:

1. Low Pressure Air Testing:

a. Test each reach of gravity sewer piping between manholes.

b. Introduce air pressure slowly to approximately 4 psig.

1) Determine ground water elevation above spring line of piping.

2) For every foot of ground water above spring line of piping, increase starting air test pressure by approximately 0.4 psi.

3) Do not increase pressure above 10 psig.

c. Allow pressure to stabilize for at least five minutes.

d. Adjust pressure to 3.5 psig or to increased test pressure as determined above when ground water is present.

e. Testing:

1) Determine test duration for reach of sewer with single pipe size from following table; do not make allowance for laterals.

Table 33 30 10.13 - 1
Air Testing Duration for Gravity Sewer Piping

NOMINAL PIPE SIZE, INCHES	MINIMUM TESTING TIME, MIN/100 FEET
6	0.7