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33 00 00. UTILITIES

33 00 03. GENERAL PROVISIONS

.1 APPLICATIONS:

.1.1 This Standard shall apply on all buildings within the Columbus campus of the Ohio State University.

.1.2 This Standard shall apply for all temporary power for construction within the Columbus campus of the University.

.1.3 This Standard may be applied for all other allied facilities and campuses of the University at various locations such as Lima, Mansfield, Marion, Newark, OARDC, Wooster, and other University properties.

.1.4 This Standard may be applied to the Columbus campus University owned and occupied buildings powered from the local Utility that have the potential in the future of being supplied from the OSU Utility distribution system.

.1.5 Requirements of this Standard are based on good engineering practice and provide a uniform and consistent basis for the design, construction, maintenance and operation of University Infrastructure and associated facilities.

Utilities maintains an Electrical Planning and Design Guide and a Chilled Water Building Connection Basis of Design that provides the technical basis for many of these requirements as they apply to the utility infrastructure on the OSU Columbus campus and should be consulted before recommending alternatives or any nonconformance.

.2 DEFINITIONS

As-Built Drawings: Drawings or computer files revised by the Contractor to show changes made during the construction process. (Ref; Ohio Department of Administrative Services, General Services Division, Ohio Facilities Construction Commission (OFCC), Standard Conditions of Contract for Construction).

Contract Documents: Collectively, the Drawings, Specifications, Addenda, Standard Conditions of Contract for Construction, Bid Form, Bid Guarantee, Contract Form and Attachments, Bond, Special Conditions, Wage Rates, Change Orders and Approved Shop Drawings, if any. (Ref; Ohio Department of Administrative Services, General Services Division, Ohio Facilities Construction Commission (OFCC), Standard Conditions of Contract for Construction).

High Voltage: Voltages higher than 35 kV (thirty five kilo-volts).

Low Voltage: Voltages less than 600V (six hundred volts).

Medium Voltage: Voltages less than 35 kV (thirty five kilo-volts) and higher than 600V (six hundred volts). 13.2 kV (thirteen-point-two kilo-volts) and 4,160V (four thousand one hundred sixty volts) are medium voltages.

Owner: The name 'owner' is prohibited language for Ohio State University projects. In all occurrences, delete 'owner' and insert 'University'.

Record Drawings: Drawings or computer files revised by the Architect/Engineer (A/E) to show changes made during the construction process, based on the As-Built Drawings furnished by the Contractor to the A/E. (Ref; Ohio Department of
Administrative Services, General Services Division, Ohio Facilities Construction Commission (OFCC), Standard Conditions of Contract for Construction, Definitions D49, most current version).

Primary: The Columbus Campus 13.2 kV Distribution system down to and including the Building Service Primary Select Switch.

Switched Primary: Primary circuits that are served from the load side of Primary Select Switches that retain the characteristics of a service pair (i.e. Two independent feeds to a building or building complex).

Lateral: A pair of cables tapped off the primary and carrying power to a building primary switch.

Load way: A cable carrying power into a building, fed from a primary select switch at 13.2 kV.

Primary Service: The 13.2 kV service to a building or building complex inclusive of Primary Select Switch, load ways, Primary transformer with fuse and disconnect means. A pair of service drops from a pair of medium voltage feeders is required to provide a Primary Service connection.

Main Power System: The 138 kV Main Power Substation(s) inclusive of High Voltage (138 kV) connections, Main power Transformers, Busses, Capacitor banks and Feeder Circuit breakers.

AEP Bulk Power: The 138 kV portion of the Main Power Substation(s) inclusive of incoming 138 kV lines, 138 kV Circuit breakers and ancillary equipment such as Potential transformers, current transformers, Disconnect Switches, 138 kV busses, communications and Protective relaying.

Note: see Figure 1 for a schematic representation of 13.2 kV distribution system

Service Connection: Electrical: 13.2 kV distribution system drop to a facility
Mechanical: Chilled water supply drop to a facility or a high pressure steam drop to a facility

University: The Ohio State University.

Utilities: Utilities Department, within the Facilities Operations and Development Division, at the Ohio State University.

.3 ACRONYMS

AEIC: Association of Edison Illuminating Companies (Codes and Standards)
AMP: Ampere (unit of electrical current)
B31.1: ASME Power Piping Code (most current version)
ANSI: American National Standards Institute (Codes and Standards)
AWG: American Wire Gauge
AWWA: American Water Works Association
BDS: Building Design Standard of Ohio State University
BTU: British Thermal Unit
CDF: Controlled Density Fill
CAT: Category
D: Diameter
DAS: Data Acquisition Software
DWG: Drawing
EEPROM: Electrically Erasable Programmable Read Only Memory
EMT: Electrical Metallic Tubing
EPR: Ethylene Polypropylene Rubber (insulation)
F: Fahrenheit
FDC: Facilities Design and Construction Department, within the Facilities Operations and Development Division, at the Ohio State University
FOD: Facilities Operations and Development Division, at the Ohio State University
FPS: Feet per Second
HMI: Human Machine Interface
Hi Pot: High Potential (high voltage testing)
HR: Hour
ICEA: Insulated Cable Engineers Association (Codes and Standards)
IEEE: Institute of Electrical and Electronics Engineers, Inc. (Codes and Standards)
ISA: International Society of Automation
ISO: International Standards Organization
KLBS: Thousand Pounds
KCMIL: Wire size unit, is the equivalent cross sectional area in thousands of circular mills. A circular mill (CMIL) is the area of a circle with a diameter of one thousandth (0.001) of an inch, (1 KCMIL = 1,000 CMIL).
kV: Kilo-volt (thousands of volts)
kVA: Kilo Volt-Amps (thousands of volt amps)
kW: Kilo-watt, a rate of energy delivered or consumed.
kW-hr: Kilo-watt hour, a cumulative sum of energy delivered or consumed.
LBS: Pounds
LCD: Liquid Crystal Display
LOTO: Lock Out, Tag Out (procedure)
mA: Milliampere
MCOV: Maximum Continuous line-to-neutral Operating Voltage
MVA: Mega Volt-Amps (millions of volt-amps)
NEC: National Electrical Code, (Codes and Standards), plus version(s) as Code-applied within the State of Ohio, Ohio Building Code (OBC)
NEMA: National Electrical Manufacturer’s Association (Codes and Standards)
NESC: National Electrical Safety Code (Codes and Standards)
NETA: International Electrical Testing Association (Codes and Standards)
NFPA: National Fire Protection Association (Codes and Standards)
NIST: National Institute of Science and Technology (Codes and Standards)
NPT: National Pipe Thread
OAC: Ohio Administrative Code
OBC: Ohio Building Code
OEM: Original Equipment Manufacturer
O-&-M: Operations and Maintenance manuals as published and provided by manufacturers and Contractors
ORC: Ohio Revised Code
OSU: Ohio State University
P&ID: Process and Instrument Diagram
PILC: Paper Insulated Lead Covered (cable and splices)
.4 SITE UTILITY IDENTIFICATION: The A/E must check with the Ohio Underground Utilities Protection Service (phone: 800-362-2764) to identify and locate all known utility lines in the construction area. Additionally they must comply with Section 153.64 of the Ohio Revised Code relative to underground utilities in relation to construction of public improvements.

Commentary: The Ohio State University became a member of the Ohio Underground Utilities Protection Service on October 17, 2016.

.4.1 All bid documents for projects with any site work identified shall contain the following statement, to appear on the appropriate site plan sheet(s), as well as in the appropriate sections of the project specifications: “Contractor shall notify the Ohio Utilities Protection Service (toll free 800-362-2764) at least 48 hours, but no more than 10 working days prior to any excavating, fencing, planting, or other work that disturbs earth for the location of existing underground facilities. All other owners of underground utilities who are not current members of OUPS should be notified two working days in advance. The Ohio State University will not permit any site work to proceed until utility marking has been completed.”

.5 COORDINATION OF DIVISIONS OF THE WORK: Extreme care is required in preparation of documents to assure no overlapping of the scope of work for the various contracts. Each contractor shall be required to perform excavation, trenching, and backfill for his installations. Materials and compaction of fill materials shall meet the requirements stipulated in Division 31, regardless of who performs this work; therefore, in Divisions 21, 22, 23, 26, 33, and 40, the requirements for earthwork may be best specified by making reference to Division 31. The reference should call attention to the fact that the paragraph regarding payment for laboratory service applies. Also see Facility Services-3.
.6 PAYMENT OF FEES: City of Columbus Sanitary Sewer Tap Fees and System Capacity Charges shall be paid by the contractor doing the work. The contractor shall pay the fees to the city prior to commencing the work and shall provide to the University a written receipt as proof of payment. The Sanitary Sewer Capacity Charge is based on the size of the domestic water service line to the building as per the City of Columbus Division of Sewerage and Drainage Schedule of System Capacity Charges. The amount due is based on the scheduled fee at the time the connection is made. The A/E must check with the City of Columbus Division of Sewerage and Drainage to determine the tap fees and capacity charges and these costs shall be noted in the bid documents.

.6.1 No tap fees or system capacity charges are required for connection to the University water system. However, the details of connection must be arranged with the University Utilities Division of the Facilities Operations and Development.

.6.2 Connections with the City of Columbus water system are subject to tap fees and system capacity charges similar to the sanitary sewer system.

.7 Standards for exterior domestic water piping, fire mains, hydrants and post indicator valves can be found in the Ohio State University Building Design Standard (OSU BDS) sections 33 11 13. Refer to the City of Columbus (COC) and Ohio Department of Transportation (ODOT) construction and materials specifications for standards not found in the OSU BDS. Refer to COC standard drawings for applicable materials and installation requirements for work within Franklin County and ODOT standard drawings for work outside Franklin County. Exterior soil and waste system University standards are described in OSU BDS section 22 10 05. Exterior gas piping requirements are described in OSU BDS 33 51 13. Division 22 provides standards for plumbing systems within buildings. OSU BDS section 23 20 07 provides requirements for underground pipeline conduit.

.8 The A/E shall specify that the contractor shall provide advance notice of at least 5 days and an inspection window of at least 4-hours before covering buried equipment and pipelines with fill. If this notice is not given and if FOD Utilities requests, based on a lack of other documentation or approved inspections, the contractor shall remove or uncover such portions of the work as directed to allow FOD Utilities to complete inspections. The uncovering or removing of fill and the replacing of the cover and restoration of the parts removed shall be at the Contractor’s expense.

.9 RISK MITIGATION PLAN: When directed, the A/E shall develop a Risk Mitigation Plan and Construction Specifications that will minimize risks of construction activities to underground infrastructure and pedestrians. When active utility lines are at risk, The Risk Mitigation Plan shall require an Excavation Permit and a Disaster Preparedness Plan.

.10 TUNNEL DESIGN: The A/E shall design for and specify station labels every 100 feet for each tunnel project. Station numbering shall be consistent with the University tunnel numbering system.

33 01 00. OPERATION AND MAINTENANCE OF UTILITIES

.1 INTRODUCTION
.1.1 To a large extent the success of any great institution depends on the strength and durability of its infrastructure. A key element of the University infrastructure is its Utilities. Utilities play a vital role in almost every aspect of the University experience, including (alphabetically) Academics, Athletics, Event Centers, Food Services, Hospitals, Housing, Medical Center, Recreational Sports, Research, Vivaria, and other allied institutions. The mission in Utilities is to provide a high standard of quality of service, and continuity of service, with a principal focus on public and employee safety. Recent increases in numbers and sizes of highly complex facilities, such as those serving the Medical Center plus various Research facilities, places even greater dependence upon safe and reliable Utilities.

.1.2 The utility infrastructure performance relies on maintenance, equipment performance, and human performance.

.1.3 Human performance relies on training, standards (design consistency) and reliable equipment (good maintenance, sound design).

.1.4 Equipment performance relies on sound design, quality components and sound maintenance practices.

.1.5 Good maintenance relies on sound planning, quality components, sound design and reliable human performance.

.1.6 No element stands alone. No one element can be sustained without the others. No one element can compensate for the absence of another. This DIVISION 33 of the BDS sets forth unique requirements applied to address the equipment performance, human performance and maintenance needs of the Utilities infrastructure of the University. These requirements should be used in conjunction with the remainder of the BDS to arrive at a design and implementation that meets the full utility performance expectation of the University and its allied institutions.

33 01 70. OPERATION AND MAINTENANCE OF ELECTRICAL UTILITIES

.1 SYSTEM DESIGN CRITERIA

.1.1 The requirements and guidelines set forth in this Standard support meeting the basic design criteria in a manner consistent with the University's objectives for service continuity and safety. Life Safety and preservation of property and business operations are the two most important factors in the design of the electrical utility system. The practices and conventions referenced herein and applied throughout the design of the Medium Voltage Distribution System and its allied facilities are the product of an engineering process directed toward optimizing safe and reliable operations. Compliance with OSHA and National Electric Safety Code requirements is fundamental. Compliance to the National Electric Code is not a design requirement and shall be invoked only on a case by case basis, conformant to the Code applicability statements and where technically useful in obtaining Utilities’ objectives for overall facility safety and reliability.

.1.2 This Standard is the ‘minimum’ requirement. This Standard is not intended as a replacement for the many excellent electrical Codes or engineering texts and handbooks commonly in use, nor is it detailed enough to be a design manual.
.1.3 General system design criteria are as follows:

.1.3.1 The main electrical system shall be designed such that a single Primary electrical power component outage shall result in prolonged outage to no more than one service connection.

.1.3.2 No service connection shall be designed or operated in a way that places the reliability of the Primary electrical power sources in jeopardy, or places the safety of the Public or University Staff in jeopardy.

.1.3.3 No single failure in the protection or control systems for critical main power system components shall result in total loss of component or system protection.

.1.3.4 No single failure of the control system shall result in loss of redundant systems or components.

.1.3.5 Equipment and circuit loading shall be kept within the ratings of the components that make up the system.

.1.3.6 System components shall be designed so as to make them maintainable and facilitate operating condition monitoring.

.1.3.7 All critical components shall be monitorable and testable.

.1.3.8 To the extent practicable, systems shall be designed to minimize operator and maintenance personnel disorientation and/or need for additional training because of unwarranted inconsistencies in operating, maintenance requirements or Human Machine Interface (HMI).

.1.3.9 Where appropriate, the design shall meet the requirements of the National Electric Safety Code (NESC) and other utility industry recognized Codes and Standards.

.1.3.10 Main electrical power system designs shall address both system reliability and component protection in a way that balances the need for continuity of service and protection of physical assets.

.1.3.11 No design shall contain features that present a risk to life safety, public or facilities personnel safety beyond what can be reasonably controlled by training, administrative safety procedures, Lock Out – Tag out (LOTO) and personal protective equipment.

.1.3.12 All components shall be Utility grade quality.

.2 SYSTEM PROTECTION

.2.1 System Protection is the protection of the electrical power system. There are two classes of electrical protection: that which is designed to protect equipment or personnel from the potentially harmful effects of overloads or inadvertent grounding and that which is designed to limit the severity or extent of loss of power supply.

.2.1.1 Common requirements of the initial class are overload devices and ground fault isolators. These act to interrupt power before damage can occur. See DIVISION 26 sections for this class of devices for these types of applications.

.2.1.2 Common requirements of the latter class are fuses set to isolate failed transformers from the Primary electrical system, and
protective relays that act to isolate faulted portions of the Primary electrical system to allow the remainder to function normally.

2.1.2.1 As a general rule, Primary electrical system protective devices are applied to isolate to protect the supply rather than operate to protect the downstream component (failed device).

2.1.2.2 Fuses or electronic fuse emulation on gas (SF₆) or vacuum switches used for the primary service drop are set to ride through transformer magnetization transients and load transients. They are not intended to provide overload protection for the transformer or downstream switchgear or bus-work. (Refer to DIVISION 26, for specific requirements concerning sizing of facility distribution system, arc flash, coordination study, load flow, and short circuit analysis.)

2.1.2.3 Primary circuit protection is designed to isolate faulted circuits from the main 13.2 kV supply bus. This protection is set to coordinate with the service drop protection and should be set to stay under the cable damage curves for faults. It provides little or no overload protection. In some instances Resettable fault Interrupters (RFIs) are applied in series or ahead of fuses in Primary circuits feeding building services. This is intended to afford Arc Flash reduction during switching operations and to aid in fault location. These devices do not provide selectivity or support coordination. RFIs applied in Primary Switches that develop a Switched Primary may be equipped with a relay protection package designed to coordinate with the Primary circuit protection.

2.1.2.4 Major Primary electrical system components are provided with differential-type protection that is designed to isolate the faulted component in a very short time (less than 50 milliseconds). This limits damage to the components, the threat of collateral damage to other components in the area or upstream electrically from the faulted component. It also serves to limit the electrical voltage transient experienced by other power system components and loads. (Examples of component and equipment afforded such protection are: large transformers, buses, generators, very large motors and cable feeders that connect major busses).

2.1.2.5 Primary power system protective relay applications are designed so that no single failure of a protective relay or fuse will result in the total loss of ability to isolate the failed component. This involves the use of a diverse relay function such as coordinated time over-current relaying. These relays are applied to wait out the time the failed relay should have taken to initiate a trip and then trip. This
protection takes longer to act and generally results in less selectivity (more components are de-energized than the faulted component).

2.1.2.6 Three key attributes of the protection system are speed, selectivity and reliability. These must be factored into every primary electrical power sources and power supply protection scheme.

2.1.2.7 Testability and routine surveillance are key to assuring the reliability of the power supply protection. Protective relays must be testable in service without lifting wires. Because of this requirement, they shall be equipped with integral test plugs or external test switches. Modern solid-state microprocessor and multifunction relays are equipped with built-in diagnostics that aid greatly in performing periodic inspections. These features do not substitute for testing and calibration checks that force currents and apply voltages and develop output trip functions.

2.1.2.8 All Primary power supply protective relays should be surveyed quarterly and subjected to a full re-calibration and trip check on a nominal five-year interval.

2.1.2.9 Any changes to the Primary power supply, primary distribution or primary service connections must be in conformance with the above stated design and operating philosophy and shall not degrade the overall performance of the Primary system.

3 A/E AND CONTRACTOR PROVISIONS

3.1 INFORMATION FOR DESIGN OF SYSTEM: During the initial planning conference, A/E shall consult with UTHVS and TSG regarding the sizing and configuration of the primary service. Refer to BDS, Part One - The Design Process, Processing the Work, paragraph 00015 Conferences, sub-paragraph .1, Initial Planning Conference, for the requirement that the A/E’s Electrical Consultant shall attend the planning conference(s).

3.2 The A/E shall specify only Underwriter’s Laboratories listed equipment, assemblies, and materials when such items are available and technically acceptable to the design. The equipment and materials shall be installed in accordance with its listing. Equipment and materials shall be selected from a pre-approved Manufacturer list, and subject to UTHVS approval (TSG consultation).

3.3 A/Es submitting proposals to provide electrical engineering, design or construction services shall be required to demonstrate adequate competency, and recent relevant work history. This requirement applies to the A/E’s supervision and work force as well as to sub-A/Es, their supervision and work force. Work experience, personnel credentials and work references shall be submitted in writing at the request of UTHVS or TSG for their review and approval. This requirement applies to all sub-A/Es as well. The A/E shall be prohibited from working in electrical substations, the medium voltage power
distribution system, the power plant, or related facilities unless they demonstrate they have established a verifiable record of safe work practices and training suitable for work around high and medium voltage equipment.

.3.4 The A/E is responsible for addressing and resolving all review comments by UTHVS and TSG concerning primary power system design to the satisfaction of UTHVS and TSG.

.3.5 In conformance with the Primary Electrical Service Policy, [https://fod.osu.edu/sites/default/files/primary_electrical_service.pdf](https://fod.osu.edu/sites/default/files/primary_electrical_service.pdf) the connection to the Utility electrical system shall not be energized if these Standards are not met or if the design or A/E approved equipment or installation fails these Standards or inspections by Utilities High Voltage Services (UTHVS) and the required inspections by the appropriate State and Local Authorities having jurisdiction over those inspections.

.3.6 The A/E shall direct the contractor(s), through the construction documents, to meet the following requirements:

.3.6.1 The Contractor(s) and its sub-contractor(s) shall purchase only Underwriter's Laboratories listed equipment, assemblies, and materials when such items are available and technically acceptable to the design. The equipment and materials shall be installed in accordance with its listing. Equipment and materials shall be selected from a pre-approved Manufacturer list, and subject to UTHVS approval (TSG consultation).

.3.6.2 Contractors submitting proposals to provide electrical construction and installation services shall be required to demonstrate adequate competency, and recent relevant work history. This requirement applies to the Contractor’s supervision and work force as well as to sub-contractors, their supervision and work force. Work experience, personnel credentials and work references shall be submitted in writing at the request of UTHVS or TSG for their review and approval. This requirement applies to all sub-contractors as well. The Contractor and sub-contractors shall be prohibited from working in electrical substations, the medium voltage power distribution system, the power plant, or related facilities unless they demonstrate they have established a verifiable record of safe work practices and training suitable for work around high and medium voltage equipment, and a verifiable record of quality of workmanship and reliability.

.3.6.3 In conformance with the Primary Electrical Service Policy, the connection to the Utility electrical system shall not be energized if these Standards are not met or if the purchased equipment or installation fails these Standards or inspections by Utilities High Voltage Services (UTHVS).

.3.6.5 Contractors shall conform their construction practices to the OSU Utilities Project Safety and Health Guide.

.4 CONFIGURATION MANAGEMENT
.4.1 A/E’s designs shall be submitted to and approved by UTHVS and TSG, before publication for Bid.

.4.2 A/E’s designs shall include related studies and reports. The A/E shall supply facility coordination studies, short circuit analysis, load flow studies, and arc flash analysis to UTHVS and TSG for approval. (See DIVISION 26 for specific requirements concerning sizing of facility Low Voltage distribution, arc flash, coordination study, load flow, and short circuit analysis.)

.4.3 A/E’s Construction Document Submittal: Drawings submitted for review and comment as “Construction Document” submittals shall be provided in full-size printed format for record as well as in native revisable format. The revisable format required for compatibility with the University CAD system is the current version of AutoCAD. This revisable format requirement is limited to main distribution substations, main feeders, power plants, and regional chiller plants. In such cases, the drawing format, content, numbering and conventions shall conform to the requirements of the University Utility drawing System and be coordinated with existing drawings maintained in that system. Where practical, the pre-existing drawings shall serve as the basis for the Associate’s project drawings. Design drawings developed for the construction of Utility facilities shall conform to the numbering and classifications given in Section .4.4.8.

.4.4 The A/E shall direct the contractor(s), through the construction documents, to meet the following requirements:

.4.4.1 Contractor’s submittals shall include related studies and reports as they related to the installed equipment.

.4.4.2 Software: Component and system software, firmware and configuration files shall also be provided in hard copy and/or electronic media form as part of the “construction” package.

.4.4.3 As-Built Drawings: As the project progresses through the construction and commissioning process, an up to date marked up set of As-Built Drawings shall be kept at site in a secure location under the control of the electrical Contractor, prime Contractor or Commissioning Authority to serve as the as-built condition for the project. Mark-ups to these drawings shall include all changes to the original design as well as a record of all changes and additions made to the design by the construction Contractor to accommodate interferences and as found conditions. These mark-ups shall be performed by qualified personnel, be complete and reflect good drafting practice. At no time shall the University be without up to date marked-up drawings for the project. Usable and complete copies of project As-Builts shall be made prior to removing the original marked-up drawings from site, and retained at site for use by the University engineering and maintenance personnel until the final Record Drawings can be issued and distributed for use.

.4.4.4 Record Drawings: At the completion of the project, these As-Built Drawings shall be submitted by the Contractor to the A/E for review and permanent incorporation onto project Record Drawings. These Record Drawings shall be provided within 90 days of project
completion to the University. The Record Drawings shall be delivered in full-size printed format, as well as electronic AUTOCAD format, most current version, for storage and use within the University CAD-based Archive system.

.4.4.5 Software/Firmware As-Builds: TSG and UTHVS require that complete and up to date software and firmware, component configuration files, source code, including printed and published formats where applicable, shall be furnished by the contractor within 90 days of project completion, as a part of his final submittal for the project. This information shall be prepared specifically for each programmable or configurable component and system included in the project.

.4.4.6 Labeling: The Contractor, at the time of installation, shall field-label all major power components. Equipment labels shall provide the name and function of the equipment as well as its power source. When the equipment is made up of two or more separately identifiable devices, sections or compartments; these too shall be individually labeled. Nomenclature used on the field-labels shall be consistent with that used on the Contract Documents, O&M documents and training materials. All field-labels shall be readable from a distance of three feet.

.4.4.7 Control devices such as control switches, relays, displays and instruments shown on One Lines, schematics, interconnection wiring diagrams etc., shall be field-labeled with nomenclature consistent with that used on the Contract Documents.

.4.4.8 The drawing numbering system shall follow drawing naming requirements. To find these requirements: click on the following link, choose the Utilities banner and click on Electronic Drawing Naming:

https://fod.osu.edu/resources

.5 TRAINING AND SUPPORT

.5.1 OPERATOR TRAINING: Operator training for routine operation of systems or equipment shall be provided: The University on a case-by-case basis shall set Training requirements. Such training shall at a minimum include one full instructor-day, minimum 8-hours per shift, of on-site instruction for the daily operation of the system, to be attended by University’s designated Operations personnel. All training shall be scheduled by the contractor in coordination with the University’s FOD Training Officer, or his designated representatives.

.5.2 ADDITIONAL TECHNICAL SUPPORT DURING WARRANTY: In addition to the warranty for labor and materials as specified in General Terms and Conditions: the contractor shall at the request of the University, provide additional technical support up to a maximum of two full person-days, minimum 16-hours, on-site support for the system during warranty. All support shall be at the request of the University’s Director of Utilities or his designated representatives.
.5.3 In addition to the above training for operation of equipment, Training for System Maintenance, shall include the OEM manufacturer's standards for:

.5.3.1 OEM hardware tools and documentation
.5.3.2 OEM software tools and documentation
.5.3.4 OEM certificate of “Authorized Warranty Service Technician” or equivalent

.5.3.5 The training shall allow the University to perform all maintenance and inspection functions. The software tools shall perform on industry standard Windows-based laptop personal computers, using industry standard MS operating systems. The University shall agree on the location of the training.

33 05 30 VENTILATION FANS

PART 1 - GENERAL

.1 RELATED DOCUMENTS

.1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

.2 DESCRIPTION OF WORK

.2.1 Provide fans as scheduled on the drawings.

.3 SUBMITTALS: Submit the following to the University for approval.

.3.1 Shop Drawings: Show fan layout, housing, materials, gauges, dimensions, weights, and installation details. Provide shop drawings indicating requirements for fan and accessories coordination with ventilation structures.

.3.2 Product Data: Manufacturer's fan performance (data includes L/S, rpm, bhp, motor nameplate data, tip speed, outlet velocity and static pressure) and sound performance (data includes sound power level ratings by octave bands) as tested in accordance with AMCA Standards 210 and 300.

.3.3 Fan Curves - Submit curves for all fans with system performance shown, and for +10% and +20% changes in fan rpm. Curves shall include plotted rpm, horsepower, CFM, static pressure and fan surge line.

.3.4 Certified AMCA Ratings - Submit ratings for air and sound performance.

.3.5 UL Listing - Submit listing specified.

.4 QUALITY ASSURANCE

.4.1 Factory balance each fan statically and dynamically, and test run before shipment.

.4.2 Fans shall operate quietly and without pulsation or vibration. Coordinate sound power level tests for each type fan at the factory in accordance with AMCA Standard 300.

.4.3 The capacity shown in the fan schedule is the minimum air quantity the fan should deliver at the static pressure and rpm specified.

.4.4 The resistances shown in the schedules are those required by the project, and do not include the internal and intake fan losses, integral outlet dampers, inlet
screens, outlet velocity heads or drive losses. The fan manufacturer shall size and provide fan motor that compensates for all losses.

.4.5 Factory performance test each fan assembled in or as part of apparatus specified to be performance tested. Test shall display scheduled performance characteristics, using certified, calibrated testing increments provided by the manufacturer of the apparatus.

.4.6 All fan performance ratings shall be based upon factory tests performed in strict accordance with AMCA Standard 210. All fans shall be certified by AMCA and carry its seal.

.4.7 Fan manufacturer shall check the moment of inertia ($W R^2$) of the fan/impeller to be certain that the speed torque curve of the motor specified will accelerate the fan wheel to design speed without overload. Furnish larger motor, if required, and show revision on submittals.

.4.8 Fans shall not operate at speeds in excess of 80 percent of their true critical speeds.

.4.9 Provide propeller exhaust utility fan as manufactured by Greenheck Model SBC-3H36-50 or approved equal.

.4.10 Testing Requirements: The following factory tests are required:

.4.10.1 Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings in accordance with AMCA Standard 210/ASHRAE Standard 51 - Laboratory Methods of Testing Fans for Rating.

.4.11 UL Listed: All fans shall be UL705 listed for all electrical components

PART 2 - PRODUCTS

.1 FANS, GENERAL

.1.1 General: Provide fans that are factory fabricated and assembled, factory tested, and factory finished, with indicated capacities and characteristics.

.1.2 Fans and Shafts: Statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower.

.1.2.1 Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of the first critical speed at the top of the speed range of the fan's class.

.1.3 Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

.1.3.1 Service Factor: 1.4.

.1.4 Belts: Oil-resistant, non-sparking, and non-static.

.1.5 Motors and Fan Wheel Pulleys: Adjustable pitch for use with motors through 15 HP; fixed pitch for use with motors larger than 15 HP. Select pulley so that pitch adjustment is at the middle of the adjustment range at fan design conditions.
.1.5.1 Fan Guard: OSHA expanded steel guards for personnel protection from rotating belts, pulleys and blades.

.1.6 Shaft Bearings: Provide type indicated, having a median life "Rating Life" (AFBMA L (50) of 200,000 hrs, calculated in accordance with AFBMA Standard 9 for ball bearings and AFBMA Standard 11 for roller bearings.

.1.7 Factory Finish: The following finishes are required:
   .1.7.1 Sheet Metal Parts: Galvanized or aluminum as specified prior to final assembly.
   .1.7.2 Exterior Surfaces: Galvanized or aluminum as specified.

.1.8 Dampers: Dampers or shutters for fans shall be gravity type with parallel blade construction.
   .1.8.1 Constructed of 16-gauge galvanized steel and incorporate a pre-punched channel style mounting frame. Damper corners shall be caulked and sealed and reinforced with die formed brackets and gussets.
   .1.8.2 Jamb sections shall incorporate stainless spring steel side plates with resilient cellular cushions.
   .1.8.3 Roll-formed blades are to incorporate tight seal gasketing and interlock when closed.
   .1.8.4 Dampers are to be provided with self-lubricating nylon bearings.
   .1.8.5 Damper shafts are to be cadmium plated steel, minimum 12-mm diameter.

.1.9 Motors: Fan motors shall have the following basic construction features and characteristics:
   .1.9.1 Torque Characteristics: Sufficient to accelerate the driven loads satisfactorily.
   .1.9.2 Motor Sizes: Minimum sizes and electrical characteristics as indicated, if not indicated, large enough so that the driven load will not require the motor to operate in the service factor range.
   .1.9.3 Temperature Rating: 60°C maximum temperature rise at 150°F (65°C) ambient for continuous duty at full load (Class F Insulation minimum).
   .1.9.4 Service Factor: 1.15 for polyphase motors and 1.35 for single-phase motors.
   .1.9.5 Motor Construction: NEMA Standard MG 1, general purpose, continuous duty, Design B. Provide permanent-split capacitor classification motors for shaft-mounted fans and capacitor start classification for belted fans.
   .1.9.6 Bases: Adjustable.
   .1.9.7 Bearings: The following features are required:
      - Ball or roller bearings with inner and outer shaft seals
      - Grease lubricated
      - Designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor
.1.9.8 Enclosure Type: The following features are required:
  • Totally enclosed motors where located in air stream
.1.9.9 Overload protection: Built-in, automatic reset, thermal overload protection
.1.9.10 Noise rating: Quiet
  • Nameplate: Indicate the full identification of manufacturer, ratings, characteristics, construction, and special features

.1.10 Starters, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 48 Electrical Sections.

.2 PROPELLER FANS

.2.1 General Description: Belt-driven propeller fans as indicated consisting of fan blades, hub, housing, orifice ring, motor, drive, and accessories. The fans shall be suited for the installed environment including ambient conditions of 150°F. Review drawing schedule for mounting orientation. Provide special construction necessary for horizontal unit installation. Special construction for horizontal mount units may include but are not limited to the following.
  2.1.1 Grooved shaft with snap rings
  2.1.2 Motor pulley retaining hardware
  2.1.3 Reinforcing angles on the fan panel
  2.1.4 Propeller retaining hardware

.2.2 Housings: Galvanized, sheet steel with flanged edges, and integral orifice ring.

.2.3 Fan Wheel: Replaceable, cast-aluminum, airfoil blades fastened to cast-aluminum hub. Factory set pitch angle of blades.

.2.4 Drive Assembly: Belt-driven.

.2.5 Belt-Driven Drive Assembly: Resiliently mounted to the housing, with the following features:
  2.5.1 Pulleys: Cast-iron, adjustable-pitch.
  2.5.2 Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
  2.5.3 Fan Shaft: Turned, ground, and polished steel drive shaft keyed to wheel hub.
  2.5.4 Motor and Drive Assembly: Resiliently mounted to the housing.

.2.6 Accessories: The following accessories are required as indicated:
  2.6.1 Fan blade guard
  2.6.2 Belt Guards: Expanded metal with reinforced edges
  2.6.3 Gravity Shutters/Back draft Dampers: Gravity-type shutters with aluminum blades in steel frames
  2.6.4 Shutter and damper guard
  2.6.5 Power disconnect switch
  2.6.6 Thermostat controls (Range 0-150°F)
  2.6.7 Switch controls
  2.6.8 Weather hoods
  2.6.9 Wall collars
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.2.6.10 Motor side guards
.2.6.11 Bird screens

.2.7 Fan housings and brackets shall be factory painted.
.2.8 Subject to compliance with the specifications and ratings requirements, provide propeller supply and exhaust wall fan as manufactured by Greenheck Model SBC-3H36 or approved equal.

.3 UPBLAST PROPELLER EXHAUST FANS
.3.1 General Description: Spun aluminum centrifugal belt driven up-blast exhaust fan with aluminum fan wheel and leak proof aluminum housing.
.3.2 Wind Band, Fan Housing, and Base: Reinforced and braced one piece heavy gauge spun aluminum, rain trough, motor and drive assembly, and fan wheel.
.3.3 Fan Wheel: Replaceable, aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.
.3.4 Belt Drives:
  .3.4.1 Resiliently mounted to housing.
  .3.4.2 Weatherproof housing of same material as fan housing.
  .3.4.3 Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
  .3.4.4 Shaft Bearings: Pre-lubricated and sealed, self-aligning, pillow-block-type ball bearings.
  .3.4.5 Pulleys: Cast-iron, adjustable-pitch motor pulley.
  .3.4.6 Motor Mount: On outside of fan cabinet in separate compartment, adjustable base for belt tensioning. Factory mounted and wired NEMA 4 disconnect switch.

.3.5 Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch- (40-mm) wood nailer. Size as required to suit opening and fan base.
  .3.5.1 Configuration: Self-flashing with built-in cant, with mounting flange.
  .3.5.2 Overall Height: 12 inches (300 mm).
  .3.5.3 Burglar Bars: 5/8-inch- (16-mm-) thick steel bars welded in place to form 6-inch- (150-mm) squares.

.3.6 Subject to compliance with the specifications and ratings requirements, provide Up-blast exhaust fan as manufactured by Greenheck Model CUBE or approved equal.

PART 3 – EXECUTION
.1 EXAMINATION
  .1.1 Examine ventilation structures, areas and conditions, for compliance with requirements for installation tolerances, and other conditions affecting performance of fans.
  .1.2 Do not proceed until unsatisfactory conditions have been corrected.
  .1.3 Inspect combination fire smoke dampers in accordance with NFPA.

.2 INSTALLATION, GENERAL
.2.1 Install fans level and plumb, in accordance with manufacturer's written instructions. Support units as described below, using the vibration control devices indicated.

.2.2 Arrange installation of units to provide access space around fans for service and maintenance as indicated but in no case less than that recommended by manufacturer.

.2.3 Adjust and balance fans for the specified airflow.

.2.4 Install combination fire smoke damper in accordance with the Manufacturer’s instructions and listing requirements.

.3 CONNECTIONS

.3.1 Electrical Connections: The following requirements apply:

.3.1.1 Electrical power wiring is specified in Division 48 Electrical Sections.

.3.1.2 Automatic control wiring and interlock wiring shall be installed as shown on the drawings and as specified in Division 48 Electrical Sections.

.3.1.3 Grounding: Connect unit components to ground in accordance with the National Electrical Code.

.3.2 Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.

.3.2.1 Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 48 Electrical Sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

.4 COMMISSIONING

.4.1 Final Checks Before Start-Up: Perform the following operations and checks before start-up:

.4.1.1 Remove shipping blocking and bracing.

.4.1.2 Verify unit is secure on mountings and supporting devices, and that connections for electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects.

.4.1.3 Perform cleaning and adjusting specified in this Section.

.4.1.4 Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.

.4.1.5 Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants when required.

.4.2 Starting procedures for fans:

.4.2.1 Energize motor; verify proper operation of motor, drive system, and fan blades. Adjust fan to indicated RPM.

.4.2.1.1 Replace fan and motor pulleys as required to achieve design conditions.
.4.2.2 Measure and record motor electrical values for voltage and amperage.

.4.3 Shut unit down and reconnect automatic control operators.

33 08 00. COMMISSIONING OF UTILITIES
33 08 70. COMMISSIONING OF ELECTRICAL UTILITIES

.1 TESTS, INSPECTIONS AND ACCEPTANCE

.1.1 Factory Testing: Factory testing for major equipment and integrated systems shall demonstrate design compliance to procurement and functional specifications. It shall be conducted to appropriate industry Standards and include third party testing and verification. The option for University acceptance by participation in the testing or through a review of the testing results shall be made available with a minimum of two weeks written notice to planned commencement of testing.

.1.2 Installation Quality Control Testing

.1.2.1 The contractor shall supply appropriate technically competent support to monitor workmanship and completeness. This shall involve in-line work inspection or audit inspection with rigorous corrective action, follow up and closure on non-conforming work products and methods. Tests and inspections shall include compliance to OSU Standards, and compliance to good industry practices. Instrument calibration and set point verification shall be included in the contractors test and inspection planning and execution.

.1.2.2 The contractor shall supply appropriate technically competent support to test and inspect installations for fitness for service in accordance with NETA guidelines.

.1.2.3 Testing shall be performed to demonstrate fitness for service of all components. A representative from UTHVS shall witness the testing. Copies of test results shall be provided to UTHVS and Technical Services Group through the OSU Project Manager.

.1.3 Post Installation Testing

.1.3.1 The contractor shall supply appropriate technically competent support to conduct thorough pre-operational testing of all installed systems and components for all modes of operation in accordance with NETA guidelines. Testing shall include equipment controls, protective relays and safety interlocks.

.1.3.2 System Functional Testing: All systems shall be tested to demonstrate their ability to function as required over the full limits of their normal operational range and for any emergency range as called for in the system design. This testing shall be conducted with the systems and associated equipment installed and operating in their normal mounted orientation, settings and conditions of power supply and environment. This testing may be conducted in an
integrated fashion with all system interfaced as designed or may be done piecemeal (overlapping) in a manner that demonstrates acceptable functionality of all interfaces, shared functions and dependencies.

.1.3.3 Interlock verification testing: Once all construction has been completed and all system installation and construction testing completed, the University or their appointed agent shall conduct testing designed to validate the proper operation of all system permissives, trips, critical sequences, operator HMI functions and annunciations.

.1.4 Certification Process: The University requires all test reports and records as well as individual certifications of any and all test authorities, the manufacturer or independent testing agencies be provided for review and acceptance. These records, along with supporting documents showing acceptable resolution of open items, test discrepancies, failures and repair, retesting etc., will serve as the basis for certifying equipment for service by the University.

.1.5 University Acceptance Process: The University, as a recognized authority for the certification of systems and facilities for safe and conformant operation, is obligated to follow due process and demonstrate due diligence in their review and acceptance of all processes relating to quality, completeness and conformance to applicable Codes and Standards. University acceptance will be granted only after the certification process has been completed to the University’s satisfaction and all documentation has been received, reviewed and accepted.

.1.5.1 Tests must be conducted in accordance with University requirements and shall be witnessed by representative(s) of UTHVS.

.1.5.2 Medium and low voltage cable testing shall comply with NETA and Association of Edison Illuminating Companies (AEIC) guidelines with the following exceptions:

.1.5.2.1 The University deviates from the Industry Standard of 64 kV and 96 kV at 133% cable insulation level due to destructive nature of this testing, field experience and the potential for cumulative damage.

.1.5.2.2 Hi-pot testing on 133% EPR insulated 13,200 volt system cable shall be a 42,000 volt DC High Pot performed by an approved test instrument witnessed by UTHVS. The 42,000 volt High Pot test shall be applied in 7,000 volt intervals of one-minute duration with a 5-minute sustained interval at 42,000 volts. High Pot testing of existing installed primary cables is limited under normal conditions to 10,000 volts. This 10,000 volt DC High Pot is applied gradually with a sustained duration at 10,000 volts for five minutes. The 42,000 volt test shall only be done after pulling, termination and splicing of new cables, but before splicing to the existing cables. A maximum of 10,000 volts DC high pot test
shall be applied for all installations after splicing to existing cable.

1.5.2.3 Hi-pot testing on shielded 133% EPR insulated 4,160 volt system cable shall be a 28,000 volt DC High Pot performed by an approved test instrument witnessed by UTHVS. The 28,000 volt High Pot test is applied in 7,000 volt intervals of one-minute duration with a 5 minute sustained interval at 28,000 volts. High Pot testing of existing installed primary cables is limited under normal conditions to 19,000 volts. This 19,000 volt DC High Pot is applied gradually with a sustained duration at 19,000 volts for five minutes. The above limits apply to cables without the presence of a surge suppressor.

1.5.2.4 Hi-pot testing for 600 volt circuits may be elevated to a maximum 2,500 VDC 1 minute duration for certain critical control components as identified by UTHVS on a case-by-case basis.

1.5.3 Primary transformer and switchgear testing shall be conducted per NETA standards and witnessed by UTHVS. The tests shall be performed after installation of the transformer and switchgear.

2 INDEPENDENT VERIFICATION

2.1 The Commissioning agent shall act independently of the Construction contractor. The Commissioning agent may report to OSU project administrative and management staff or to the University Utility technical, administrative or management staff.

2.2 The Commissioning agent may direct the construction contractor in the execution of critical aspects of the construction work scope and may, if authorized by Utilities energize or otherwise operate equipment and coordinate checkout, and coordinate commissioning activities such as instrument calibration and set point verification with equipment vendors directly.

2.3 The Commissioning agent may reject construction contractor work for quality related reasons, and delay commissioning activity for incompleteness or lack of documentation.

2.4 All Construction contractor conducted testing is subject to review and approval by the Commissioning agent.

2.5 For projects requiring coordination of activities with an outside Utility, the Commissioning agent may be called upon to establish liaison and coordinate testing and checkout activity

2.6 The Commissioning agent may be called upon to coordinate commissioning activity with the testing and commissioning activity of equipment manufacturers.

2.7 All Commissioning activities shall be conducted in conformance and in support of the UTILITIES ELECTRICAL PROJECT SAFETY AND HEALTH GUIDE.
33 09 00.  INSTRUMENTATION AND CONTROL FOR UTILITIES

.1 General
This section addresses the control of major substation and distribution system electrical equipment such as switchgear, large power transformers and auxiliary support systems and equipment such as station battery systems, automatic transfer controls medium and low voltage motor control centers and transfer switches. The requirements contained in this section are to be used in conjunction with the requirements of other BDS DIV 33 and DIV 48 sections giving detail requirements relating to specific equipment and systems and their wiring and physical installation. Included in this section are requirements for controls using solid state and electromechanical relays, Programmable Logic controllers, motor starters, transfer switches, medium and low voltage switchgear, custom manufactured package systems, 125 v DC systems, power transformers of all sizes.

This section addresses the principal design criteria for the control of this equipment. The instrumentation referred to in this section is the power instrumentation required for the operation, testing and maintenance of this equipment such as ammeters, voltmeters, indicator lights, current transformers, potential transformers, shunts, meters, data acquisition systems, etc.

.2 Operability
Controls shall be designed to address the range of normal and emergency service requirements relating to the equipment and systems being controlled.

If controls are limited to manually initiated control functions, they should conform closely to conventions and practices widely used elsewhere for similar systems and equipment. Instrumentation needs to be present (at or near the control location) to assist the operator in determining the effectiveness of the control actions taken.

If the controls are automatic, they should contain features that provide status on the controls, the process and or parameters being controlled. These features should not depend on the same instruments providing the control variable inputs to the automation. Where automation has been applied to supplant manual control, the capability of some basic level of manual override should be provided along with the means for the operator to assess the situation and receive feedback on any manual operations undertaken (example: and E stop with indication).

.3 Maintainability
Controls should be designed to facilitate planned maintenance for the systems and equipment being controlled. An example of this would be the inclusion of a manual control station to facilitate draining or filling operations or system post maintenance startup.

Automatic controls should be provided with information relating to the availability of system equipment when it has been removed from service for maintenance.

LOTO considerations relating to local power disconnects, power source lock-out, etc. must be accommodated.

.4 Constructability
Controls must be designed in conformance with the physical constraints of the facility. Control stations, cabinets, panels and compartments must be designed to facilitate cable access and provide adequate areas for orderly field cable marshalling and termination. Since the standards require the use of multi-conductor color coded jacketed and labeled cables with wire sizes in the AWG 10 to 14 for control conductors and AWG 16 for some instrumentation cables. Cable management requires careful planning and design.

.5 Testability
Controls need to be designed to facilitate planned preoperational and post maintenance testing for the systems and equipment being controlled. This may mean designing the controls with build in test modes of operation, or it may simply involve designing the controls to facilitate LOTO depending on system complexity and the various types of testing to be accommodated. Automatic controls should be provided with information relating to the availability of system equipment when it has been removed from service for testing.

.6 Human Factors
.6.1 Accessibility
Control stations need to be located where they can be conveniently reached and where they will not be in the way of routine or planned maintenance. Mounting control stations on equipment or in areas where access cold be restricted because of ambient noise, high temperature or a higher than normal risk of steam or water leaks should be avoided.

.6.2 Lighting
Control stations need to have lighting adequate to support the operator’s actions planned as well as sufficient access and egress lighting. Where task lighting cannot be supplied at high enough levels to accommodate operator needs, displays should be designed with back lighting or the control station should have its own source of task illumination.

.7 Human Machine Interface
.7.1 Type
The HMI selected should be appropriate to the task being performed. Hard wired controls for simple control actions, touch screens for more complex tasks and where visual or process displays would be helpful, analog displays for displaying rapidly changing parameters, digital where slow moving parameters are involved, where there is a wide range in the variable, or where precision is needed.

.7.2 Information displayed
The information displayed at a control station should be compatible with and adequate for the control actions planned for the station. Information displayed should be organized in a logical manner in relation to the control devices. Clutter should be avoided.

.7.3 Controls available.
Control devices available at a control station should be limited to what is required for the intended operations. Main or frequently used controls should be located centrally within the easiest reach of the operator. Less frequently used control should be positioned in their own functional grouping, out of the
central control area. Some controls that are not intended for normal control operations such as E-stops, or devices that would cause serious disruption if inadvertently operated should be placed in an accessible location but away from the more frequented areas of the control station. Functional grouping of controls is preferred. Clutter should be avoided. Guards should be provided or the “two independent action” rule should be employed where inadvertent operation could have grave repercussions.

.8 Environment
.8.1 Temperature, Humidity
Apply control components and locate control stations where they will not be exposed to adverse ambient temperatures, humidity and dew point cycling if at all possible. Enclosures should be designed with cabinet heaters for high humidity environments and should have a NEMA enclosure design consistent with the environment.

.8.2 Water hazards
Where water hazards could exist, control station equipment should be water tight or resistant. Care must be taken to insure that cable access is from below or low to the side. Where moisture intrusion is considered a risk, the control cabinet should be equipped with a bottom drain point that is screened to exclude insects and rodents.

.8.3 Proximate hazards
Locate control stations only where there is minimal risk of exposure to proximal hazards such as steam leaks, rupture diaphragms, safety valves, electrical Arc Flash, falling or tripping. Access to control stations should not involve climbing or the use of any temporary structures or scaffolding.

.9 FMEA
.9.1 Design practices
The design of the controls should observe to the extent practicable established and standardized control practices to benefit from past experience and lessons learned. The application of control components should be standardized around a limited set of approved components and manufacturer product lines to simplify spare parts stocking and training. Control circuit designs should be replicate between similar pieces of electrical power equipment and between similar systems.

.9.2 Failure modes
Control circuit failure modes should be identified and evaluated. Predominant failure modes should be accommodated by designing adequate annunciation and or indication to assure that the operator is aware of the failure and can take appropriate operator action. The impact of individual component failures should be minimized by applying the component in a manner so that the dominant failure mechanism would have the least significant impact on the system operation or potential for equipment damage.

Power dependencies should be identified and evaluated. Power sources should be selected to conform to the overall power dependencies of the prime movers in the system. The choice of control voltage should be based on
the characteristics of the control power sources available. Battery-backed 125 vdc is the most reliable source but designs powered from battery-backed 125 vdc should be energized to actuate, normally de-energized and be capable of being de-energized with critical systems in operation without the controlled system tripping. 125 vdc is the preferred source for electromechanical controls that must operate under blackout conditions and when system ac power is lost.

120 vac inverter backed control is the preferred power for electronic controls and instrumentation that must remain in service independent of the availability of system ac power. Inverter use should be restricted to this type of load and under no condition should an inverted backed ac source power motors or load with significant startup transients with the possible exception of switching type power supplies. Inverter sources are inherently current limiting, so the exposure of these circuits to shorts or grounds is a concern. This can be mitigated somewhat by providing a solid state transfer switch to an alternate source of ac with great fault support capacity. If electromechanical control devices such as relays and solenoids are powered off an inverter backed source, coil suppression is recommended.

Diesel-backed ac is the preferred source for controls that can sustain a momentary or short term loss of ac power and still function acceptably once power is restored. In the case of Emergency Diesel Generator power, restoration usually occurs in around ten (10) seconds. In the case of Standby generators, restoration may take as long as a minute or more.

.9.3 System effects
The system effects of a control system or component failure need to be assessed and addressed in the control design. Control failure modes must be compatible with system and component preferred failure states. A fail-closed, air-operated valve will generally require a solenoid and control circuit design where a solenoid coil or control power failure will result in the valve closure as well. A circuit breaker control which is designed to open and close the breaker is generally designed to fail as is. Safety considerations are another factor to be considered in control design. A failure in the trip circuit of a circuit breaker should remove power to both the close and trip portions of the breaker control circuits. This is a useful safety feature to avoid the possibility of closing a breaker whose trip circuit has already failed. Likewise, powering the closed indication of a circuit breaker by having the closed indicator light powered from the trip circuit through the trip coil of the breaker insures that the loss of closed indication on breaker closing will alert the operator to a possible abnormal situation with the breaker.

.9.4 Situational awareness
Particular care must be taken to insure that the instrumentation provided with controls provides adequate situational awareness for the operator to assess the effectiveness of automatic controls and to monitor manual control actions. Instruments and displays provided for monitoring the condition of the controlled system generally should not share signals with the instruments
controlling the system. As a general rule instrumentation that the automatic control function relies upon for its control action should be independent of the instrumentation relied upon to determine effectiveness of the automatic controls or depended upon to take manual control action.

.9.5 Recovery and use of lower tier controls

It is customary to provide echelon control to complex systems. Echelon control involves applying controls in layers. A system may have a master control that provides system level commands from a system operator or automatic dispatch control. This Master control may control only that one system or a variety of systems to coordinate their individual automatic operations. A system then may have subsystems that have their own automation and so on. Each of these layers may have both automatic and manual control modes.

As a general rule, a system or group of systems that share an echelon control architecture should have their controls designed to allow higher echelon automation to automatically detect the loss of lower echelon automation and take appropriate compensatory action to address system control needs including operator situational awareness and appropriate adjustment of lower tier operating modes, set points and limits.

Echelon controls should not be applied where loss of a subsystem’s automation will result in a wholesale loss of system automation and wholesale reversion to manual control. Loss of automatic control at any level should always be readily recoverable by skilled operator action or result in placing the subsystem in a safe condition or operational mode with minimum disruption to the remainder of the control system.

33 11 13 SITE WATER DISTRIBUTION

PART 1 – GENERAL DESCRIPTION
.1 This OSU Building Design Standard includes guidance for project A/E’s on:
.1.1 Pipe, fittings and accessories for site water line including domestic water line and fire protection water line.
.1.2 Installing valves of type and size that the A/E shows on their project plans.
.1.3 OSU Fire Hydrants are per City of Columbus CMS Item 809.02 except where stated herein.
.1.4 Water line pressure testing.
.1.5 Disinfection of potable water distribution system.
.1.6 Testing and reporting results.

.2 REFERENCES
.2.1 City of Columbus, Construction and Material Specifications, Item 800 Water Supply and Distribution, 2012 Edition
.2.2 AWWA B300 - Standard for Hypochlorites
.2.3 AWWA B301 - Standard for Liquid Chlorine
.2.4 AWWA C651 - Standard for Disinfecting Water Mains
.2.5 National Fire Protection Association (NFPA) Standards 13, 24, and 25

.3 SUBMITTALS
.3.1 Specify that the Contractor shall record actual locations of piping mains, valves, connections, thrust restraints and invert elevations.
.3.2 Specify that the Contractor shall certify that products provided meet or exceed the contract requirements.
.3.3 Specify that the Contractor shall submit product data on pipe materials, pipe fittings, valves, valve boxes, indicator posts, hot taps, fire hydrants, utility marking tape, backfill, and accessories.
.3.4 Test report:
   .3.4.1 The A/E shall specify that the Contractor must provide test report with water at 150 psi pressure in accordance with AWWA procedures.
   .3.4.2 Test Reports shall indicate results comparative to specified requirements.
   .3.4.3 Certificate: Specify that the Contractor shall provide written certification of the cleanliness and sterilization of the water distribution system meets or exceed AWWA requirements. Specify that the Contractor shall submit bacteria test results to the A/E and the University prior to the water line being energized for service.

.4 QUALITY ASSURANCE
.4.1 New domestic cold water utility piping shall not be designed to be routed through campus tunnels or through campus facilities. If no other reasonable alternative exists, routing the underground domestic cold water utility through a tunnel or through a campus facility requires a design variance submitted to the University Engineer. Any exposed domestic cold water pipe must be designed with restraints to account for thrust forces. The project designing and installing the exposed domestic cold water line shall provide third party inspection on the installed water line prior to the water line being energized for testing.
.4.2 Specify that the work shall be in accordance with the plans.
.4.3 Specify that the Contractor shall deliver and store material in shipping containers with labeling in place. The Construction Manager and A/E shall inspect on site materials for conformance prior to installation by the Contractor. Materials that do not conform to project and OSU Building Design Standards will not be allowed to be installed.
.4.4 Specify that the Contractor shall use a Water Treatment Company specializing in disinfecting potable water systems with a minimum of three (3) years’ experience. If a Water Treatment Company is not going to be used by the Contractor, then the Contractor shall submit their qualifications and experience for disinfecting potable water systems.
.4.5 Specify that the Contractor’s Water Testing Company specializing in testing potable water systems is certified by the State of Ohio. The Contractor shall submit bacteriologist’s signature and authority associated with the water testing.
.4.6 Specify that OSU Utilities is the Authority Having Jurisdiction (AHJ) over domestic cold water lines installed on Columbus Campus. Specify that the State of Ohio Fire Marshall is the State’s AHJ for underground fire water lines that provide fire water to campus fire hydrants and facilities. OSU Utilities and the State of Ohio Fire Marshall will inspect and authorize water service if the installation meets the appropriate standards and no substandard practices, workmanship or non-conformant conditions are discovered, the water system is deemed safe for public consumption, and the A/E has provided their final signed and stamped by a State of Ohio Professional Engineer (Ohio PE) inspection results and determined that the installation meets or exceeds the A/E’s design.

.4.7 Columbus Campus domestic cold water pressure is not regulated by OSU Utilities. The water is provided to OSU’s Columbus Campus from the City of Columbus’ water distribution system. The site, the building fire and plumbing systems designers for the A/E team are advised that domestic cold water pressure for campus fire and domestic water services will vary between 80 psig to 120 psig with demand, time of day, maintenance, outages, and other distribution system factors. The site water system piping shall be designed for a 120 psig maximum operating pressure and account for the range of operating pressures in the design. Building system pressure requirements shall be coordinated by the A/E Team. Any required pressure reduction will be within the building system.

.4.8 OSU Utilities maintains and updates a domestic cold water model for Columbus Campus water demand. Domestic cold water system site pipe sizing and building system water demands shall be reviewed and coordinated with OSU Utilities. The project team shall submit a completed Utilities request form for new and modified domestic cold water services. The form can be downloaded from the website by clicking on the following link, selecting the Utilities banner and choosing ‘Utilities Request – New or Change’:

https://fod.osu.edu/resources

.4.9 In some cases OSU property is served by City of Columbus water lines and not OSU water lines. If that is the case, the A/E shall specify that the installing Contractor be authorized and have licensing approval to work on City of Columbus water line systems. This is in accordance with Columbus City Code 1103.02 and 1103.06 to perform work on City of Columbus water lines, including water service lines and taps.

.5 PROJECT RECORD DOCUMENTS

.5.1 Specify that the Contractor is responsible for maintaining accurate and up-to-date red line prints on the project site. The red-line prints shall show the as-built conditions of the water line. The Construction Manager and A/E shall regularly inspect and verify red-line prints for accuracy.

.5.2 Specify that the contractor shall notify OSU Campus Surveyor to have the water line surveyed (for OSU archive information) prior to backfilling the water piping. If the water piping is backfilled prior to survey, the contractor shall uncover piping at the Contractor’s expense to allow for OSU survey.
.5.3 Specify that the Disinfection report contain the following minimum amount of information:
   .5.3.1 Type and form of disinfectant used
   .5.3.2 Date and time of disinfectant injection start and time of completion
   .5.3.3 Test locations
   .5.3.4 Initial and 24-hour disinfectant residuals (quantity in treated water) in ppm for each outlet tested
   .5.3.5 Date and time of flushing start and completion
   .5.3.6 Disinfectant residual after flushing in ppm for each outlet tested

.5.4 Specify that the Bacteriological report contain the following minimum amount of information:
   .5.4.1 Date issued, project name, and testing laboratory name, address, and telephone number.
   .5.4.2 Time and date of water sample collection.
   .5.4.3 Name of person collecting samples.
   .5.4.4 Test locations.
   .5.4.5 Initial and 24-hour disinfectant residuals in ppm for each outlet tested.
   .5.4.6 Coliform bacteria test results for each outlet tested.
   .5.4.7 Certification that water conforms, or fails to conform, to bacterial standards of the AWWA.

PART 2 - PRODUCTS
.1 MATERIALS
.1.1 WATER SERVICE CONNECTIONS 3-INCH AND LARGER
   .1.1.1 Material
      .1.1.1.1 Ductile iron pipe for 3-inch and larger up to the meter inlet.
      .1.1.1.2 Marked from the factory with the words: DUCTILE IRON.
      .1.1.1.3 Specify pipe with a bituminous-coated cement lining that complies with AWWA C104 Specifications and an outside coating of bitumastic-enamel or approved equal.
      .1.1.1.4 Provide ductile iron pipe cast, cleaned, cement lined, coated, tested, and certified at a single manufacturing facility with all manufacturing units contiguous to one another.
      .1.1.1.5 Gauge full from the end of the spigot to two feet from the flare of the bell ten (10) percent of the ductile iron pipe supplied to the project.
      .1.1.1.6 Corrosion Control: OSU Utilities requires polyethylene encasement in accordance with AWWA C105 on buried ductile iron pipe, fittings, and accessories.
      .1.1.1.7 Material physical properties and wall thicknesses shall be:

                      Hardness   Rockwell B-90 maximum
                      Yield Strength   42,000 psi minimum
                      Tensile strength   60,000 psi minimum
Elongation in 2 inch  10% minimum

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<thead>
<tr>
<th>Nominal Size</th>
<th>Class</th>
<th>Wall Thickness</th>
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<tbody>
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</tr>
<tr>
<td>20 inch</td>
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</tr>
</tbody>
</table>

.1.1.2 VALVES AND APPURTENANCES:
.1.1.2.1 Valves 3-inch and greater shall be specified as Gate Valves in accordance with item 802 of the City of Columbus’ Construction and Material Specifications.
.1.1.2.2 Valves 2-inch and smaller shall be curb stop type or a 2-inch gate valve.
.1.1.2.3 For 20-inch valves and larger, specify and design on the plans 6-inch bypass piping and valves across each 20-inch valve.
.1.1.2.4 Specify valve supports of the sizes shown on City of Columbus Standard Detail Drawing L-6306 under all valves. Specify and provide valve restraints if necessary.
.1.1.2.5 Manufacturer’s name and pressure rating shall be marked on valve body.

.1.1.3 A/E shall specify and design on the plans Thrust Restraints that comply with City of Columbus Section 801.
.1.1.3.1 Concrete for Thrust Restraints: Concrete shall be City of Columbus Class C.
.1.1.3.2 University Utilities requires that restrained joints (Megalug by EBAA Iron Inc., TR-Flex by US Pipe, Super Lock by Clow Corporation, or Flex-Ring by American Cast Iron Pipe Company) be installed at each fitting along with concrete thrust blocking.

1.1.4 Pipe shall have slip ring joints and fittings shall be Class 250 gray cast iron with mechanical joints.

1.1.5 Indicator Posts
.1.1.5.1 A/E shall coordinate indicator posts with the City of Columbus Fire Department, Fire Marshall, the University Landscape Architect, and City of Columbus Standards. Indicating posts shall be adjustable type and of sufficient length to allow that target windows be 30” above finished grade. Operating nut shall be National Standard Pentagon.
measuring 1-1/2" from point to opposite flat, 1-1/4" square, with locking type operating wrench and shall turn counter-clockwise to open, Mueller No. A-20804 or as approved.

- Assembly to be tapped for, and provided with, supervisory switch.

1.1.6 Fire Hydrant

1.1.6.1 Fire Hydrant shall be Clow-Eddy model F-2641 or equivalent with break flange/compression type (AWWA C502-80) with 7/8 inch tapered to 1 inch operating nut (turning clockwise to open and counter-clockwise to close), rising center stem, safety coupling, compression type valve, 4-1/2-inch minimum valve opening, factory sealed drain opening, and a 4-inch pumper nozzle. Nozzle thread and finish shall comply with City of Columbus Fire Departments’ standard. Hydrant shall be designed for 150 pounds working pressure and tested to 200 pounds hydrostatic pressure. Hydrants inlet connection shall be 6 inch mechanical joint type.

1.1.6.2 Auxiliary shut off valves shall be Clow #F-5065 or equivalent with mechanical joints, cast iron body, bronze wedges, non-rising bronze stem and O-ring packing. Valve boxes shall be Clow #F-2450 cast iron three piece screw extension type with labeled lid as required by local code.

1.1.6.3 Piping shall be Clow or equivalent mechanical joint ductile iron (AWWA C106) 250 pounds working pressure with cement-lining, Class 52 thickness bitumastic enamel coating, and rubber ring gasket.

1.1.6.4 University fire hydrants and valve box lids are to be painted RED with the hydrant caps painted GRAY, similar to existing University hydrants.

1.1.6.5 Specify that all of the fire hydrant backing shall be concrete. No wood backings allowed. A/E shall update and modify details on drawings to reflect the concrete blocking.

1.1.7 Tapping Sleeves

1.1.7.1 Specify that tapping sleeves shall comply with City of Columbus Section 803. OSU Utilities prefers JCM fabricated steel tapping sleeves or an approved equal.

1.1.7.2 Specify that hot taps have to be submitted and approved by the A/E and OSU Utilities prior to hot tap being permitted.

1.1.7.3 Specify prior to hot tapping that contractor shall expose the proposed hot tap location and confirm existing pipe material if not already known. Specify that hot taps are only permitted on existing or new ductile iron piping. Old existing cast iron water piping on campus will not be allowed to be hot tapped by OSU Utilities.
.1.7.4 The A/E shall design tapping sleeves for the use on the class of pipe the Contractor plans to tap.

.1.2 WATER SERVICE TAPS 2-INCH AND SMALLER
1.2.1 Material: 2 inch and smaller, use Type K, soft temper copper tubing conforming in all respects to ASTM B 88 or Federal Specification WW-T-799 for all pipe from the water main connection to the control valve, unless specifically called for differently on the plans. Use fittings of high quality copper brass with approved compression type joints. Do not use fittings between the water main connection and the control valve, unless otherwise approved by OSU Utilities.

.1.3 VALVE BOXES
1.3.1 Specify cast iron per ASTM A 48 Class 30B screw type valve boxes with enlarged base and the necessary extensions based on depth of the water line.
1.3.2 Specify that each box lid shall have the word “WATER” cast neatly and legibly on it and held securely in place by a bronze or brass bolt.

.1.4 DISINFECTION CHEMICALS
1.4.1 Chemicals: AWWA B300, Hypochlorite, AWWA B301, Liquid Chlorine

PART 3 - EXECUTION

.1 PREPARATION
1.1 Remove scale and dirt on inside and outside before assembly.
1.2 Prepare pipe connections to equipment with flanges or unions.
1.3 Cut pipe ends square, ream pipe and tube ends to full pipe diameter, remove burrs.

.2 BEDDING
2.1 Hand trim excavation for accurate placement of pipe to elevations indicated.
2.2 Excavate pipe trench per Item 801 of the Columbus Construction and Material Specifications.
2.3 Place bedding material at trench bottom, level fill materials in one (1) continuous layer not exceeding six (6") inches compacted depth; compacted to 95% of the Standard Proctor maximum dry density.
2.4 Form and place concrete for pipe thrust restraints at every change of pipe direction. Place concrete to permit full access to pipe and pipe accessories.
2.5 Backfill around sides and to top of pipe with cover fill, tamp in place and compact to 95% of the Standard Proctor maximum dry density. Maintain optimum moisture content of bedding material to attain required compaction density.
2.6 Specify installation of non-detectable utility marking tape. Marking tape shall be blue in color for water and associated lines.

.3 INSTALLATION
.3.1 Water supply piping shall not be designed within campus tunnels.
.3.2 Design casing pipes for 6” or larger water supply piping crossings under tunnels or culverts.
.3.3 Pipe shall be routed in straight lines.
.3.4 Design water pipe and position drains at low points.
.3.5 Specify that the Contractor shall install ductile iron piping and fittings per AWWA C600.
.3.6 Design separation of water main from sewer piping 10’ horizontally and 18” vertically. Water main should be placed above the sewer line preferably or a 20’-long protective casing should be specified.
.3.7 Specify that the Contractor shall install pipe to allow for expansion and contraction without stressing pipe or joints.
.3.8 A/E shall establish elevations of buried piping to ensure not less than 48-inches of cover. Field inspections by the A/E and Construction Manager (if applicable) shall confirm 48-inches of cover.
.3.9 Design and specify that the Contractor shall form and place concrete for thrust restraints at each elbow or change of direction of pipe main.
.3.10 Specify that the valve box shall be centered and plumb over valve.
.3.11 Specify that the valve box cover is flush with finished grade. OSU will not accept valve box covers that are not flush with finished grade.
.3.12 All valve boxes shall be extended to final grade or pavement.
.3.13 Valve boxes shall be furnished on all valves of water service piping.
.3.14 Specify and provide a detail on the drawings that a three- (3”) inch galvanized steel pipe shall be installed in each valve box to prevent misalignment.

.4 OPERATION
.4.1 Specify that University personnel only will operate valves that affect the flow of water through water lines in service, or any valves installed against a University main. The University will not guarantee water-tight valve shutoffs. Coordinate all valve shutoffs with University personnel.

.5 HYDROSTATIC TESTS
.5.1 A hydrostatic test as required in Section 4 of the Standard AWWA Specification C600 shall be applied to the whole or in individual valved-off sections of the main and fire hydrant leads either before or after trench is backfilled. The pressure during the test shall be maintained at 150 PSI. The duration of each pressure test shall be at least one hour.

University Utilities shall witness and approve all hydrostatic pressure tests. Contractor shall provide materials and test certificate according to requirements of NFPA 13. University contact for hydrostatic tests is Utilities Manager of Support Services (phone: 614-292-6383). Specify that the project’s contractor or Construction Manager shall contact OSU’s Office of Emergency Management and Fire Prevention at 614-247-4911 to schedule a day and time with The State of Ohio Fire Marshall for inspection and witness of underground waterlines and hydrostatic tests. Specify that domestic cold
water lines shall not be buried until OSU Utilities and The State Fire Marshall have approved the installation.

6 FLUSHING AND DISINFECTION
   6.1 Perform operations in accordance with Item 801 of Columbus Construction and Material Specifications.
   6.2 Verify that piping system has been cleaned, inspected, and pressure tested.
   6.3 Perform scheduling and disinfecting activity with start-up, testing, adjusting and balancing, demonstration procedures, including coordination with related systems.
   6.4 Provide and attach required equipment to perform the work of this Section.
   6.5 Introduce treatment into piping system.
   6.6 Maintain disinfectant in system for 24 hours.
   6.7 Flush, circulate, and clean until required cleanliness is achieved; use domestic water.
   6.8 Replace permanent system devices removed for disinfection.

7 WATER SUPPLY OUTAGES
   7.1 Specify that University personnel only will operate valves that affect the flow of water through water lines in service, or any valves installed against a University main. The University will not guarantee water tight valve shutoffs. Specify that the Contractor or Construction Manager must notify The Ohio State University, Facilities Operations and Development, 14 calendar days prior to any utility service outages. Representatives of The Ohio State University must be present at such outages. Failure to notify University Utilities in a timely manner will result in a denial of the requested utility outage. Utilities will work with the Contractor(s) to schedule the utility outage and installation; and University Utilities reserves the right to schedule the best time that fits within the requirement of the Campus at large and the local customers affected. For waterline work, University Utilities contact is Utilities Manager of Support Services, (phone: 614-292-6383).

33 12 33. WATER UTILITY METERING
   1 DOMESTIC WATER SUPPLY METERS
      1.1 Temporary services shall be metered. Refer to Division One, 01 51 00.2 for metering requirements.
      1.2 Water supply to buildings shall be metered for new buildings and major additions and renovations. (Part Four, FS-2.4)
      1.3 Meters shall conform to the requirements and policies of the City of Columbus, Department of Public Utilities, and the AWWA as referenced. Meters shall read in cubic feet consistent with the City of Columbus requirements or as required by the authority having jurisdiction.
      1.4 Remote registers shall be provided when the meter location prevents direct reading of the meter register from a standing position on grade or finished floor. Remote registers shall be installed at 4’ to 5’ above grade or finished floor. Remote registers shall be compatible with the installed meter, shall be
from the same manufacturer, and shall have a straight reading odometer type display.

.1.5  Meter shall provide one set of dry contacts that give a pulse output for every 10 cubic feet of usage recorded by the meter.

.1.6  No battery powered registers, including remote registers, are permitted.

.1.7  Easy access shall be provided to meters for maintenance, repairs, and meters shall be flanged and valved to permit convenient replacement of metering.

.2  SEWER AUXILIARY METERS

.2.1  Complete metering of cooling tower make-up water, cooling tower system blow-down, cooling tower chemical treatment systems, irrigation systems, water cooled devices discharging directly to a storm sewer and any process that qualifies for deduct credit is required.

.2.2  Sewer Auxiliary Meters shall read in cubic feet and conform to requirements of and meet final inspection and approval by the City of Columbus Department of Public Utilities Division of Sewerage and Drainage or as required by the authority having jurisdiction.

.2.3  Yokes shall be used in the metering system whenever possible.

.2.4  Remote registers shall be provided when the meter location prevents direct reading of the meter register from a standing position on grade or finished floor. Remote registers shall be installed at 4’ to 5’ above grade or finished floor. Remote registers shall be compatible with the installed meter, shall be from the same manufacturer, and shall have a straight reading odometer type display.

.2.5  No battery powered registers, including remote registers, are permitted.

.2.6  Easy access shall be provided to meters for maintenance, repairs, and meters shall be flanged and valved to permit convenient replacement of metering.

33 32 25  DRAINAGE SYSTEMS

PART 1 – GENERAL

.1  RELATED DOCUMENTS

.1.1  Drawings and general provisions of Contract, including General Conditions and Supplemental General Conditions, apply to this Section.

.2  DESCRIPTION

.2.1  Gravity and pumped storm water and sanitary discharge from Utility tunnels and trenches including piping, equipment, and all necessary accessories as designated in this section.

.3  REFERENCED CODES, STANDARDS AND APPLICABLE PUBLICATIONS

.3.1  General: The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

.3.1.1  Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS)
.4 SUBMITTALS
.4.1 Product Data: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:
   .4.1.1 Manufacturer's technical product data, installation instructions, and dimensioned drawings for each type of pipe and pipe fitting.
   .4.1.2 Piping schedule showing manufacturer, ASTM number, ASTM type, ASTM grade, pipe or tube weight, fitting type, and joint type for each piping system.
   .4.1.3 The piping and accessories submittal shall clearly describe what components are going to be used for each piping group.
   .4.1.4 Records and reports required for certain pipe groups as specified in individual piping group specifications.
   .4.1.5 Provide ISO 9001 and Independent Test Reports if applicable per Quality Assurance paragraph below.
   .4.1.6 “Fire Watch” safety procedures.

.4.2 Maintenance Data: In accordance with submit the following: Section 01 78 00 – CLOSEOUT SUBMITTALS
   .4.2.1 Maintenance data and parts lists for each type of mechanical fitting.

.4.3 Quality Control Submittals: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:
   .4.3.1 Manufacturer's Data: Copy of mill certificates, laboratory test and manufacturing reports relating to chemical and physical properties of pipe, fittings, and related materials.
   .4.3.2 Independent Testing Agency Qualifications: As specified in this Section.
   .4.3.3 ISO 9001 and Independent Test Reports: As specified in Quality Assurance below.

PART 2 – PRODUCTS
.1 PIPE, FITTINGS, AND JOINTS
   .1.1 General: Items are referred to by type and shall conform to the latest editions of standards listed below:
   .1.2 Pipe Materials:
      Type                     Designation
      Copper water tube, Type K (heavy wall), Soft, ASTM B88    A
   .1.3 Fitting Materials:
      Type                     Designation
      Wrought copper and bronze drainage fittings, ANSI A16.29   I
.1.4 Joint Materials:

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<th>Type</th>
<th>Designation</th>
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<tr>
<td>Soldered</td>
<td>ASTM B32 tin-antimony 95-5</td>
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.1.5 Piping Assembly: Pipe, fittings, and joints shall be provided for each system based on the table below:

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<tr>
<th>Service Pipe</th>
<th>Fittings</th>
<th>Joints</th>
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<tr>
<td>.1.5.1 Pumped (forced), designated as “PSAN” On Contract Drawings</td>
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<td>.1.5.1.1 Underground</td>
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<td>.1.5.1.2 Trenches and Manholes</td>
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.2 VALVES (SUMP PUMP DISCHARGES AND BEYOND)

.2.1 Shut-Off:

2.1.1 3 inches and Smaller: Single-piece, full port ball valve with replaceable internal parts. Valve shall have swing out design, bronze body, stainless steel, ball and stem (ASTM A276 Type 316), reinforced TFE Seats. Provide blow out proof stem and extended stem for insulation thickness. Body bolts and nuts shall be zinc dichromate plated steel. Valve shall be rated for 150 psig saturated steam service. Valve shall be soldered to suit piping system which it is installed.

.2.2 Check:

2.2.1 3 inches and Smaller: Bronze body and bonnet, ASTM B61, or B62. 125 PSI, solder connections. Must be non-slam style. All check valves shall be lift or ball check style and installed in a vertical pipe run.

.2.3 Throttling:

2.3.1 3 inches and Smaller: Globe style body with dial indicator handle for position setting shall be lockable in position. Valve will be used to add pressure drop for sump pump discharge to prevent pump curve run-out. Valve shall have bronze body and bonnet, ASTM B61 or B62, Class 125 with solder connections.

.3 MISCELLANEOUS

.3.1 Pipe Sleeves:

3.1.1 Sleeves in masonry and concrete walls, floors, roofs in accordance with ASTM A53, Schedule 40 or Standard Weight, hot-dip galvanized steel pipe sleeves.

3.1.2 Provide where piping passes entirely through walls, roofs, and floors. Secure sleeves in position and location during construction.
3.2 Pipe Hangers and Supports: Provide MSS SP-58 and MSS SP-69, Type 1 with adjustable type steel support rods, except as specified or indicated otherwise. Attach to Steel W or S beams with Type 21, 28, 29, or clamps. Attach to steel angles and vertical web steel channels with Type 20 clamp with beam clamp channel adapter. Attach to horizontal web steel channel with drilled hole on gauge line and double nut and washer. Attach to concrete with Type 18 insert or drilled expansion anchor.

3.3 Flanges: Flanges shall be Class 150, Solder connection in accordance with ANSI B 16.24 and flat faced. Material shall conform to ASTM B 62.

3.4 Bolting Materials: Bolting shall consist of a bolt head which requires one nut on the opposite side on the threaded end in accordance with ANSI B 1.1, Class 2A. Material shall conform to ASTM A 193, Grade B7. Nuts shall be heat-treated, heavy, hexagonal nuts, semi-finished, and in accordance with ANSI B 18.2.2 and B1.1, Class 2B. Material shall conform to ASTM A 194, Grade 2H.

3.5 Gaskets: Gaskets shall be spirally wound, Type 304 Stainless Steel with non-asbestos filler material and carbon steel outer ring. Gasket shall be 1/16-inch thick and conform to the flange face on which they are used. Acceptable products from acceptable manufacturers include: Flexitallic Style CGI with Flexicarb Filler and 316L winding, manufactured by Flexitallic Inc., or approved equal.

4 DRAINAGE SUMP PUMPS

4.1 Refer to Section 33 32 30 – DRAINAGE PUMPS

PART 3 – EXECUTION

1 INSTALLATION

1.1 General:

1.1.1 Install piping from tunnel or trench drain to manhole sump to (but not including) piping in trench (stainless steel) as shown on P Series and Civil drawings. Pump discharge pipe shall penetrate the utility structure with a watertight pipe sleeve and seal and extend to approximately 3'-0" below grade and then pitch down at a minimum slope of 2% to the sewer system.

1.1.2 Pipe shall be round and straight. Cutting shall be done with proper tools.

1.1.3 All pipe runs shall be laid out to avoid interference with other work.

1.1.4 Installation of piping system, materials and workmanship shall be in accordance with the applicable Plumbing Code.

1.2 Pipe Supports

1.2.1 Maximum spacing between supports:
1.2.2 Vertical Piping: Support piping at 5 foot intervals.
1.2.3 Horizontal Piping: Support piping at 10 foot intervals and support piping at each change of direction.

.2 TESTS
.2.1 General: Test system either in its entirety or in sections.
.2.2 Sump Pump Piping:
   2.2.1 Water Pressure Test: If entire system is tested, tightly close all openings in pipes except highest opening, and fill system with water to point of overflow. If system is tested in sections, tightly plug each opening of section under test, fill each section with water and test with at least 50 PSIG of water. Keep water in system, or in portion under test, for at least 15 minutes before inspection starts. System shall then be tight at all joints.
   2.2.2 Correct defects and repeat tests until work is in compliance with contract requirements. Furnish water, electricity, instruments, connecting devices, and personnel for performing tests.

33 32 30 DRAINAGE PUMPS

PART 1 – GENERAL
.1 RELATED DOCUMENTS
   .1.1 Drawings and general provisions of the Contract, including General Conditions and Supplemental General Conditions, and other Division 01 Specification Sections, apply to this Section.
   .1.2 Refer to Division 48 Section “Low Voltage Electrical Power Conductors and Cables” for wiring requirements.

.2 SUMMARY
   .2.1 This Section specifies submersible drainage pumps including sump pumps.

.3 SUBMITTALS
   .3.1 General: Submit the following:
      .3.1.1 Product data including certified performance curves, weights (shipping), furnished specialties, and accessories, plus installation and start-up instructions
      .3.1.2 Shop drawings showing layout of sump pit and connections for submersible drainage pump
      .3.1.3 Auxiliary high level float switch
      .3.1.4 Wiring diagrams detailing wiring for power, signal, and control systems; differentiating between manufacturer-installed wiring and field-installed wiring
      .3.1.5 Maintenance data for pumps and switches, for inclusion in Operating and Maintenance Manuals

.4 QUALITY ASSURANCE
.4.1 Hydraulic Institute Compliance: Design, manufacture, and install submersible drainage pump in accordance with “Hydraulic Institute Standards.”

.4.2 National Electrical Code Compliance: Components shall comply with NFPA 70 “National Electrical Code.”

.4.3 UL Compliance: Submersible drainage pump shall be listed and labeled by UL and comply UL Standard 778 “Motor Operated Water Pumps.”

.4.4 NEMA Compliance: Electric motor and components shall be listed and labeled NEMA.

.4.5 SSPMA Compliance: Test and rate submersible drainage pump in accordance with the Sump and Sewage Pump Manufacturers Association (SSPMA) Standards.

.4.6 Design Criteria:

.4.6.1 The Drawings indicate size, profile, connections, and dimensional requirements of sump pumps and are based on the specific manufacturer type and model indicated. Pumps having equal performance characteristics by other manufacturers may be considered, provided that deviations in dimensions and profiles do not change the design concept or intended performance as judged by the A/E. The burden of proof for equality of the pumps is on the Contractor.

.4.6.2 The design of drainage pumps and sump level alarm systems in utility tunnels will consider the risk of flooding due to pump failure or excessive hydraulic loads caused by flooding or pipeline failure.

.5 DELIVERY, STORAGE, AND HANDLING

.5.1 Store pump in a dry location.

.5.2 Retain shipping protective covers and protective coatings during storage.

.5.3 Protect pump internals against damage from sand, grit, and other foreign matter.

.5.4 Comply with manufacturer’s rigging instructions for handling

PART 2 – PRODUCTS

.1 MANUFACTURERS

.1.1 Products: Subject to compliance with requirements, provide one of the following:

.1.1.1 High Temperature Submersible Sump Pumps:

- Weil
- Federal
- Crane Barnes
- Goulds
- Zoeller

.2 SUBMERSIBLE DRAINAGE PUMPS – DUPLEX SYSTEM

.2.1 General Description: Pumps shall be vertical, centrifugal, end suction, single stage, complete with integral inlet strainer and float switch controls. The pump shall be rated to handle liquids in continuous duty up to 200°F. The pump shall have 1/2-inch solids handling capability.
.2.2 Casing: Stainless steel with integral stainless steel inlet strainer and stainless steel or Ryton legs to elevate the pump to permit flow into the impeller. Discharge female threaded connection shall be arranged for vertical discharge and suitable for plain-end pipe connection. Provide stainless steel lifting ring, screws, and bolts.

.2.3 Impeller: Statically and dynamically balanced, open or semi-open, overhung, single suction, vortex style, fabricated from Nylon or stainless steel, keyed to shaft and secured by a locking capscrew. Volute to be stainless steel.

.2.4 Pump and Motor Shaft: Cold rolled steel. Upper and lower bearings shall be INPRO bearing isolators. More information can be found at: http://www.inpro-seal.com/

.2.5 Seals: Mechanical seals. Stainless steel spring, Viton parts, carbon and Ni-Resist faces.

.2.6 Submersible Motor: 460V, 3-phase, 60 hertz, as scheduled, oil filled for rapid heat dissipation, with 15-foot, 3-conductor SOOW Type cord with bare lead ends. Motor shall be high temperature, rated for submerged in 212°F water.

.2.7 Basin: Concrete construction under Division 3, Section 03 30 00.

.2.8 Duplex Sump Pump Control Panel: A dedicated control panel in a wall mountable NEMA 4X stainless steel enclosure with a lockable disconnect is required. The Duplex Pump control panel shall utilize a four float system. Floats to initiate pump stop, lead pump start, lag pump start, and high water alarm. “Lead” and “lag” pumps will alternate. Duplex control panel shall include two motor starters with separate overload relays, two red pump run lights one for each pump, two pump motor overload amber indication lights one for each pump, two reseatable pump run time hour meters one for each pump, two hand-off-auto switches one for each pump, one dedicated and separately fused control circuit transformer, one high water alarm with test mode and isolated output contact, one high water alarm amber indication light, one lag pump alarm with test mode and isolated output contact, and one amber lag pump alarm amber indication light. Duplex Pump panel high water and lag pump alarm contacts to be utilized as determined by the design and flood risk assessment. Duplex Pump panel high and lag pump alarm annunciation can be through Building Automation System, campus security system or Utility central control system.

.2.9 Sump Disconnect Panel and Starters: Specified in Division 48. Disconnect panels shall be located in sump manhole. Starters shall be installed in remote building per Electrical Drawings.

.2.10 Float Switches:

.2.10.1 Provide 4 floats on one stand mounted to bottom of sump manhole. Floats shall have adjustable settings. Floats shall be rated for 90°C (194°F) service. Anchor Scientific manufactures the “Roto float-SST, Type P” float switch that has the highest temperature rating believed to be commercially available. High level float switch shall be normally closed.

.2.10.2 Sump float switches shall be mounted from top to bottom in the following order:
.2.10.2.1 Lag Pump On
.2.10.2.2 High Level Alarm
.2.10.2.3 Lead Pump On
.2.10.2.4 Lag and Lead Pump Off
.2.10.3 Pump sequence of operation shall be as follows:
.2.10.3.1 Sump empty: Pumps off.
.2.10.3.2 Sump level rises to lead pump float switch: Start lead pump.
.2.10.3.3 Sump level rises to a high level alarm float switch: Activate remote alarm.
.2.10.3.4 Sump level rises to lag pump float switch: Start lag pump.
.2.10.3.5 Shut off pumps when level falls below low level float switch.
.2.10.3.6 The design intent of the alarm is such that an intermittent high level alarm will indicate a lead pump failure and a continuous high level alarm will indicate both lead and lag pump failures.

.2.11 Install a non-slam lift or ball check valve and gate valve on the discharge side of pump.

PART 3 – EXECUTION
.1 EXAMINATION
.1.1 Examine areas, concrete sump and conditions for compliance with requirements for installation and other conditions affecting performance of submersible drainage pump. Do not proceed with installation until unsatisfactory conditions have been corrected.
.1.2 Examine rough-in for drainage piping system to verify actual locations of piping connections prior to installation.

.2 INSTALLATION
.2.1 General: Comply with the manufacturer’s written installation and alignment instructions.
.2.2 Install pump in location and arrange to provide access for periodic maintenance, including removal of entire pump assembly from pit; allow for maintenance, repair and replacement of motors, impellers, couplings, and accessories.
.2.3 Support pump and piping separately so that the weight of the piping system does not rest on the pump.
.2.4 Basin/sump pit: Install submersible drainage pump in indicated location and connect to drainage discharge line. Refer to Division 3 for concrete work.

.3 CONNECTIONS
.3.1 General: Install valves that are same size as the piping connecting the pump.
.3.2 Install discharge pipe size equal to or greater than the diameter of the pump nozzle.
.3.3 Install a non-slam lift or ball check valve and gate valve on the discharge side of pump.
.3.4 Electrical wiring and connections are specified in Electrical Sections.

.4 COMMISSIONING
.4.1 Final checks Before Start-Up: Perform the following preventative maintenance operations and checks before start-up:

.4.1.1 Lubricate oil-lubricated bearings.
.4.1.2 Remove grease-lubricated bearing covers and flush the bearings with kerosene and thoroughly clean. Fill with new lubricant in accordance with the manufacturer’s recommendations.
.4.1.3 Check that pump is free to rotate by hand. If the pump is bound or even drags slightly, do not operate the pump until the cause of the trouble is determined and corrected.
.4.1.4 Test the high level switch. Prove alarm operation.
.4.1.5 Test all float switches and their elevations.

33 40 00. STORM DRAINAGE UTILITIES

.1 PREPARATION OF DOCUMENTS: Before preparing final documents, consult the University Architect. On some projects, it might be desirable to make this work a part of the Plumbing Contract.

.2 MATERIALS: The City of Columbus Specifications and Standard Construction Drawings shall apply for work within Franklin County. Work outside Franklin County shall use local codes or ODOT, whatever is stricter.

.2.1 PIPING
FOR PIPE 12” and larger:
- Reinforced Concrete pipe
- Corrugated Polyethylene Pipe and fittings – smooth interior – type S
- Ribbed Poly Vinyl Chloride (PVC) – smooth interior – Uni-bell

FOR PIPING less than 12”:
- Service weight cast iron
- Poly Vinyl Chloride (PVC) – smooth interior – Type PSM
- Ribbed Poly Vinyl Chloride (PVC) – smooth interior – Uni-bell
- Corrugated Polyethylene Pipe and fittings – smooth interior – type S

.2.2 CATCH BASINS, CURB INLETS, MANHOLES

.2.2.1 BASIN LID AND FRAME: Cast iron construction, heavy duty, removable lid.

.2.2.2 SHAFT AND TOP SECTION: Reinforced precast concrete, lipped male/female joints; nominal dimensions as shown on plans. Cast-in-place, brick or block side walls may be used in place of precast construction. Brick or concrete block side walls shall be 8 inches nominal thickness. When brick or concrete block is used, the outside walls of the manhole shall be plastered with a 1/2-inch coat of lime cement mortar.
.2.2.3 **BASE PAD:** Cast-in-place concrete of type specified in Section 03 30 00; leveled top surface to receive concrete shaft sections, sleeved to receive storm sewer pipe sections. Precast base sections may be used in lieu of cast-in-place base.

.2.3 **UNDER DRAINS**

.2.3.1 **FILTER AGGREGATE:** ODOT #8/Type H.

.2.3.2 **TUBING:** Polyethylene tubing, ASTM F-405

.2.4 **CLEANOUTS**

.2.4.1 **CLEANOUTS SHALL BE** adjustable, vandal-proof with heavy duty cast iron top for exterior use.

.2.5 **TRENCH DRAINS**

.2.5.1 **LID AND FRAME:** Cast iron construction, heavy duty, minimum 4” wide inside conduit size

.2.5.2 **SURFACE DRAINAGE:** Must have slope no less than 1 percent to insure positive drainage. Drain away from sidewalks and driveways.

.2.5.3 **YARD/AREA DRAINS:** Are not generally permissible. If one is needed, approval is needed from University Engineer.

.2.5.4 **BENDS IN PIPING AND AT MANHOLES:** All piping shall be run straight, structure-to-structure. If a bend is necessary, a cleanout shall be provided. Transitions at manholes shall not be 90 degrees or less.

.2.6 **DRAIN OPENING PROTECTION:** Install removable bars or grills at open ends of culverts, drains and pipes 10-inch diameter and larger to prevent access by children or animals.

.2.7 **MANHOLES AND CATCH BASINS:**

.2.7.1 Refer to City of Columbus standard drawings for manhole and catch basin standard materials and installation requirements within Franklin County and the State of Ohio Department of Transportation standard drawings for work outside Franklin County.

.2.7.2 Refer to City of Columbus and the Ohio Department of Transportation construction and materials specifications for minimum requirements.

.2.8 **STORM WATER MANAGEMENT FACILITIES:**

.2.8.1 Proprietary materials used in storm water best management practices (BMPs) need approved by University Engineer.
DIVISION 33 – UTILITIES

.1.3 American Gas Association, AGA
.1.4 Code of Federal Regulation (CFR) Title 49 Part 192 – Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards
.1.5 ASTM D2513 – Polyethylene (PE) Gas Pressure Pipe, Tubing and Fittings
.1.6 ASTM F2620 – Standard Practice for Heat Fusion Joining of PE Pipe and Fittings
.1.7 ASTM D3350 – Standard Specification for PE Plastics Pipe and Fittings Materials
.1.8 All other applicable Federal, State of Ohio, ANSI, ASTM, ASME standards
.1.9 Ohio Administrative Code 4901:1 Utilities
.1.10 Columbia Gas of Ohio – Materials for Customer Service Lines

.2 QUALIFICATIONS
.2.1 The Ohio State University Utilities Division requires all natural gas line installers provide written and performance verification of Department of Transportation (DOT) Operator Qualifications for all individuals performing covered tasks on Columbus Campus natural gas pipelines. Being “qualified” means that a Third Party Qualifier has evaluated and verified the contractor’s ability to perform the various covered tasks. Natural gas line work will not be allowed to commence until all individuals qualifications are submitted for review and approval.
.2.2 Experience: Specify that the Contractor shall provide examples and demonstrate previous relevant experience for all covered tasks and gas pipeline construction work included in the contract documents.

.3 SUBMITTALS
.3.1 Contractor shall submit a list of materials to be furnished, the names of the suppliers, and the appropriate shop drawings for all PE pipe, fittings, and valves as required in the Project Specifications. Pipe dimension ratio (DR) computation, minimum bend radius, and other physical properties shall be included with the submittal.
.3.2 A/E shall specify that the Contractor shall submit shop drawings showing installation method and the proposed method and specialized equipment to be used, including but not limited to manufacturer’s recommended fusing procedures for the products.
.3.3 A/E shall specify that Contractors shall submit DOT Operator qualifications and resumes for all personnel performing installation, excavation, backfilling, fusing, welding, and supervising of PE pipe for each covered task. This includes, but is not limited to written, verifiable proof that the Contractor is certified by the fusion systems manufacturer(s) as a fully-trained user. Contractor shall comply with qualifications as stated above and submit required qualification data.
.3.4 Specify that the Contractor shall submit steel pipe welder information.
.3.4.1 Welder Qualification Data: Copies of certification; include names, home addresses and identification numbers of welders.
.3.4.2 Welding Procedures: Shall include QW-482 "Suggested Format for Welding Procedure Specification (WPS)" and QW-483 "Suggested Format for Procedure Qualification Record (PQR)" for different weld types.

.3.4.3 Welders' Certificates: Shall include QW-484 "Suggested Format for Manufacturer's Record of Welder or Welding Operator Qualification Tests (WPQ)" for all welders for all weld types.

.3.5 Incomplete, insufficient, or out of date DOT Operator qualifications are not acceptable.

.3.6 OSU Utilities does not provide qualification services for natural gas line installers. The contractor shall obtain all DOT Operator qualifications necessary to perform the work.

.3.7 A/E shall specify that the Contractor shall submit fusion map showing placement of all proposed joints. Joints shall be numbered individually.

.3.8 A/E shall provide PE-to-Steel transition fitting details on the Contract Drawings, and specify at minimum, that the Contractor shall include the fabricator's name, qualification, and quality compliance verification. It shall also include detailed dimension of the fitting, material used, fabrication process, test method, and any special field handling requirements.

.4 DESIGN AND INSPECTIONS

.4.1 Specify that each length of pipe and each other component must be visually inspected at the site of installation to ensure that it has not sustained any visually determinable damage that could impairs its serviceability.

.4.2 All natural gas pipeline work shall be inspected by the University and the A/E to ensure that it is constructed in accordance with Code. The University has the authority to halt construction if specifications and standard construction practices are not being followed. Whenever any portion of these specifications is violated, the University may order further construction to cease until all deficiencies are corrected.

.4.3 The Public Utilities Commission of Ohio (PUCO), has identified OSU Utilities as the Operator of the Columbus Campus Master Meter Gas Pipeline Systems. OSU Utilities is also the Authority Having Jurisdiction (AHJ) for Columbus Campus natural gas pipelines. OSU Utilities will comply with Federal and State regulations to provide a safe, reliable natural gas system. As the Operator of the system on Columbus campus, OSU Utilities is accountable for all aspects of the installation, maintenance, and operation of the system. Natural gas system contractors must adhere to all Federal and State laws and regulations, and OSU Utilities policies and procedures, or be disqualified from construction or servicing work on gas pipeline systems.

.5 WARRANTY AND ACCEPTANCE

.5.1 Specify that all work shall be warranted free from defects in workmanship and materials for a period of one year from the date of completion of all construction.
PART 2 - PRODUCTS

1 MEDIUM DENSITY POLYETHYLENE PIPE (YELLOW) AND FITTINGS

1.1 Specify medium density polyethylene pipe (yellow) for natural gas piping on OSU’s Columbus Campus whose operating pressure will be below 25 psig.

1.2 Provide polyethylene pressure pipe and fittings manufactured from PE2406/PE2706 medium density polyethylene meeting ASTM D2513 standards. Resin shall meet the requirements of ASTM D 3350.

1.3 Pipe shall be legibly marked, at intervals of no more than 5 feet. 40’ long sections shall be used for the pipe that is installed by horizontal directional drill method.

1.4 Where medium density PE pipe is joined to medium density PE pipe, it shall be by thermal butt fusion. Fusion shall be accomplished in accordance with the pipe manufacturer and fusion equipment supplier specifications.

1.5 Fittings and Custom Fabrications: Shall comply with ASTM D2513 or ASTM D2683. Fittings and custom fabrications shall be provided of the same resin as the adjacent pipe. Butt fusion outlets shall be made to the same outside diameter, wall thickness, and tolerances as the mating pipe.

2 HIGH DENSITY POLYETHYLENE PIPE (BLACK) AND FITTINGS

2.1 Specify high density polyethylene pipe (black) for natural gas piping on OSU’s Columbus Campus whose operating pressure will be between 50 psig - 100 psig.

2.2 Provide polyethylene pressure pipe and fittings manufactured from PE4710 high density polyethylene meeting ASTM D2513 standards. Resin shall meet the requirements of ASTM D 3350.

2.3 Pipe shall be legibly marked, at intervals of no more than 5 feet. 40’ long sections shall be used for the pipe that is installed by horizontal directional drill method.

2.4 Where High Density Polyethylene (HDPE) pipe is joined to HDPE pipe, it shall be by thermal butt fusion. Fusion shall be accomplished in accordance with the pipe manufacturer and fusion equipment supplier specifications.

2.5 Fittings and Custom Fabrications: Fittings and custom fabrications shall be provided of the same resin as the adjacent pipe. Butt fusion outlets shall be made to the same outside diameter, wall thickness, and tolerances as the mating pipe.

2.6 Fabricated Fittings: Fabricated fittings shall be made by heat fusion joining specially machined shapes cut from pipe in accordance with ASTM F2206. Directional fittings 12” and larger, such as elbows, tees, etc., shall have a plain-end inlet for butt fusion and plain-end directional outlets.

3 STEEL PIPE AND FITTINGS

3.1 Specify all pipes through 12-inches shall be seamless carbon steel conforming to ASTM A53 Grade B Type S or ASTM A 106 Grade B Type S. Pipe shall have a wall thickness of schedule 40. Specify that shop or factory applied epoxy coating shall be provided.
.3.2 Specify that epoxy coating shall be a 100% solid, thermosetting, fusion-bonded, dry powder epoxy resin. Color shall be per Part 3-Execution; Section .6-PAINTING.

.3.3 Specify that shop or field applied epoxy coating for repairs and patching shall be a two-component, 80% solid, and liquid epoxy resin. Color shall be per Part 3-Execution; Section .6-PAINTING.

.3.4 All threaded pipe nipples shall be Schedule “XSTG” conforming to ASTM A 106, Grade B.

.3.5 Joints 2-inches and smaller shall be socket welded.

.3.6 Joints larger than 2-inches shall be butt welded.

.3.7 All sizes shall be flanged where required to connect to flanged valves, fittings, or equipment.

.3.8 Flanges shall be Class 150 welding neck type in accordance with ANSI B16.5 and flat faced, except they shall be Class 300 and raised face to match existing. Material shall conform to ASTM A 105. Welding neck flanges shall be bored to match the same ID as the attached pipe.

.3.9 Fittings 2 inches and smaller shall be 3000 pound socket-weld in accordance with ANSI B16.11. Material shall conform to ASTM A 105.

.3.10 Fittings 2-1/2 inches and larger shall be seamless forged steel, butt-welding type in accordance with ANSI B16.9 and with the same wall thickness as the attached pipe. Material shall conform to ASTM A 234, Grade WPB.

.3.11 Bolting shall consist of a bolt head which requires on nut on the opposite side on the threaded end in accordance with ANSI B1.1, Class 2A. Material shall conform to ASTM A 105. Nuts shall be heat-treated, heavy, hexagonal nuts, semi-finished and in accordance with ANSI B18.2.2 and B1.1, Class 2B. Material shall conform to ASTM A 194, Grade 2H. Bolt isolators shall be provided where necessary.

.3.12 Unions 2 inches and smaller shall be 3000 pound forged steel socket weld with steel to steel seats. Material shall conform to ASTM A 105.

.3.13 Unions 2-1/2 inches and larger shall be made with flanges.

.4 Transition Fittings: Specify manufactured pipe fitting with one PE pipe end for thermal butt fusion connection to PE pipe and with one ASTM A53, Schedule 40 steel pipe end for welded connection to the steel pipe.

.5 Service-Line Risers: Specify manufactured PE pipe fitting with PE pipe inlet for thermal butt-fusion connection to underground PE pipe; PE pipe riser section with protective-coated, anode less, steel casing and threaded connection to above ground steel piping.

.6 VALVES

.6.1 Each valve shall meet the minimum requirements of API 6D. A valve may not be specified under operating conditions that exceed the applicable pressure-temperature ratings contained in those requirements.

.6.2 Each valve shall comply with the following:

.6.2.1 The valve must have a maximum service pressure rating for temperatures that equal or exceed the maximum service temperature.
.6.2.2 The valve shell must be tested in the fully open position with no leakage.
.6.2.3 The valve seat shall be pressure tested.
.6.2.4 Each valve shall be able to meet the anticipated operating conditions.

.6.3 Valve Boxes:
.6.3.1 Specify cast-iron lid and top rim, plastic slide adjustment shaft, cover stamped with “GAS” lettering, bottom section with base to fit over valve and barrel a minimum of 5-inches in diameter, and adjustable extensions of length required for bury depth.
.6.3.2 Suggested Manufacturer is Bingham and Taylor, series 500 Plastic Valve Boxes.

.7 PRESSURE REGULATORS
.7.1 Specify self-operated diaphragm-type natural gas regulators. Consult with OSU Utilities for the natural gas distribution system pressure provided in the area of service.
.7.2 Specify that each pressure regulator relief vent shall be:
   .7.2.1 Rain and insect free
   .7.2.2 Located at a place where gas from the vent can escape freely to the outside atmosphere to a safe location away from openings into the building.
   .7.2.3 Elevated to prevent submergence in areas where floods may occur.
   .7.2.4 Protected from damage.
   .7.2.5 Short as practical.
   .7.2.6 If tubing is used for the vent line, the tubing shall be metallic and one size larger than the vent opening.

.8 HOT TAPPING AND PLUGGING
.8.1 When necessary, specify hot tapping and plugging existing natural gas pipeline(s) on The Ohio State University property while continuously maintaining natural gas service to campus facilities.
.8.2 Specify that the hot tap fittings shall be full encirclement, low profile spherical 3-way tee. All plugs and fittings shall be specified and rated for the operating and test pressures.
.8.3 Specify that the contractor shall provide means to pull back the cut coupon out of the pipe and turn the coupon over to the University.

.9 GAS PIPELINE MARKERS
.9.1 When applicable under Federal Safety Standards 192.707, specify that the contractor shall provide and install post markers where called for on the contract drawings. Posts shall be 2-inch diameter white PVC pipe with top cap. Post shall be 5-feet in length, buried in the ground 2-feet and extending above grade by 3-feet. Label on post shall be UV stable, yellow in color with black lettering with letters that are 1-inch high by ¼” stroke that reads as follows:
PART 3 - EXECUTION

.1 INSTALLATION OF PIPE AND FITTINGS

.1.1 Specify that installation of all polyethylene and steel pressure pipes shall be as shown on plans and per Manufacturer’s requirements. Piping shall not be run under buildings or basement floors.

.1.2 High static electric charges can develop on plastic piping products; observe all safety procedures for controlling and discharging static electricity and all requirements for personal protection.

.1.3 Establish elevations of buried main piping to ensure not less than thirty-six (36”) inches of cover.

.1.4 Each main pipe line shall be installed with at least 12 inches of clearance from any other underground structure not associated with the main line. If this clearance cannot be attained, the main line shall be protected from damage.

.1.5 Installation of new main gas pipes in the University’s tunnel system is prohibited.

.1.6 PE mains shall be installed with sufficient clearance or must be insulated from any source of heat so as to prevent the heat from impairing the serviceability of the main pipe.

.1.7 Each buried service line to the facility must be installed with at least 12 inches of cover on the building’s property and at least 18 inches of cover in streets and roads.

.1.8 Where an underground structure (e.g. Duct bank, Tunnel) prevents the installation of a main line or a service line with the minimum cover, the main line or service line in question may be installed with less cover if it is provided with additional protection to withstand anticipated external loads.

.1.9 Wrap valve and valve box with polyethylene tape and heat shrink.

.1.10 Each valve installed in plastic pipe must be designed so as to protect the plastic material against excessive torsional or shearing loads when the valve or shutoff is operated, and from any other secondary stresses that might be exerted through the valve or its enclosure.

.1.11 Center and plumb valve box over valve. Set box cover flush with finished ground surface. Prevent shock or stress from being transmitted through valve box to valve.

.1.12 Each tap made on a pipeline under pressure must be performed by personnel trained and qualified to make hot taps, with demonstrable prior experience.

.1.13 At each branch off of the main pipeline, the A/E shall design for three-valve clusters at the branch location.

.1.14 Provide isolation fittings, cathodic protection, and test stations for each underground steel piping system.

.1.15 Underground buried steel piping shall be protected with anodes and shall be provided with test stations as follows:

Schedule 40 Pipe Magnesium Anode
Pipe Size (inches) | Anode Size (pounds) | Anode Spacing (feet)
--- | --- | ---
2 or smaller | 5 | 100
2-1/2 | 5 | 70
3 | 17 | 180
4 | 17 | 140
6 | 17 | 95
8 | 17 | 75
10 | 32 | 110
12 | 32 | 95

.1.16 Conform to Columbia Gas of Ohio, Inc. standards and specifications for magnesium anodes, anode size, and attachment method. Loop lead wire around the pipe to reduce possible stress on connection.

.1.17 Test Stations for Anode Protected Gas Pipe: Each isolated gas pipe system must have at least 2 test stations. Maximum spacing between test stations is 300 feet. Each test station shall be located in a plastic curb box identical or equal to those used by Columbia Gas of Ohio, Inc. Connections to the pipe shall be the same as required for anodes and shall have two single strand, single conductor, No. 12 copper lead wires extending from the pipe connection to the terminal block at grade in the curb box.

.1.18 Specify that the Contractor shall provide and install insulating flange at the point of service entrance, to electrically isolate interior and exterior piping.

.1.19 Steel gas piping shall not be used as a grounding electrode.

.1.20 Gas piping shall enter the building above grade. Wall shall be sleeved and caulked at entrance.

.1.21 Gas distribution piping standards in this Division 33 shall be applied on all gas pipelines up to the building pressure regulator.

.1.22 Natural gas meter and regulator settings (with or without regulator vents) shall be located a minimum 10’-0” radius away from electrical equipment; 3’-0” away from any window or opening; 2’-0” away from any communications box or water spigot; and 12” away from the corner of a building. The bottom of the gas meter shall have a 6” minimum clearance above finish grade and the bottom of the gas line shut-off shall have an 8”minimum clearance from finish grade.

.1.23 Specify non-detectable 6-inch wide polyethylene marking tape that is yellow in color with black lettering “Buried Gas Line”.

.1.24 Squeeze-off is a technique used to control the flow of gas or liquid in PE pipe by compressing the pipe between two parallel bars until the surfaces make contact. Specify that approval must be granted by the A/E and the University prior to a contractor “squeezing off” new or existing plastic pipeline(s). If approved, Contractors utilizing squeeze-offs must have the correct tools, follow the pipe manufacturer's requirements, be within ASTM standards and address indicated safety concerns. Note that there are also static electricity concerns for gas squeeze-offs. Proper safety and grounding procedures shall be in place during squeeze-off operations.

.2 FUSION JOINING
.2.1 Butt Fusion Joining – Contractor shall make joints between plain end pipes and fittings by butt fusion using only procedures that are recommended by the pipe and fitting Manufacturer and ASTM F2620.

.2.2 Ensure that persons making butt fusion joints are certified according to the standards and have proven experience to make fusion welds following Manufacturer’s recommended procedures.

.2.3 External and internal beads resulting from butt fusion joining shall not be removed.

.2.4 Use caution to protect the exposed butt ends of pipes from exposure to oils, greases, or hydrocarbons. Any pipe exposed to hydrocarbons of any type shall be cut-out and removed prior to butt fusion.

.3 FOUNDATION AND BEDDING

.3.1 Lay pipe on grade and on a stable foundation. Remove unstable or mucky trench bottom soils, and install a 6-inch bedding of sand per City of Columbus Item 703.05 to pipe bottom grade. Deposit sand to a depth of 3 inches above the piping. Compaction rates should be as specified in ASTM D2321. Remove excess groundwater from the trench before laying the foundation or bedding and the pipe. Pipe shall be laid when the conditions of trench are dry. A trench cut in rock or stony soil shall be excavated to 6 inches below pipe bottom grade, and brought back to grade with bedding material noted above. Remove all ledge rock, boulders, and stones larger than 3 inches in any dimension from excavated trench prior to placing sand bedding and pipe.

.4 PIPE HANDLING

.4.1 At all times through delivery, storage, on-site staging and installation, the Contractor shall protect and ensure that the HDPE pipe is not exposed to liquid hydrocarbons. If any portions of the pipe are exposed to hydrocarbons, that section of pipe shall be cut-out and removed from use.

.4.2 The Contractor shall exercise care in pipe handling. Gouges exceeding 10% of pipe wall thickness shall be cause for rejection of the pipe.

.5 TRACER WIRE

.5.1 Tracer wire shall be placed with all plastic pipe and shall be insulated, #12 AWG Reinforced Tracer Wire. Direct burial #12 AWG solid, 21% conductivity annealed copper-clad high carbon steel high strength tracer wire, 380# average tensile break load, 30 mil high molecular weight, high density yellow polyethylene jacket complying with ASTM D-1248, 30-volt rating. The tracer wire shall be connected to valves. The buried sections of tracer wire shall be continuous.

.5.2 All splices or connections shall be made at accessible locations inside vaults. All spliced or repaired wire connections in the tracer wire system shall be made using a Wing Nut Wire Connector (for two to four number ten wires), and made waterproof using an approved buried service wire closure.

.5.3 The tracer wire shall be tested upon completion of the installation to ensure conductivity for locating. If any areas appear to be disconnected or
conductivity appears incomplete, the tracer wire shall be excavated, inspected and replaced.

.5.3.1 Tracer wire may not be wrapped around the pipe and contact with the pipe must be minimized but is not prohibited.

.6 PAINTING

.6.1 Specify that the Contractor shall paint exterior exposed metal service piping, service valves, service regulators, service meters and meter bars, and piping specialties except units with factory-applied paint or protective coating. Yellow epoxy paint shall normally be used. Exterior and exposed natural gas piping on or near campus buildings with high and sensitive visibility shall have the paint color approved by the University Landscape Architect and OSU Utilities. See also Part 2-Products; Section .3 STEEL PIPE AND FITTINGS.

.6.2 Specify that the Contractor shall paint buried metal valve boxes and their metal covers with rust inhibitive primer and one (1) coat of yellow epoxy paint.

.6.3 Damage and Touchup: Specify that the contractor shall repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

.7 TESTING, PURGING AND INSPECTION

.7.1 Pressure Testing:

.7.1.1 For gas lines operating less than 25 psig, specify that the pressure test shall be at 90 psig and hold for 24 hours to be considered an acceptable pressure test.

.7.1.2 For gas lines operating between 50 psig - 100 psig, specify pressure test shall be at 90 psig or 150 percent of the maximum operating pressure, whichever is greater, and hold for a minimum of 6 hours to be considered an acceptable pressure test.

.7.2 Nitrogen shall be used to pressure test the pipe.

.7.3 Pressure tests shall be by a recording line chart over 24 consecutive hours. Specify that the original recording line chart shall be turned over to OSU Utilities for record keeping.

.7.4 Specify that temporary natural gas piping used for buildings under construction shall be metered, undergo and pass a pressure test, and be witnessed by OSU Utilities prior to gas service being energized for the application.

.7.5 University Utilities shall witness and approve natural gas pressure testing.

.7.6 If tests indicate work does not meet specified requirements, remove piping, replace piping and retest.

.7.7 Purging of Pipelines: Comply with NFPA 54 for purging of gas lines. Specify that the Contractor shall submit a detailed Purging Plan along with a written request to purge the pipeline to the A/E and University for review, comment, and acceptance 6 weeks prior to the planned purge date. Purging shall be performed by the Contractor in conformance with recommendations of and
7.8 Interior (House Lines) Gas Distribution: Test, inspect, and purge natural gas lines according to the International Fuel Gas Code, Ohio Administrative Code, and Authorities Having Jurisdiction.

7.8.1 Existing House Gas Line Testing – specify that this shall be by the Contractor with assistance from OSU Maintenance Staff.

7.8.1.1 For re-establishing gas service, testing shall be completed using one of the following methods:

- **Pressure Test:**
  - Test house lines at operating pressure. Minimum test duration shall be specified at a minimum of 3 minutes.
  - Test appliance drops at operating pressure. Minimum test duration shall be specified at a minimum of 3 minutes.
  - Specify that the operating pressure for existing gas lines shall be measured by the contractor prior to disconnecting any portions of the existing gas system.

- **Dial Test (only applicable when service has been off for less than 30 days and for portions of piping located after the building meter):**
  - Specify that the contractor shall test the existing gas lines at operating pressure for the minimum duration determined by the smallest graduation on the existing meter listed below:
    - Meter dial cubic feet: ¼ or ½ = 5 minutes
    - Meter dial cubic feet: 1 = 7 minutes
    - Meter dial cubic feet: 2 = 10 minutes
    - Meter dial cubic feet: 5 = 20 minutes
    - Meter dial cubic feet: 10 = 30 minutes

7.8.1.2 Specify that natural gas piping will be subject to the Utility Service Connection and Inspection Standards: [https://fod.osu.edu/sites/default/files/utility_service.pdf](https://fod.osu.edu/sites/default/files/utility_service.pdf) and considered defective if it does not pass tests and inspections.

7.8.1.3 Specify that the contractor shall prepare all test and inspection reports and submit to the A/E and University for review and acceptance.

8 DEACTIVATION AND ABANDONMENT

8.1 Specify that all deactivation and abandonment of natural gas piping shall be in accordance with Code of Federal Regulations CFR 192.727. All pipelines deactivated in place must be disconnected from all gas supply sources, purged, and sealed at both ends.
33.51.3 Natural Gas Utility Metering

.1 Gas Supply Meters

.1.1 Temporary services shall be metered. Refer to Division One, for metering requirements.

.1.2 Gas supply to buildings shall be metered for new buildings and major additions and renovations. (Part Four, Facility Services) Meters shall be temperature and pressure compensated when installed upstream of the building pressure regulator and subject to varying supply pressure. Pressure compensating devices shall maintain meter accuracy.

.1.3 Meters shall conform to the requirements and policies of the utility system providing the gas and AGA as referenced. Meter shall be located in a boiler room or outside of the building. Venting pipes shall be vented to the outside of the building.

.1.4 Remote registers shall be provided when the meter location prevents direct reading of the meter register from a standing position on grade or finished floor. Remote registers shall be installed at 4' to 5' above grade or finished floor. Remote registers shall be compatible with the installed meter, shall be from the same manufacturer, and shall have a straight reading odometer type display.

.1.5 Meter shall provide one set of dry contacts that give a pulse output for every 10 cubic feet of usage recorded by the meter.

.1.6 No battery powered registers, including remote registers, are permitted. Backup battery power is acceptable.

.1.7 A/E shall design for MODBUS RS-485 communications to give data back to OSU's eDNA. Devices to be specified are as follows but not limited to: NEMA 4X enclosure, B&B Electronics Model MESR901 RS-485 to Modbus TCP/IP converter, Protocol Translator (PT) Board, Sola HD power supply catalog number SDP 5-5-100T, and PULS model ML30.100 24 VDC power supply. A/E shall consult with OSU Utilities during selection and design on these communication devices.

.1.8 A/E shall provide detailed wiring diagrams in the contract drawings for both meter power and communication connections.

.1.9 A/E shall specify that meters with fixed pressure factors shall have the pressure factor documented and provided to OSU ESS. Documentation shall be in the form of a calibration certificate.

.1.10 Easy access shall be provided to meters for maintenance, repairs, and meters shall be flanged and valved to permit convenient replacement of metering.

33.61.33. Hydronic Energy Distribution Metering

Part 1 General

.1 Applications

.1.1 The main objective of this design standard is to outline the specifications of a hydronic energy distribution meter for chilled water and hot water to measure the consumption of energy in total Ton-hours of Refrigeration (Ton-hr), British Thermal Units (BTU), provided to the buildings utilized by The Ohio State University and to communicate this consumption locally and to the
campus-wide Energy Metering & Monitoring system (InStep eDNA server). The hydronic energy distribution meter shall include the instantaneous energy rate in Tons or BTU/hr and totalized energy consumption in Ton-hr or BTU.

.1.2 The hydronic energy distribution meter, elements and devices, shall meet custody transfer requirements. Custody transfer measurement furnishes quantity and quality information which can be used as the basis for a change in ownership and/or a change in responsibility for materials, e.g., billing for rate of energy demand plus totalized energy transfer.

.1.3 Products: Describes the general requirements for a totalizing hydronic energy distribution meter, primary element, transmitters, secondary elements, RTD temperature sensors/transmitters, and a flow computer.

.2 DOCUMENTATION

.2.1 Data sheets and catalog literature for the hydronic energy distribution meter, the transmitters, the RTD temperature sensors/transmitters and the flow computer must be sent to The Ohio State University for evaluation.

.2.2 Interconnections and drawings for installation of the primary, secondary, and tertiary elements of the corresponding devices shall be submitted for review and approval prior to installation. P&ID’s shall be furnished in accordance to ISA S5.

.2.3 Provide flow computer program setup parameters as written hard copy and as Windows based electronic Adobe Acrobat PDF format file.

.2.4 Certificates for the conformance of the hydronic energy distribution meter according to engineering procedures and practices, and standards, shall be supplied. Density correction with temperature and pressure for water or glycol solutions, coefficients, linear regressions, constants, equations, methodologies and basis of calculations to establish the energy rates shall be provided.

.2.5 Certificates of calibration for the hydronic energy distribution meter with water or other liquids available in the calibration facility, as well as a certificate of calibration conformance for the transmitters in accordance to NIST shall be provided.

PART 2 PRODUCTS

.1 PREMISES FOR THE SELECTION OF THE HYDRONIC ENERGY DISTRIBUTION METER AND FLOW COMPUTER

.1.1 The selection of the hydronic energy distribution meter shall be based on the following parameters and recommendations to guarantee that the accuracy of the hydronic energy distribution meter lies within ± 2%, and the repeatability within ± 1%.

.1.2 The supply pressure could vary between 60 psig and 120 psig; whereas the supply temperature can vary between 38°F and 180°F and the return temperature can be 5°F to 25°F higher than the supply temperature.

.1.3 The volumetric flow rate shall be computed in gallons per minute. The flow sensor turndown shall be no less than 15 to 1.

.1.4 The pressure drop through the primary element, sensor, shall not be greater than 10 inches w.g.c. for the maximum volumetric flow rate.
DIVISION 33 – UTILITIES

.1.5 The flow computer shall provide a 4-20 mA signal for the energy rate in Tons or BTU/hr and/or a pulse signal for the totalized energy consumption in Ton-hr or BTU. The flow computer shall be equipped with a MODBUS TCP/IP RTU communications port or MODBUS RTU RS-485 over AWG-18 twisted pair shielded cable to another meter in the same location. Prior to flow computer approval, the flow computer must be submitted by the Contractor for testing by OSU Utilities to prove interoperability with the campus-wide Energy Metering & Monitoring system (InStep eDNA server) and/or the Utilities Distributed Control System as applicable. Cat-6 shielded cable and conduit shall be installed between the flow computer or group of flow computers connected by twisted pair and the nearest building network switch.

.1.6 The flow computer shall provide precise and reliable measurement of absolute and differential pressure, sensor and electronics temperatures, and process temperature from an external RTD. It shall calculate water densities, or glycol solutions according to an appropriate reference source.

.1.7 The flow computer shall be supplied with at least 12 feet of AWG-18 shielded twisted pair cable for the RTD input connection. Parameters and measurements shall be stored in non-volatile memory to avoid data loss during power failure. Data shall be restored from internal memory upon restoration of power.

.1.8 The flow computer shall be supplied with two isolated outputs that permit external system, e.g. Building Automation Systems, to monitor selected meter parameters.

.2 PRIMARY ELEMENT, FLOW SENSOR

.2.1 Magnetic flow element, along with RTDs, which measure supply and return temperatures, shall be used as the primary elements of the hydronic energy distribution meter. The material of the components of the flow sensor and the RTDs must be 316 stainless steel. The nominal size of the sensor shall match the size of the pipe where the flow sensor will be installed. The primary element shall comply with applicable standard codes such as but not limited to ISO, ASME.

.2.2 Where applicable, the flow sensor shall be installed in lug type arrangement, constructed of 316 stainless steel rated for 150 psig and 250°F.

.2.3 Calculations, equations and/or methodology used to determine the size of the flow sensor shall be supplied to The Ohio State University for acceptance. Where applies, Reynolds Number dependent equations shall be checked for maximum and minimum volume flow rates.

.3 RESISTANCE TEMPERATURE DETECTOR (RTD) AND TEMPERATURE TRANSMITTER

.3.1 Furnish a spring-loaded Dual Element 100 ohm platinum RTD temperature sensor assembly. The accuracy shall be ±0.5% at 32°F utilizing a three-wire single element with aluminum waterproof head and a 316 stainless steel nipple-union-nipple extension. The length shall be determined by the system piping where the meter will be installed.

.3.2 The temperature process input range shall be 20°F to 800°F.
.3.3 The thermo-well shall be 316 stainless steel; long enough for the size of the process piping system with a 4-inch lagging allowance; and provided with a 3/4-inch NPT process connection. The well finish shall be 15Ra maximum, electro-polish finish.

.4 Certifications
.4.1 Calibration and Calculations
.4.1.1 A manufacturer’s conformance certificate for the calibration of the hydronic energy distribution meter shall be provided.
.4.1.2 A certified calculation, for the maximum and minimum volume flow rates at working conditions of temperature, pressure, additive concentration, if present, and pressure shall be supplied.
.4.1.3 Calibration of the transmitter(s) shall be accomplished following NIST standards. A certification of conformance shall be submitted.

.5 Communication
.5.1 Meter data in the form of total consumption, flow rate and a meter diagnostic must be communicated over the university Ethernet network back to the InStep eDNA server. Consumption will be in billable units. Meter diagnostic will be in the form of Normal or Failure. MODBUS data registers shall be provided, at a minimum, for instantaneous flow rate, totalized mass value, temperature, pressure, and differential pressure.
.5.2 Meters will utilize a combination of MODBUS RTU over RS-485 and MODBUS over Ethernet. A/E shall specify a B&B Model MESR901 RS-485 to Modbus TCP/IP converter for flow computers without built in Modbus TCP/IP.

.6 Manufacturers
.6.1 ABB, Rosemount, Toshiba, or Yamatake magnetic flow meters
.6.2 Burns Engineering, or Sensor Tec RTDs.
.6.3 Temperature Transmitters are HART SensorTec Model Q4, PR Electronics Model 5335A, or Rosemount Model 248.
.6.4 A Kessler-Ellis Products (KEP) flow computer shall be supplied.
.6.5 Other models and manufacturers require submittal by the A/E and approval by The Ohio State University Utilities before including in the Design Development Documents.
.6.6 All flow meters will be considered for approval on the basis of life cycle cost analysis by the A/E.

PART 3 EXECUTION
.1 WARRANTY
.1.1 The supplier/manufacturer of the above specified equipment shall guarantee for twenty four (24) months from equipment startup or thirty (30) months from date of shipment, whichever occurs first, that the equipment shall be free from defects in design, workmanship or materials.
.1.2 In the event a component fails to perform as specified or is proven defective in service during the warranty period, the manufacturer shall promptly repair or replace the defective part at no cost.
.1.3 The manufacturer or contractor shall furnish OSU Utilities and Energy Services and Sustainability group with an installation, operation and maintenance manual for the energy distribution meter and all its components including a program manual for the flow computer.

.2 INSTALLATION

2.1 Follow manufacturer’s guidelines and submit installation drawings to OSU Utilities for review and approval prior to installation.

2.1.1 Outages to existing utility systems must be planned and scheduled at least two weeks in advance. See outage procedure: https://ap.osu.edu/sites/default/files/utility_outage_procedures.docx

2.1.2 The Contractor shall obtain assistance from FOD in following the manufacturer’s installation specifications such as but not limited to location of the meter components, Ethernet connection, electrical connections, local disconnect, enclosure type, and all other applicable issues.

2.2 Power shall be obtained from a dedicated 20 Amp circuit in the nearest local building electrical panel.

2.3 The pipe diameter shall be known and shall never be reduced to install the flow sensor.

2.4 The location of the components of the hydronic energy distribution meter shall comply with the straight-run pipe upstream and downstream requirements recommended by the manufacturer(s). The straight-run pipe distance shall not be less than 15 times the diameter (15D) of the pipe, 10D upstream and 5D downstream.

2.5 Work performed without the assistance of the manufacturer’s technical erection supervisor and/or OSU Utilities shall adhere to dimensional requirements, assembly methods, and installation procedures specified herein and in the manufacturer’s instruction manuals and drawings.

2.6 The Contractor shall comply with all erection and installation methods, techniques, sequence, and procedures requested by the manufacturer’s representative and/or OSU Utilities.

2.7 Where manufacturer’s written instructions differ significantly from those proposed by the manufacturer’s representative, OSU Utilities shall determine the method used.

2.8 The hydronic energy distribution meter shall be aligned with the direction of the flow in a horizontal line.

2.9 Gaskets shall be installed in proper alignment, free of tears and wrinkles. Bolted connections shall be tightened per gasket manufacturer’s torque and sequence requirements to provide a uniform tight seal to insure uniform stress over the entire gasket area.

2.10 All conduit and conduit connections shall be sealed connections and meet the design and installation standards applicable for the installation area.

2.11 Installation services shall include all conduit and wiring to provide a fully functional meter and communication wiring to the building Ethernet switch.
Termination of Ethernet communication cable at the building Ethernet switch shall be by OSU. See Part 2-PRODUCTS; Sections .1.5 and .1.7 (under .1-PREMISES FOR THE SELECTION OF THE HYDRONIC ENERGY DISTRIBUTION METER AND FLOW COMPUTER) for communication and cable requirements.

.2.12 Panel addressing shall be assigned by OSU Utilities.

.2.13 All meters and ancillary equipment shall be installed in such a manner as to provide access for routine inspections, maintenance, and a means of removal.

.2.14 The flow computer readout/display shall be located between 5 feet and 6 feet above finished floor level.

.2.15 All meters shall be supported independent from the piping systems.

.2.16 Structural steel supports and miscellaneous steel required for supporting and/or anchoring meters and piping furnished under this standard shall be provided and installed in accordance with Division 5.

.2.17 All anchors and structural steel supports shall be built to template and reinforced as required for loads imposed on them.

.2.18 Equipment and pipe internals shall be cleaned and inspected prior to placing in service.

3 TRAINING

.3.1 The supplier/manufacturer shall train OSU Utilities and Energy Services and Sustainability personnel to program, calibrate, operate and maintain the above-mentioned devices for at least 3 hours. Training shall be scheduled within two weeks of completion of the installation.

4 INSPECTION AND COMMISSIONING

.4.1 A representative of OSU Utilities will inspect the installation and performance of the hydronic meter for acceptance and approval before commissioning. OSU Utilities reserves the right to witness factory testing and calibration.

.4.2 Provide for review of required closeout documentation.

.4.3 Provide for review loop sheets with point to point wiring diagrams in AutoCAD .dwg format.

.4.4 Document and provide for review all electrical power sources with breaker and panel numbers.

.4.5 Provide for review all calibration data sheets.

.4.6 Download or load programming setup parameters.

.4.7 The integrity and polarity of all terminations shall be checked and verified.

.4.8 All piping connections must pass a service test.

.4.9 Final system checks and closeout shall be performed.

.4.10 Utility service will not be reinstated by OSU Utilities until installation of the energy distribution meter is inspected by OSU Utilities and found to meet the requirements of the energy distribution meter manufacturer and these design and installation standards.
.1.1 Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

.2 SUMMARY
.2.1 This Section includes the following:
    2.1.1 Codes conformance
    2.1.2 Coordination
    2.1.3 Record documents
    2.1.4 Maintenance manuals
    2.1.5 Cutting and patching
    2.1.6 Installation of equipment
    2.1.7 Grout

.3 SUBMITTALS
.3.1 Product Data and Shop Drawings: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:
    3.1.1 Grout product data
    3.1.2 Hot-dip galvanizing process data and galvanizing repair paint data
    3.1.3 Shop drawings for metal fabrications for piping equipment and pipe supports
    3.1.4 Coordination Drawings

.3.2 Project Record Documents: In accordance with Section 01 78 00 – CLOSEOUT SUBMITTALS, submit the following:
    .3.2.1 Red line drawings

.4 CODE CONFORMANCE
.4.1 Codes include but are not limited to:
    .4.1.1 State Power Piping Code
    .4.1.2 ASME Power Piping Code B31.1

.5 QUALITY ASSURANCE
.5.1 Equipment and appurtenances shall be designed in conformity with ANSI, ASME, IEEE, NEMA, OSHA, AGMA, ASTM, and other generally accepted applicable standards.
.5.2 All machinery and equipment shall be safeguarded in accordance with the safety codes of the ANSI, OSHA, and local industrial codes, including but not limited to, shaft guards on all rotating shafts, cages around exposed fan blades, etc.
.5.3 All mechanical work shall be performed by mechanics who are qualified to do such work and who are normally engaged in this type of work.

.6 PROJECT PIPING WORK REQUIREMENTS AND COORDINATION
.6.1 The project requires piping systems to be fully coordinated and integrated. The piping systems shall be designed and installed to comply with the ASME B31.1 Power Piping Code. The Contractor shall coordinate requirements for
fully integrated piping systems that utilize and are comprised of pipe expansion joints, pipe expansion loops, pipe supports, pipe anchors, valves, specialties, and pipe insulation. Coordination drawings shall be provided demonstrating compliance with ASME B31.1 for all piping systems. The Coordination drawings shall indicate all piping system requirements including pipe thermal expansion and contraction axial and lateral travel, pipe support criteria, pipe anchor placement, expansion joint requirements, and similar items.

.6.2 Coordinate requirements for cast-in-place concrete embedded anchor bolts for pipe anchors and similar components with other trades.

PART 2 – PRODUCTS

.1 MATERIALS

.1.1 General: Materials shall be new and shall conform to the materials specified on the Contract Drawings and as follows:

.1.1.1 Shim stock used in leveling and alignment shall be Type 304 stainless steel.

.1.1.2 Leveling plates and blocks shall conform to ASTM A 36. Steel plate stock with a thickness of 1/2-inch or less shall have sheared edges; thicker stock may be flame cut with burrs removed.

.1.1.3 Grout shall be an approved premixed, prepackaged, non-shrink grout which requires only the addition of water. Grout shall be non-shrink, nonmetallic, and in accordance with ASTM C 1107, Grade B.

.1.1.3.1 Characteristics: Post-hardening, volume-adjusting, dry, hydraulic-cement grout, non-staining, noncorrosive, nongaseous, and recommended for interior and exterior applications.

.1.1.3.2 Design Mix: 5000 psig, minimum 28-day compressive strength.

.1.1.3.3 For high temperature applications at HPS and PC anchors, use Five Star HTR Grout by Five Star Products, Inc. Grout at HPSS and PCR pipe slide and guide locations shall be non-high temperature rated.

.1.1.4 Metal fabrications and fasteners for pipe supports and anchors shall be provided in accordance with the drawings and specifications Section 05 50 00 – METAL FABRICATIONS with the following exceptions:

.1.1.4.1 Structural Steel Plates and Bars shall conform to ASTM A36.

.1.1.4.2 Structural Steel Shapes shall conform to ASTM A36.

.1.1.4.3 Anchor Rods, bolts and washers shall be carbon steel ASTM F1554 grade 55.

.1.1.5 Metal fabrications, anchors, pipe supports, embedded anchor rods and similar items shall be galvanized unless indicated otherwise. Galvanizing shall be by the Hot-dip process complying with ASTM A123 or A153. Galvanizing repair paint shall be field applied for
touch-up on field welds and similar finish repairs. Galvanizing repair shall comply with ASTM A780. Cold Galvanizing repair paint shall contain 95% zinc dry and shall have a temperature resistance of 350°F continuous and 750°F intermittent. Cold galvanizing is not required where welds are to be covered with insulation.

.1.1.6 Expansion anchors and high strength bolts, nuts and washers shall be zinc plated as per Section 05 50 00 – METAL FABRICATIONS.

PART 3 – EXECUTION

.1 COORDINATION

.1.1 It is the responsibility of the Contractor to coordinate the work of his trade with all other trades prior to the commencement of construction and during construction. It is the responsibility of the Contractor to provide, in his original bid, all necessary offsets, fittings, and transformations to provide a complete project. Any conflicts must be brought to the attention of the A/E. Any work requiring removal and reinstallation due to the lack of coordination shall be the responsibility of the Contractor with no additional cost to the University.

.1.2 Refer to Part 1-General, Paragraph .6.1.

.1.3 Coordinate requirements for cast-in-place concrete embedded anchor bolts for pipe anchors and similar components with other trades.

.1.4 During coordination meetings, discuss amongst the contractors scheduling, sequencing, movement, and positioning of large equipment during construction. Refer to Section 01 31 00 – PROJECT MANAGEMENT AND COORDINATION.

.2 MAINTENANCE MANUALS

.2.1 Prepare maintenance manuals in accordance with Section 01 78 00 – CLOSEOUT SUBMITTALS. Include the following information for equipment items:

2.1.1 Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.

2.1.2 Manufacturer's printed operating procedures to include start up, break in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.

2.1.3 Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.

2.1.4 Servicing instructions and lubrication charts and schedules.

2.1.5 One complete set of non-reproducible (white print or blue print) as-built drawings.

2.1.6 A copy of all of the satisfactory reviewed submittals.

.3 INSPECTION
.3.1 Prior to performing work required under Division 33 carefully inspect all
existing conditions and the installed work of all other trades and verify that all
conditions and all such work is complete to the point where the work may
properly commence.

.3.2 In the event of discrepancy, immediately notify A/E and UTHQ. UTHQ shall
perform the piping inspections on behalf of the University, not ODIC.

.4 QUALITY ASSURANCE
.4.1 Ample clearance shall be provided for repairs, inspection and adjustment.
Protruding members such as joints, corners and gear covers shall be finished
in appearance. All exposed welds shall be ground smooth and the corners of
structural shapes shall be rounded or chamfered.

.4.2 Secure and pay for all necessary fees, permits, inspections and approvals, as
required for the work of Division 33 specifications.

.5 CUTTING AND PATCHING
.5.1 Perform cutting, fitting, and patching of piping equipment and materials
required to:
.5.1.1 Uncover Work to provide for installation of ill-timed Work.
.5.1.2 Remove and replace defective Work.
.5.1.3 Remove and replace Work not conforming to requirements of the
Contract Documents.
.5.1.4 Remove samples of installed Work as specified for testing.
.5.1.5 Install equipment and materials in existing structures.

.5.2 A/E shall specify that the contractor shall perform in accordance with the
Project’s Cutting and Patching specification section in Division 01.

.6 PERFORMANCE
.6.1 Perform all work that is essential in completing the intended installation in the
proper manner.

.6.2 Field verification of all dimensions is required.

.6.3 Wherever obstructions are encountered in the path or course of the work that
are not shown nor anticipated in the Contract Documents, do not proceed
with the installation of the work before advising the A/E and receiving
detailed information or drawings or both.

.7 INSTALLATION OF EQUIPMENT, SPECIALTIES AND SUPPORTS
.7.1 All equipment shall be installed true, level and in the location shown on the
Drawings to within ±0.002”. Precision gauges and levels shall be used in
setting all equipment.

.7.2 Furnish, install and protect all necessary guides, bearing plates, anchor and
attachment bolts, and all other appurtenances required for the installation of
equipment.

.7.3 All equipment shall be installed in such a manner as to provide access for
routine maintenance, including lubrication.
.7.4 All equipment piping shall be routed from previously-set equipment to reduce any pipe strain.

.7.5 Structural steel supports and miscellaneous steel required for supporting and/or hanging equipment and piping furnished under this Division shall be provided and installed in accordance with section 05 50 00 – METAL FABRICATIONS.

.7.6 All anchors and structural steel supports shall be built to template and reinforced as required for loads imposed on them.

.8 INSTALLATION

.8.1 Technical Erection Supervision:

.8.1.1 Work performed without the assistance of the manufacturer's technical erection supervisor shall adhere to dimensional requirements, assembly methods, and installation procedures specified herein and in the manufacturer's instruction manuals and drawings.

.8.1.2 The Contractor shall comply with erection and installation methods, techniques, sequence, and procedures requested by the manufacturer's representative, if the manufacturer's representative is present.

.8.1.3 Where manufacturer's written instructions differ significantly from those proposed by the manufacturer's technical erection supervisor, the A/E shall determine the method to be used.

.8.2 Manufacturer's Drawings and Instruction Books: Manufacturer's drawings and instruction books for University-furnished equipment and materials to be installed will be made available to the Contractor. Upon completion of the Work, all instruction books shall be returned to the University.

.8.3 Pre-installation Requirements:

.8.3.1 Protection:

.8.3.1.1 The Work, material, and equipment installed by the Contractor shall be adequately covered and protected against dirt, water, frost, chemical, and mechanical damage. The Contractor shall make good, at his own expense by repair or replacement as directed by the University and by using approved equivalent materials, any and all damages to equipment or buildings caused directly or indirectly by his workmen, workmanship, or by his failure to properly protect his Work.

.8.3.1.2 Equipment that may be damaged by freezing shall be checked to insure that all water has been drained from the unit prior to placing the equipment in storage or on its foundation.

.8.3.1.3 The shafts of assembled rotating equipment shall be rotated a minimum of once per week while in storage, unless the manufacturer's instructions advise otherwise.
Bearings shall be checked to insure lubrication prior to rotating.

8.3.1.4 Material shall not be stacked or piled on finished surfaces unless the surfaces are positively protected by substantial wooden covers rigidly secured in place. Finished bottom surfaces shall be set only on clean, dry wooden dunnage.

8.3.2 Cast-in-place embedded anchors: Cast-in-place anchors shall be checked to determine that there are no errors in anchor bolt locations and projections from that shown on the Drawings or otherwise required. The University shall be notified if any cast-in-place embedded anchors are determined to be defective or incorrect.

8.3.3 Cleaning:

8.3.3.1 Protective coatings, shipping protection, oil, grease, and loose material shall be removed from the surfaces of the equipment.

8.3.3.2 Just prior to assembly, all finished surfaces shall be uncovered and thoroughly cleaned of loose paint, foreign matter, and rust. Rust shall be removed by means of a high-grade rust remover applied with lint-free cloths.

8.3.3.3 The underside of all equipment shall be cleaned of all dirt, oil, grease, and loose material. Foundation anchor bolts shall be straightened and the threads rerun with a suitable die prior to setting the equipment on its foundation.

8.4 Equipment Handling: Proper and adequate handling equipment and rigging shall be used at all times. Equipment and rigging shall be examined and checked at frequent intervals. The weights and dimensions of the equipment shall be obtained from the manufacturer's drawings, as required, to insure the use of adequate equipment.

8.5 Leveling: Leveling shall comply with the manufacturer's leveling instructions or with the following procedure where the manufacturer's instructions are not available:

8.5.1 Equipment, supports and specialties shall be lowered over anchor bolts holding the underside of the base a minimum of 1 inch above the surface of the foundation (unless indicated otherwise) to allow adequate space for grouting.

8.5.2 Units equipped with leveling screws: Rectangular steel leveling blocks shall be placed on the foundation close to and straddling each foundation bolt. Additional steel leveling blocks shall be placed directly under all parts of base which carry direct heavy loads. Leveling blocks shall be placed close enough to give uniform support and shall not project excessively beyond the edge of the base. Each block shall rest solidly on good concrete.
.8.5.3 With the unit resting on leveling blocks, the unit shall be adjusted to alignment and elevation established by the Drawings. Level shall be checked in both directions with a precision level.

.8.5.4 Shims shall be installed, as required, to maintain even weight distribution on all leveling blocks. In building up shim height, thickness shall be selected to minimize the number of shims required. If wedges are used in adjusting elevation, the base shall be supported in the final level position entirely by the leveling blocks and not partially by wedges.

.8.5.5 Level of base shall be determined by use of accurate precision spirit levels, resting wherever possible on leveling pads or clean, finished surfaces. Painted surfaces shall not be used as a datum for checking level.

.8.5.6 When the unit has been satisfactorily leveled in all directions, the foundation bolts and nuts shall be drawn down tight.

.8.6 Gaskets: Gaskets shall be installed in proper alignment, free of tears and wrinkles. Bolts shall be tightened evenly all around to insure uniform stress over the entire gasket area. Refer to Section 33 63 45 – GASKETS.

.8.7 Grouting of Equipment, Supports and Specialties:

.8.7.1 Equipment, supports and specialties shall be grouted as specified herein. The premixed grout shall be delivered to the site in the manufacturer's original container. Each package of premixed grout shall be accompanied by printed instructions from its manufacturer for mixing, placing, and curing and shall include temperature limitations for use of the grout.

.8.7.2 Mixing: Premixed grout shall be mixed in accordance with the manufacturer's instructions. The water-to-grout ratio shall not exceed that shown on the manufacturer's test results for the desired strength. Water mixed with grout shall be a minimum and shall not exceed the quantity required to place the grout.

.8.7.3 Before grouting, the A/E's written approval shall be obtained to proceed with each piece of equipment. Unless specified otherwise, the equipment to be grouted shall be in place on its foundation, leveled, aligned, and completely assembled.

.8.7.4 Rigid connections to equipment shall not be made until grout has been placed and allowed to cure for a minimum of 5 days.

.8.7.5 Surface Preparation and Forms:

.8.7.5.1 The surface of the concrete shall be either bush hammered or chipped to present a sound, rough surface free of laitance, oil, and other contamination.

.8.7.5.2 The baseplate undersurface shall be cleaned of loose rust, mill scale, oil, grease, and other foreign materials before being set into place.

.8.7.5.3 The concrete surface anchor bolt holes shall be thoroughly saturated by being maintained visibly wet for 24 hours immediately before grout is placed. Standing water,
including water in anchor bolt holes, shall be removed before grout is placed.

.8.7.5.4 Formwork shall be fixed around each baseplate to the level of the top of the plate or to above the level of high, trapped areas under the plate, whichever is higher. Forms on the pouring side of the plate shall be raised to provide a sufficient head for the grout to flow under the plate. Forms shall be caulked on the inside to prevent leakage, using the same grout material as is to be poured but mixed to a plastic consistency.

.8.7.6 Placement of Grout:

.8.7.6.1 Anchor bolt holes shall be filled first. If interference from formwork is anticipated, anchor bolt holes may be filled a day or two in advance, provided presoaking of the concrete is resumed as soon as the holes have been filled.

.8.7.6.2 Grout shall be poured from only one side of the plate, starting at one corner and moving across the same side to the other corner, until the entire space is filled and the grout is visible on the opposite side at the top of the plate.

.8.7.6.3 The grout mix can preserved during short pauses in pouring by working it with flat steel straps (not chains) preferably inserted from pouring side.

.8.7.6.4 Grout shall not be placed when the temperature of air, plate, or foundation concrete is below 45°F or the temperature specified by the manufacturer, whichever is higher. The temperature of the grout shall be maintained at a minimum of 45°F or in accordance with the manufacturer's instructions, whichever is higher, for 24 hours after the grout has been placed. Thereafter, it shall be maintained above freezing until the grout has attained a compressive strength of 3000 psi or for 6 days, whichever occurs first.

.8.7.6.5 If the ambient temperature exceeds 80°F, the baseplate and concrete shall be cooled by means such as shading and placing soaking burlap on the baseplate before grouting is begun.

.8.7.6.6 Whenever sufficient handling and placing time is desired at ambient temperatures near 80°F, iced mixing water may be used in place of some of the batch water to extend the usable life of the grout, provided the temperature of the grout after mixing is not below 45°F. The total of water plus ice shall not exceed the mix design water content.

.8.7.7 Finishing and Curing: Grout shall be cured as follows, unless the manufacturer recommends otherwise:
.8.7.7.1 As soon as grout reaches initial set (such that grout is not damaged by wet cloth or burlap), all exposed surfaces shall be covered with cloth or burlap which shall be maintained constantly wet until forms are stripped to prevent moisture loss from grout. When multiple lifts are used, the grout shall be covered with wet cloth or burlap for 48 hours after each lift.

.8.7.7.2 When grout has thickened sufficiently to be troweled, any excess grout that has spilled over and accumulated on top of the plate shall be removed until grout is flush with the top of the plate. The curing cloth may be removed temporarily for this purpose.

.8.7.7.3 Forms shall not be removed nor grout disturbed below the level of the underside of the plate until grout is sufficiently hard that it cannot be penetrated by the point of a hand-held trowel.

.8.7.7.4 After removal of forms, the exposed edges of the grout shall be chamfered or bull-nosed and all exposed surfaces coated with curing compound.

.8.7.7.5 Unless the Drawings indicate otherwise, shims shall remain in place for at least 48 hours after completion of the grouting and then shall be removed. After removal of shims (or screws), voids shall be filled or back-packed with grout.

.8.7.8 Rechecking Level and Alignment after Curing Grout:

.8.7.8.1 After grout has cured a minimum of 5 days and after rigid connections have been made, level and alignment of the equipment shall be checked completely, and all adjustments necessary to correct level and alignment shall be made.

.8.7.8.2 Where possible, shims required for adjustments between component parts of the equipment shall be installed without disturbing the bond between the grout and under the surface of the equipment base.

.8.7.8.3 Where the necessary level and alignment adjustments require breaking of the bond between the equipment base and grout, the original grout shall be removed and the base re-grouted after completion of leveling and alignment.

.8.7.9 Securing Anchor Bolts: The anchor bolt nuts shall be tightened securely, after confirmation of correction of equipment level and alignment on the grout, in accordance with manufacturer’s torque requirements. Leveling screws shall be backed off at this time so that equipment is supported on the grout. If the manufacturer’s torque requirements are not provided, the foundation bolt nuts shall be tightened to the following minimum torque requirements:

- 1/2-inch dia: 15 lb-ft
- 5/8-inch dia: 25 lb-ft
• 3/4-inch dia 40 lb-ft

.8.8 Doweling: Doweling, where required by manufacturer's drawings and instructions or where directed by the A/E, shall be installed only after hot and cold initial operation of equipment, unless the manufacturer's instructions advise otherwise. The holes shall be drilled and reamed, as necessary, to install the dowels.

.9 CLEANING
.9.1 Cleaning and Flushing Installation:
  .9.1.1 Equipment and pipe internals shall be cleaned, inspected and flushed prior to placing in service. Chilled water piping systems shall be flushed with water and an approved cleaning solution. Refer to Section 33 63 10 – COMMON WORK RESULTS FOR PIPING for additional pipe cleaning and flushing requirements.
  .9.1.2 The Contractor shall be responsible for any damage to equipment and piping caused by dirt, chips, and any foreign materials.

33 63 10 COMMON WORK RESULTS FOR PIPING
PART 1 – GENERAL
.1 RELATED DOCUMENTS
  .1.1 Contract Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to work of this Section.
  .1.2 Requirements of the following Specification Sections apply to this Section:
    .1.2.1 Piping materials and installation methods for each pipe group are specified as subsections of this Section.
    .1.2.2 Section 33 63 50 – IDENTIFICATION FOR PIPING AND EQUIPMENT
    .1.2.3 Section 33 63 25 - PIPING SPECIALTIES
    .1.2.4 Section 33 63 45 – GASKETS
    .1.2.5 Section 33 63 20 – METERS AND GAUGES
    .1.2.6 Section 33 63 40 - HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT
    .1.2.7 Section 33 63 55 - PIPING INSULATION

.2 DESCRIPTION OF WORK
.2.1 This Section specifies piping materials and installation methods common to more than one section of Division 33 and includes basic piping installation instructions. This Section covers piping that falls under the ASME B31.1 Power Piping Code. Refer to Division 33 Drainage System Sections for drainage piping and related work that falls under ASME B31.9 and local codes.
.2.2 Types of pipes and pipe fittings specified in this Section include the following:
  .2.2.1 Steel Pipes
  .2.2.2 Stainless Steel Pipes
  .2.2.3 Copper Pipes
  .2.2.4 Miscellaneous Piping Materials/Products
.2.3 Pipes and pipe fittings furnished as part of factory-fabricated equipment are specified as part of the equipment assembly in other Division 33 Sections and in general shall comply with the requirements of this Section.

.3 SUBMITTALS

.3.1 Product Data: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:

.3.1.1 Manufacturer's technical product data, installation instructions, and dimensioned drawings for each type of pipe and pipe fitting

.3.1.2 Piping schedule showing manufacturer, ASTM number, ASTM type, ASTM grade, pipe or tube weight, fitting type, and joint type for each piping system

.3.1.3 The piping and accessories submittal shall clearly describe what components are going to be used for each piping group.

.3.1.4 Records and reports required for certain pipe groups as specified in individual piping group specifications

.3.1.5 Provide ISO 9001 and Independent Test Reports if applicable per Quality Assurance paragraph below.

.3.1.6 “Fire Watch” safety procedures

.3.2 Maintenance Data: In accordance with Section 01 78 00 – CLOSEOUT SUBMITTALS submit the following:

.3.2.1 Maintenance data and parts lists for each type of mechanical fitting.

.3.3 Quality Control Submittals: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:

.3.3.1 Installers Qualification Data:

.3.3.1.1 Welder Qualification Data: Copies of certification; include names, home addresses and identification numbers of welders.

.3.3.1.2 Welding Procedures: Shall include QW-482 "Suggested Format for Welding Procedure Specification (WPS)" and QW-483 "Suggested Format for Procedure Qualification Record (PQR)" as specified in Welding Quality Assurance below for different weld types.

.3.3.1.3 Welders' Certificates: Shall include QW-484 "Suggested Format for Manufacturer's Record of Welder or Welding Operator Qualification Tests (WPQ)" for all welders for all weld types as specified in Welding Quality Assurance below.

.3.3.1.4 Welder Identification List

.3.3.2 Manufacturer's Data: Copy of mill certificates, laboratory test and manufacturing reports relating to chemical and physical properties of pipe, fittings, and related materials.

.3.3.3 Independent Testing Agency Qualifications: As specified in this Section.
.3.3.4 ISO 9001 and Independent Test Reports: As specified in Quality Assurance below.

.3.4 Piping Tests: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:

.3.4.1 Hydrostatic Testing Records: The Contractor shall maintain a constantly updated log (as described in this Section) available to the University and A/E at all times. The Contractor shall submit a final log to the A/E for his records.

.3.4.2 Visual Examination Examiner's Qualifications: Provide as specified in this Section.

.3.4.3 Visual Inspection Reports: Provide as specified in this Section.

.3.4.4 Radiography Examination Written Procedure: Provide as specified in this Section.

.3.4.5 Radiography Examination Reports: Provide as specified in this Section.

.3.4.6 Radiography Examination Examiner's Qualifications: Provide as specified in this Section.

.3.4.7 Independent Testing Agency Information: The Contractor and the independent testing agency shall provide a signed statement that the testing agency has no affiliation with the Contractor and can serve as an independent agency to provide the testing as specified.

.3.4.8 Welder Identification List: Provide as specified in this Section.

.4 QUALITY ASSURANCE

.4.1 Codes and Standards:

.4.1.1 All piping systems with the exception of potable city water, sanitary, and other plumbing systems piping shall be designed, fabricated, erected, and tested in accordance with ASME B31.1.

.4.1.2 All welders performing welding to this procedure shall be qualified to this procedure in accordance with ASME Boiler and Pressure Vessel Code, Section IX, “Welding and Brazing Qualifications.”

.4.1.3 Conform to ASME Boiler and Pressure Vessel Code and ASME B31.1 Power Piping Code for administrative and technical requirements for Boiler External Piping and Non-boiler External Piping.

.4.1.4 Comply with the latest editions of the publications of the following Agencies to the extent referenced in this Section:

- ANSI - American National Standards Institute
- API - American Petroleum Institute
- ASME - American Society of Mechanical Engineers
- ASTM - American Society for Testing and Materials
- AWS - American Welding Society
- AWWA - American Water Works Association
- CISPI - Cast Iron Soil Pipe Institute Association
- FM - Factory Mutual
- NFPA - National Fire Protection Association
- PFI - Pipe Fabrication Institute
.4.2 Special Precautions

.4.2.1 Torch cutting will be permitted only with the specific written approval of the University. Any cutting method, which may create sparks, must include "Fire Watch". Submit "Fire Watch" procedure for approval. Obtain and use the “Hot Work” forms from OSU; the Hot Work form can be provided by the Office of Environmental Health and Safety (EHS) or from OSU Utilities Manager of Support Services. Make sure the plan contains contact names and phone numbers, end of work plan, posting of emergency contact numbers, fugitive emissions control, ventilation for welding and shutdown of exhaust fans in case of fire, and procedures that are specific to this project.

.4.2.2 Draining operations must not damage building components or endanger human health.

.4.3 Country of Fabrication:

.4.3.1 All piping, fittings, and piping accessories not manufactured, fabricated, and/or assembled in the United States of America or Canada must be manufactured, fabricated, and/or assembled by an ISO 9001 registered corporation.

.4.3.2 Submit ISO 9001 registration certificates for all corporations where the piping, fittings, and piping accessories are not manufactured, fabricated, and/or assembled in the United States or Canada.

.4.3.3 For all piping, fittings, and piping accessories not fabricated in the United States or Canada, submit an independent test report for all materials to be provided.

.4.3.4 No piping, fittings, and piping accessories manufactured, fabricated, and/or assembled in China including Taiwan are permitted to be provided in this Contract.

.5 WELDING QUALITY ASSURANCE

.5.1 Welding Procedures: In the form of a submittal, the Contractor shall record in detail and shall qualify the Welding Procedure Specifications for every welding procedure that he proposes. Procedures shall be developed for all metals included in the work. The procedures for making transition welds between different materials or between plates or pipes of different wall thickness shall be qualified. Qualification for each welding procedure shall conform to the requirements of ASME B31.1, and to this specification. The method for each system shall be fully described including the number of beads, the volts, the amperes, and the welding rod for various pipe thicknesses and materials. The welding procedures shall specify end preparation for butt welds including cleaning, alignment, and root openings. Preheat, interpass temperature control, and post-heat treatment of welds shall be as required by approved welding procedures, unless otherwise indicated or specified. Approval of any procedure does not relieve the Contractor of the sole responsibility for
producing acceptable welds. Welding procedures shall be identified individually and shall be clearly referenced to the type of welding required for this project. These procedures shall be the same as those used for all pipe welder qualification tests, all shop welds, and all field welds. The Contractor shall provide Procedure Qualification Records for all proposed Welding Procedure Specifications (WPS).

5.2 Welding Procedure Submittals: Submit the following:

5.2.1 Welding Procedure Specifications: Provide for each weld type. It is highly recommended that the Contractor use ASME Form E00006, QW-482 "Suggested Format for Welding Procedure Specification (WPS)".

5.2.2 Procedure Qualification Records: Provide for each weld type. It is highly recommended that the Contractor use ASME Form E00007, QW-483 "Suggested Format for Procedure Qualification Record (PQR)".

5.3 Welder Qualification:

5.3.1 WPQs: Provide welder qualifications for each welder for each weld type. It is highly recommended that the Contractor use ASME Form E00008, QW-484 "Suggested Format for Manufacturer's Record of Welder or Welding Operation Qualification Tests (WPQ)". The WPQs shall be performed under the witness of an independent agency. The witness shall be a representative of an independent testing agency, Authorized Inspector, or consultant, any of which must be approved by the National Certified Pipe Welding Bureau. The qualifying test segment must be a 2 inch nominal pipe size with wall thickness within range of the WPS. Tests position shall be "6G" per ASME Section IX.

5.3.2 Evidence of Continuity: Welder qualifications must be current. If the qualification test is more than 6 months old, provide record of welding continuity for each welder. Record of welding continuity shall show that the welder in question has performed welding to the procedure in question without a 6-month continuous span of inactivity since the date that the welder qualification test was passed for the submitted welding procedure. Record of welding continuity shall include, at a minimum, the welder's employer name and address, the date the welder qualification test was passed, and the dates indicating welding continuity including welding procedure for each date.

5.4 Weld Records:

5.4.1 For all welding within the scope of ASME B31.1, the Contractor shall submit for approval an administrative procedure for recording, locating, monitoring, and maintaining the quality of all welds to be performed on the project. This quality control document record shall include but not be limited to drawings and schedules identifying location of each weld by individual number,
identification of welder who performed each weld by individual welder’s name, stamp number, date and WPS used.

.5.4.2 After achieving qualification, but before being assigned work, each qualified person shall be assigned an identifying number by the Contractor that shall be used to identify all of his welds. A list of qualified persons with their respective numbers shall be submitted by the Contractor and shall be maintained accurately with deletions and additions reported promptly.

.5.4.3 Upon completing a joint, the welder shall mark the pipe not more than 6 inches from the weld with the identifying number and the last two digits of the year in which the work was performed. Identification marks shall be made by using a rubber stamp or felt-tipped marker with permanent, weatherproof ink or other methods approved by the A/E that do not deform the metal. For seam welds, identification marks shall be placed adjacent to the welds at 3-foot intervals. Identification by die stamps or electric etchers will not be allowed. The markers are to be provided by the Contractor. Substituting a map of welds with welders’ names shall not be acceptable.

.5.5 Welder Pre-Qualification

.5.5.1 All welders shall be pre-qualified for this project by having the first weld tested via radiographic (RT) method by the independent testing agency (ITA), whose services shall be paid for by the Contractor. Acceptance standards shall be in accordance with Paragraph 136.4.5 of ASME B31.1. The procedure shall be in accordance with Article 2 of Section V of the ASME Boiler and Pressure Vessel Code. The ITA shall submit the written procedure as described in Paragraph T-221 of Article 2 of Section V of the ASME Boiler and Pressure Vessel Code. The ITA shall provide a report in accordance with Paragraph T-291 of Article 2 of Section V of the ASME Boiler and Pressure Vessel Code. All persons performing and evaluating radiographic examinations shall be certified for NDT Level II RT as recognized by the ANST. A nationally certified Level III RT technician per ANST shall be on staff at the testing laboratory. A Corporate Level III RT without National Certification is not acceptable. Welders shall do one weld and then have that weld tested and approved via RT before doing any more welding work. Maintain an active approved list with the University.

.6 DELIVERY, STORAGE, AND HANDLING

.6.1 Piping material shall be packaged in accordance with ASTM A 700 and as specified herein.

.6.2 Pipe Storage: Upon the receipt of each shipment of pipe on the job, the Contractor is responsible for maintaining the marking and for the storage of all pipe in such a manner that the ASTM material specifications and method of manufacture (seamless, etc.) of each piece of pipe will be clearly discernible at
the time of its installation in the system. If at the time of its installation any piece of pipe is not readily identifiable, it will be subject to rejection, or arbitrary downgrading by the A/E to the lowest grade which has been received on the job to that date.

.6.3 Provide factory-applied plastic end-caps on each length of pipe and tube, except for concrete, corrugated metal, hub-and-spigot, and clay pipe. Maintain end-caps through shipping, storage and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.

.6.4 Protect stored pipes and tubes. Elevate above grade and enclose with durable, waterproof wrapping. When stored inside, do not exceed structural capacity of the floor.

.6.5 Protect flanges, fittings, and specialties from moisture and dirt by inside storage and enclosure, or by packaging with durable, waterproof wrapping.

.6.6 Austenitic Stainless Steel Material: The following shall apply to handling, fabrication, and storage of austenitic stainless steel piping, tubing, and material to prevent surface contamination:

.6.6.1 Care shall be taken when handling stainless steel piping and tubing to minimize contact with carbon steel.

.6.6.2 Stainless steel material shall be protected against contact with lead, zinc, copper, and other low melting point materials.

.6.6.3 Tube cutters, grinding wheels, brushes, and files used to work on stainless steel material shall not have been previously used on other material.

.6.6.4 Brushes used on stainless steel shall have stainless steel bristles.

.6.6.5 Grinding wheels used on stainless steel shall be resin-bonded aluminum oxide or silicon carbide.

.6.6.6 Cutoff saws may be used on stainless steel material without special precautions, where followed by a grinding or machining operation.

.6.6.7 Carbon steel packing bands shall not be used in direct contact with stainless steel piping and tubing.

.6.6.8 Nylon slings shall be used in handling stainless steel material.

.6.7 External machined surfaces, flange facings, and bolt holes shall be protected against corrosion during shipment, storage, and installation with the application of one coat of water-soluble, rust-inhibiting coating.

.6.8 All edges prepared for field welding shall be protected against corrosion during shipment, storage, and installation with one coat of rust-inhibiting coating (deoxaluminate or University-approved equivalent) applied after inspection and cleaning.

PART 2 - PRODUCTS

.1 GENERAL

.1.1 Code: The fabrication and erection of all applicable piping shall conform to the latest edition and all current revisions of ASME Code for Power Piping B31.1. In addition, the fabrication and erection of all piping shall conform to all applicable Federal, State, and Local laws.
.1.2 Piping Materials: Provide all pipe and tube of type, joint type, grade, size and weight (wall thickness or Class) indicated for each service. Where type, grade or class is not indicated, provide proper selection as determined by the intended service use, comply with governing regulations and industry standards, and obtain approval from the A/E prior to any work.

.1.3 Pipe/Tube Fittings: Provide factory-fabricated fittings of type, materials, grade, class and pressure rating indicated for each service and pipe size. Provide sizes and types matching pipe, tube valve or equipment connection in each case. Where not otherwise indicated, comply with governing regulations and industry standards for selections as determined by the intended service use and install in accordance with pipe manufacturer's recommendations. In addition, obtain approval from the A/E before performing any work.

.1.4 All materials shall be submitted for review prior to being incorporated in the Work. Material for pipes, fittings, and accessories shall be new and in accordance with ASTM specifications. Welded attachments shall be made of material compatible with the piping. Where the material for a specific component is not specified, it shall be selected by the Contractor for review by the A/E. Material and equipment specified by brand or manufacturer are typical and designate the type, quality, and purpose of the items. Similar and equivalent items of equal standards may be accepted if, in the opinion of the A/E, they are equivalent in all important respects and are equally suitable for the purpose intended. The Contractor shall submit descriptive literature and secure the A/E’s written approval for any substitutions before orders are placed.

.2 PIPE IDENTIFICATION SYSTEM

.2.1 General: A system has been established which identifies the specific piping materials and, insulation, gaskets, and other components for each type of pipe identified in the Contract Drawings. The specific pipe specification is linked by the service number as listed in the "Piping, Gasket, Insulation, and Service Group Index", which appears in this Section.

.2.2 Pipe Identification System Description: The system used on the Contract Drawings to indicate the specific materials and construction required for each pipe line is illustrated by the following example.

.2.2.1 A typical pipe line may be called out as:

10" HPS, where:

- 10": Indicates nominal pipe size of line
- HPS: Is the abbreviation for the piping system contents and is the service group as depicted in the "Piping, Gasket, Insulation and Service Group Index". In this example the abbreviation is for Steam, High Pressure. In this example, the service group "HPS" requires Pipe Group 3, and Gasket Group "HP."
- Gasket groups are specified in detail in Section 33 63 45 - GASKETS.
- Pipe material and erection specification groups appear as subsections of this Section. For example in the above example the service group is "HPS" which according to the index
corresponds to Pipe Group 3: refer to Section 33 63 10.20
PIPING GROUP 3 - CARBON STEEL - HIGH PRESSURE STEAM
PIPE-HPS for the material and erection specification of this pipe line.

- Valve groups are identified and specified in Section 33 63 35 – VALVES.
- Insulation groups are specified in detail in Section 33 63 55 - PIPING INSULATION.

.3 PIPING, GASKET, INSULATION, AND SERVICE GROUP INDEX: THE FOLLOWING PAGES CONTAIN THE "PIPING, GASKET, INSULATION, AND SERVICE GROUP INDEX".

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.4 IMPULSE LINES

.4.1 Impulse lines for pressure gauges shall be per Piping System Specification of the PIPE GROUP as identified in the table shown in .3 PIPING, GASKET, INSULATION, AND SERVICE GROUP INDEX. However, regardless what is specified, impulse line for steam systems shall be socket-welded Schedule 80 ASTM A106 Seamless Carbon Steel.

PART 3 – EXECUTION

.1 GENERAL

.1.1 Inspection by the A/E and FOD Utilities: Material, equipment, design, and workmanship shall at all times be subject to the inspection of the A/E and FOD Utilities and, upon being notified in writing by the A/E, any material, equipment, or workmanship not meeting the specified requirements shall be replaced or reworked immediately without additional cost to the University.
Inspection by the A/E and/or FOD Utilities shall not relieve the Contractor from the responsibility for full compliance with the specified requirements.

.1.2 University-Furnished Drawings: The Drawings supplied by the University including the Contract Drawings are not intended to be fabrication drawings. Dimensions for pipe fabrication shall be field checked prior to fabrication.

.1.3 Do not interrupt utility services unless permitted in writing by the accountable University representative. Outages to existing utility systems must be planned and scheduled at least two weeks in advance. See outage procedure: https://ap.osu.edu/sites/default/files/utility_outage_procedures.docx

.2 PREPARATION

.2.1 Remove scale, slag, dirt, and debris for both inside and outside of piping and fittings before assembly.

.2.2 Conformance: The Contractor shall be responsible for checking and conforming to size, location, and flange drilling of all piping, valves, flow nozzles, and material furnished by the University for this piping installation.

.2.3 Measurement Verification by the Contractor: Before fabrication, the Contractor shall verify all measurements at the site and obtain all necessary additional information for completion of the Work, including the following:

.2.3.1 Actual location of weld nozzles, flanges, or other type of terminal connections and verification of weld nozzle ends and flange facings that are existing, to which the Contractor’s Work must connect.

.2.3.2 Exact location of existing piping with supports and hangers in place

.2.3.3 Exact location of new and existing structures and equipment

.2.3.4 Interferences and difficulties that may exist

.2.3.5 The Contractor shall take such field measurements and allow for such makeup lengths or closures necessary for accurate alignment and assembly.

.3 INSTALLATIONS

.3.1 General: Install pipes and pipe fittings in accordance with recognized industry practices which will achieve permanently-leak-proof piping systems, capable of performing each indicated service without piping failure. Install each run with minimum joints and couplings. Reduce sizes (where indicated) by use of reducing fittings. Align piping accurately at connections, within 0.05 inches misalignment tolerance.

.3.2 Piping Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location arrangement and restrictions of the piping systems. Location and arrangement of piping layout shall take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated.

.3.3 Piping Alignment:

.3.3.1 For piping systems between anchors that contain externally pressurized or slip-type (packed) expansion joints, use a laser to align the piping so that it is straight and that there will be no binding when the pipe thermally expands into the expansion joint. Use the laser alignment during fabrication of the piping system and when
adjusting pipe support, guide, expansion joint, and anchor vertical elevations. Laser alignment equipment shall remain attached to the piping system until approved to be removed by the A/E after the A/E has witnessed the alignment.

.3.3.2 Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.

.3.3.3 Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated on the Contract Drawings.

.3.3.4 Locate groups of pipes parallel to each other, spaced to permit applying full insulation, servicing of valves, and thermal expansion of piping systems.

.3.4 Install drains at low points in mains, risers, and branch lines consisting of a tee, reducing tee, weld-o-let, or soc-o-let fitting, applicable 3/4-inch shut-off valve, 3/4-inch nipple, and cap for pipe sizes 6 inches and smaller; provide 2-inch shut off valve, nipple, and cap for pipe sizes 8 inches and larger. All components shall conform to the piping systems described in this Section and to Section 33 63 35 –VALVES. The location of the high point vents and low point drains shall be approved by the A/E.

.3.5 Electrical Equipment Spaces: Do not run piping through transformer vaults and other electrical rooms or electronic equipment spaces and enclosures. In no instance shall piping be routed above electrical equipment.

.3.6 Interferences: Do not run piping or conduits through ducts or equipment cabinets.

.3.7 Shop Prefabrication:

.3.7.1 Where shop prefabrication is not specified but is done as the Contractor’s choice, any adjustments necessary due to inaccuracies in equipment setting and dimensions or location of existing obstructions shall be done at no additional cost. No shop fabrication sketches will be checked by the A/E, but Contractor shall submit drawings to the A/E for information.

.3.7.2 All shop fabrication shall be fabricated to dimensional tolerances in accordance with Pipe Fabrication Institute Standard ES-3. Accumulated tolerances between fixed points shall not exceed plus or minus 3/8 inch.

.3.8 Connections Equipment and Piping Specialties:

.3.8.1 Contractor shall erect and support piping in manner that shall not put undue strain on the equipment or piping specialty.

.3.8.2 The procedure for connection of piping to equipment or piping specialty shall be as follows:

.3.8.2.1 After the equipment piping specialty has been set and grouted, the Contractor shall run the pipe from the equipment.

.3.8.2.2 Flat faced flanges and full face gaskets shall be used on piping connecting to equipment with flat faced flanges.
Raised faces of standard flanges may be machined off flat to accomplish this. Bolting for these joints shall be per ASME B31.1.

.3.8.2.3 Flanges shall be checked by the A/E to assure that no strain is placed on the equipment. If pipe is not in correct alignment, the Contractor shall remove piping and correct. The correction in alignment shall not be made while the pipe is connected to the equipment.

.3.8.3 After alignment is found correct by the A/E, the Contractor shall bolt up the flanges.

.3.8.4 When required by the A/E after the equipment has been in service, tested at operating temperatures, and with the lines and equipment still hot, the Contractor shall loosen flange connections to pumps, tanks, and equipment, and check for alignment, position, expansion, and strain applied to the equipment; make any adjustments necessary, and obtain approval of the A/E before reconnecting.

.3.8.5 Provide temporary strainers as directed per Section 33 63 25-PIPING SPECIALTIES.

.3.9 Thermal Cutting: When thermal cutting is required, the material shall be in accordance with ASME B31.1 welding preheat requirements. Thermal cut surfaces shall be ground to remove all slag, oxide, and surface irregularities to 1/16 inch. Austenitic stainless steel pipe shall be cut by mechanical means only.

.3.10 Welded Attachments:

.3.10.1 Welded attachments shall include lugs, brackets, and similar devices welded to pipe for hangers, supports, and guides. Weld procedures used to attach such devices shall be compatible with the base material. Preheating shall be in accordance with ASME B31.1 requirements for piping material.

.3.10.2 All areas where lugs or attachments are removed or repaired shall be tested hydrostatically to meet accepted standards stated in ASME B31.1. Any linear indications shall be removed and the area retested. The procedure shall be repeated until no indications are noted.

.4 FITTINGS AND SPECIALTIES

.4.1 Use fittings for all changes in direction and all branch connections. For piping greater than 2 inch NPS, if the change in direction is less than 5 degrees, a miter is acceptable and must be provided in accordance with ASME B31.1. No miters are acceptable for angles greater than 5 degrees. For changes in direction greater than 5 degrees, cut a forged fitting. For pipe sizes 2 inch NPS and smaller, changes in direction shall be done with standard 45 and 90 degree elbows – no miters or cut fittings acceptable.
.4.2 Pipe Elbows: Provide pipe elbows where depicted on the Contract Drawings. Use long radius elbows except where specifically designated on the Contract Drawings.

.4.3 Branches: Wherever branch pipe is indicated, install type of fitting shown on Contract Drawings, i.e. forged branch connection fitting, regular "T" fitting, or reducing "T" fitting. If the type of fitting is not shown on the Contract Drawings or specified in the piping specifications, the Contractor may choose between the above mentioned fittings, within the limits of the following:

.4.3.1 Forged branch connection fittings may only be used if the smaller branch pipe is at least two standard nominal pipe sizes smaller than the larger main pipe.

.4.3.2 All fittings and procedures conform to the specific piping group specification as scheduled in this Section.

.4.3.3 The Contractor shall provide taps into existing mains that will remain energized at up to piping system design pressure where a hot tap is specifically indicated on the Contract Drawings. This procedure is also known as wet tapping. Hot or wet tapping shall be performed by experienced personnel with special hot tap fabrication equipment. All hot tapping shall be coordinated with the University. Hot tapping is only allowed where indicated on the Contract Drawings or by written approval from the University.

.4.4 Reducers: Unless explicitly stated on Contract Drawings, use forged fittings. Use concentric fittings except for steam systems, for reducers in horizontal in direction of flow, use eccentric flat on bottom to allow condensate to continue flowing in direction of steam travel.

.4.5 Install dielectric unions to connect piping materials of dissimilar metals in dry piping systems (gas, compressed air). Unions shall be rated for the design basis working pressure and temperature of the piping system per this specification.

.4.6 Refer to Section 33 63 25 - PIPING SPECIALTIES for specification of pipe specialties including steam traps, strainers, etc.

.5 JOINTS

.5.1 Threaded Joints:

.5.1.1 Thread pipe with tapered pipe threads in accordance with ANSI B1.20.1. Cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Immediately before erecting the piping, all threads on pipe and all fittings shall be thoroughly cleaned of cuttings, dirt, oil, or other foreign matter.

.5.1.2 Ordinary or special-type screwed joints shall be kept to a minimum to reduce any possibility of leakage. Continuous runs of piping shall be used, wherever possible. All screwed connections shall have full threads of true taper and shall be accurate to gauge. Only Teflon shall be used on threaded joints that have a design temperature less than 500°F. Pipe compound shall be used on threaded joints that
have a design temperature greater than 500°F. Care shall be taken to prevent obstruction of pipe or tubing when using Teflon tape.

.5.1.3 When screwed connections are specified to be seal welded, the pipe shall be threaded so that not more than one thread remains outside the joint. The pipe to be welded shall be cleaned to bare metal and free of oil, scale, and dirt. The joint shall be made up hand-tight, without tape, and shall be welded with not less than two light beads with the weld cleaned between successive passes. The seal weld shall completely cover the thread with no undercut on the pipe. Plugs to be installed in seal weld fitting shall be installed using Teflon tape, after all welding is complete.

.5.2 Welded Joints:

.5.2.1 General:

.5.2.1.1 Weld pipe joints only when ambient temperature is above 0°F where possible.

.5.2.1.2 Bevel pipe ends at a 37.5 degree angle where possible, smooth rough cuts, and clean to remove slag, metal particles, and dirt.

.5.2.1.3 Use pipe clamps or tack-weld joints with 1-inch long welds; 4 welds for pipe sizes to 10 inches, 8 welds for pipe sizes 12 inches to 20 inches.

.5.2.1.4 Build up welds with stringer-bead pass, followed by hot pass, followed by cover or filler pass. Eliminate valleys at center and edges of each weld. Weld by procedures which will ensure elimination of unsound or unfused metal, cracks, oxidation, blow-holes, and non-metallic inclusions.

.5.2.1.5 Do not weld-out piping system imperfections by tack-welding procedures; refabricate to comply with requirements.

.5.2.1.6 If piping component ends are bored, such boring shall not result in the finished wall thickness after welding less than the minimum design thickness.

.5.2.1.7 The inside diameters of piping components to be butt-welded shall be aligned as accurately as is practicable within existing commercial tolerances on diameters, wall thickness and out of roundness. Alignment shall be preserved during welding. The internal misalignment of the ends to be joined shall not exceed 0.05 inch.

.5.2.2 Welding Processes:

.5.2.2.1 All welding on metal piping systems shall be done using qualified welding and qualified welders and welding operators in accordance with Section IX of the ASME Boiler and Pressure Vessel Code.

.5.2.2.2 All welding shall be done by a process that is compatible with the work being welded and the working conditions.
Shielded metal-arc welding (SMAW) shall not be used on work less than 3/16 inch thick.

5.2.2.3 Where a specific welding process is called for in the piping group, it shall govern.

5.2.2.4 All stainless work shall use 316L electrodes for the filler metal except 304L for the PED piping. All stainless steel work less than 3/16 inch thick shall be welded by the gas tungsten-arc (GTAW) process with the backside purged. Work thicker than 3/16 inch shall have a root pass by the GTAW Process with the back purged and the balance of the weld may be completed by SMAW Process or any other suitable process.

5.2.2.5 The root pass for all steam piping shall be per the GTAW tungsten inert gas (TIG) method with E6010 and another hot pass with E6010. The E6010 can be substituted with ER-70S-2 or ER70S-3.

5.2.2.6 Pulse welding in the form of MIG (Metal Inert Gas) is not allowed for welds of this project. No spray welding is allowed.

5.2.3 Welding Grooves:

5.2.3.1 The ends of steel pipe and fittings to be erected with butt welded joints shall be beveled to form welding grooves in accordance with ANSI B16.25, except where otherwise noted in these Specifications, or on the Contract Drawings.

5.2.3.2 Welding grooves for butt welded joints in pipe of unequal wall thickness shall be beveled in accordance with ASME Code for Pressure Piping B31.1 - latest edition, latest revision and section that is applicable.

5.2.4 Backing Rings: Backing rings or consumable inserts shall not be used and are not allowed.

5.2.5 Cleaning of Welding: All slag or flux remaining on the bead of welding shall be completely removed before laying down the next successive bead and at the completion of the weld.

5.2.6 Preheating of Welded Joints: Pipe adjacent to joints before and during welding shall be preheated by any suitable method in accordance with the qualified welding procedure and in all cases shall be in accordance with ASME B31.1, Paragraph 131.

5.2.7 Weld Quality:

5.2.7.1 All welds shall have full penetration and complete fusion with a minimum of weld metal protruding on the inside of the pipe.

5.2.7.2 The finished weld contour shall be uniform, with the toe or edge of the weld merging smoothly into the base material. Butt welds shall have a slight reinforcement build-up gradually from the toe or edge toward the center of the pipe.
weld. The limitation on butt weld reinforcement shall be in accordance with ASME B31.1, Table 127.4.2 and shall apply separately to both inside and outside surfaces of the joint. Fillet welds may be slightly concave on the furnished surface.

.5.2.8 Identification of Welders: Refer to Quality Assurance paragraph of Part 1 of this Section.

.5.3 Socket Welding Joints: Where socket welding valves or fittings are used, the pipe shall be spaced with a minimum of 1/16-inch clearance between the end of the pipe and the socket so that no stresses will be imparted to the weld due to "bottoming" of the pipe in the socket. The fit between the socket and the pipe shall conform to applicable standards for socket weld fittings and in no case shall the inside diameter of the socket exceed the outside diameter of the pipe by more than 0.075 inches.

.5.4 Non-ferrous Pipe Joints:

.5.4.1 Brazed and Soldered Joints: For copper tube and fitting joints, braze joints in accordance with ASME B31.1.

.5.4.2 Thoroughly clean tube surface and inside surface of the cup of the fittings, using very fine emery cloth, prior to making soldered or brazed joints. Wipe tube and fittings clean and apply flux. Flux shall not be used as the sole means for cleaning tube and fitting surfaces.

.5.5 Flanged Joints:

.5.5.1 Joint and flange assembly personnel for the Contractor shall follow the most recent guidelines published for Pressure Boundary Bolted Flange Joint Assembly ASME PCC-1. The Contractor shall submit to the A/E a flange-assembly procedure that includes start-up re-torque procedures and engineering risk analysis as described in 10. d.

.5.5.2 Before assembly is started, the Contractor shall clean and examine flange and fastener contact surfaces. If applicable, remove all indications of the previous gasket installation from the gasket contact surfaces. Use approved solvents and/or soft-wire brushes, if required, for cleaning to prevent surface contamination and damage to existing surface finish. Avoid using carbon steel brushes on stainless steel flanges.

.5.5.3 Match flanges and provide proper alignment of all joint members within the piping system and at connections with valves and equipment where specified. Follow the Flange Joint Alignment Guidelines as specified in Appendix E of ASME PCC-1.

.5.5.4 Place a new gasket in position after determining the absence of unacceptable gasket sealing imperfections and flatness tolerance deviations, as well as joint alignment considerations.

.5.5.5 Protect gasket surfaces from inadvertent application of approved lubricants. Only apply approved lubricants to working surfaces with
the bolt/nut/washer. Lubricants shall be chemically compatible with the bolt/nut/washer materials. All bolts shall be well lubricated over the entire thread. Contractor shall use White Hi-Temp Anti-Seize by Loctite or approved equal bolt lubricant on steam system piping.

5.5.6 Once the flanges are aligned, install the gasket and install bolts and nuts so they are hand-tight with the marked ends of the bolts and nuts located on the same side of the joint and facing outward to facilitate inspections. Tighten the joint using either the torque increment rounds shown in ASME PCC-1 Table 2; and either the companion in ASME PCC-1 Table 4 or Table 4.1 cross-pattern tightening sequences when using a single tool as described in Section 11, or one of the alternative tightening procedures shown in Alternatives #1, #2, and #3 of Appendix F of the ASME PCC-1.

5.5.7 All bolts in flanged construction shall be uniformly tightened with proper tools only. Hammering and bumping are prohibited. Care shall be taken to secure uniform pressure on the gasket to avoid overstressing of the bolts, dishing of flanges, and compression of the gasket beyond limits.

5.5.8 All slip-on flanges are to be welded on front and back, no exceptions. Welding neck flanges shall be bored to match the attached pipe.

5.5.9 Contractor shall be sure to release any aligning devices used to align jointed assemblies.

5.5.10 Start-up re-torque (also referred to as hot torque) shall be performed to decrease the likelihood of leakage during operation. Start-up re-torque is performed on steam system piping, hot water piping, or when the temperature of the pipe contents are between 300°F and 450°F or within 24 hours of unit start-up if the joint temperature remains below 300°F. The start-up re-torque shall be performed in accordance with the following:

5.5.10.1 The ambient-temperature assembly Target Torque value should be adjusted to account for any change in nut factor with temperature.

5.5.10.2 Once the unit is brought online and the metal temperature is between 300°F and 450°F or within 24 hours of unit start-up if the joint temperature remains below 300°F, then contractor shall proceed in a cross pattern and retighten each bolt to the specified torque in ASME PCC-1. The use of multi-tool tightening on opposing bolts is acceptable, but a cross pattern should be used.

5.5.10.3 Continue tightening in the cross pattern until the nuts no longer turn.

5.5.10.4 An engineering and risk analysis of the proposed start-up re-torque operation shall be carried out by the installing Contractor to establish that the operation can be performed safely. The Contractor shall take into account...
CLEANING, FLUSHING, INSPECTING

.6.1 General: Clean exterior surfaces of installed piping systems of superfluous materials, and prepare for application of specified coatings (if any). Inspect each run of each system for completion of joints, supports, and accessory items.

.6.2 Flush out and clean and then treat and refill the chilled water piping systems with a cleaning contractor. Contractor shall provide a cleaning procedure and treatment program for review and approval by the Architect/Engineer and FOD Utilities. Before proceeding, inspect each run of each system for completion of joints, supports, and accessory items.

.6.3 Provide steam blow for steam piping per Section 33.63.15 – STEAM BLOWING.

.6.4 The PCR piping receives no steam blow or flushing.

PIPING TESTS - HYDROSTATIC

.7.1 All non-boiler external piping shall be hydrostatically tested in accordance with Paragraph 137 of the ASME B31.1 Power Piping Code.

.7.2 General:

.7.2.1 Provide temporary equipment for testing, including pump and gauges. The gauge shall be accurate to within 3 PSIG and shall be calibrated within six months of the test as recorded on a sticker on the gauge. Test piping system before insulation is installed. Pressure testing shall be performed following the completion of post-weld heat treatment, nondestructive examinations, and all other fabrication, assembly, and erection activities required to provide the system or portions thereof subjected to the pressure test with pressure retaining capability. Remove control devices before testing. Test each natural section of each piping system independently but do not use piping system valves to isolate sections where test pressure exceeds valve pressure rating. Fill each section with water and pressurize for indicated pressure and time. The Contractor shall provide air vents at all high points in the system to purge air pockets while the system is filling.

.7.2.2 The Contractor shall test each section of pipe before it is insulated and buried. Provide temporary piping including welded caps prior to the termination into existing piping so that new piping can be hydrostatically tested without having cold water against an active hot valve. After successfully hydrostatic testing, remove the temporary piping and caps and provide new piping to tie into existing piping. It is recognized that the final connection pieces to existing piping will not be hydrostatically tested; however, flow (at normal operating pressure) shall be established through the final
connection pieces and fittings, with no visual evidence of weeping or leakage, prior to insulation and burial.

.7.2.3 Air or other gas testing is not acceptable.

.7.3 Test Pressure:

.7.3.1 Test all steam, condensate, and pumped condensate at 1-1/2 times the design pressure listed in the table in Section .3 PIPING, GASKET, INSULATION, AND SERVICE GROUP INDEX. For example, for HPR, the design pressure is 200 PSIG. Therefore, the test pressure shall be 300 PSIG.

.7.3.2 The test pressure shall be continuously maintained for a minimum time of 4 hours. During this 4-hour period, no pressure drop shall be measured. After the 4-hour period, if necessary, the pressure may then be reduced to design pressure and held for such time as may be necessary to continue to conduct the examinations for leakage. Examinations for leakage shall be made of all joints and connections. The piping system shall show no visual evidence of weeping or leaking. Hydrostatic testing shall be witnessed by the University or Engineer. After any leaks are found and corrected, the test shall be repeated.

.7.4 Test Blinds:

.7.4.1 If during the field testing of piping it becomes necessary to insert test blinds in any part of this piping, the Contractor shall provide test blinds and all work required including the flanges and welding of flanges.

.7.4.2 Test blinds shall be equipped with a long handle.

.7.4.3 The Contractor shall submit a written description of the location of test blinds before testing.

.7.4.4 The Contractor shall remove all test blinds after testing.

.7.5 Repair piping systems sections which fail required piping test, by disassembly and re-installation, using new materials to extent required to overcome leakage. Do not use chemicals, stop-leak compounds, mastics, or other temporary repair methods.

.7.6 Records:

.7.6.1 It is the responsibility of the Contractor to keep accurate, updated records of all hydrostatic testing. The Contractor shall submit a final log of all hydrostatic testing for the Owner's records.

.7.6.2 The Contractor shall maintain a constantly updated list of the following for all hydrostatic tests:

.7.6.2.1 Date and time of test

.7.6.2.2 Hydrostatic test pressure

.7.6.2.3 Piping system tested

.7.6.2.4 Extent of piping system tested so that it can be clearly identified up to what point a piping system has been tested.
.7.6.2.5 Test results. All failures shall be indicated with the cause explicitly stated.
.7.6.2.6 Signed witnesses of each test which shall be one employee of the Contractor and by the Engineer

.8 PIPING TESTS - VISUAL EXAMINATION
.8.1 General: Visually examine all pipe welds per ASME B31.1. As described below, visual examination of welds shall be performed by the Contractor. This type of testing is required by the code and shall not be paid for by the A/E.
.8.2 Acceptance Standards:
   .8.2.1 The acceptance standards for visual examination shall be as defined in ASME B31.1, Paragraph 136.4.2.A, and are repeated here for convenience. The following indications are unacceptable:
   - Cracks-external surface
   - Undercut on surface which is greater than 1/32-inch deep
   - Weld reinforcement greater than that specified in Table 127.4.2. of ASME B31.1
   - Lack of fusion on surface
   - Incomplete penetration (applies only when inside surface is readily accessible)
   - Any other linear indications greater than 3/16 inch long
   - Surface porosity with rounded indications having dimensions greater than 3/16 inch or four or more rounded indications separated by 1/16 inch or less edge to edge in any direction. Rounded indications are indications which are circular or elliptical with their length less than three times their width
   .8.2.2 In addition, acceptance will also be based on the proper lay-out, materials, and methods, as specified.

.8.3 Failed Welds:
   .8.3.1 All welds not passing visual examination shall be repaired or replaced at no expense to the University.
   .8.3.2 Visual defects found shall require additional VT as recommended by inspector.
   .8.3.3 Do not begin to repair or replace the weld until the weld report has been submitted to the A/E and the A/E gives approval for repairing the weld with the method that the Contractor proposes. Repair shall be performed using the qualified welding procedures applicable to the original weld.

.8.4 Reporting:
   .8.4.1 Reports for visual examinations of welds shall be required for all piping larger than 3 inch NPS except for vent and drain services. Reports preformed for visual examinations by the Contractor are not required to be submitted, but shall be kept available for review at any time by the University or A/E.
.8.4.2 Each weld report shall include the following:
.8.4.2.1 Date of weld examination
.8.4.2.2 Type of examination
.8.4.2.3 Examiner's name
.8.4.2.4 Welders' names including all persons who worked on the weld and their work involved
.8.4.2.5 Piping system
.8.4.2.6 Weld location
.8.4.2.7 Weld procedure and materials
.8.4.2.8 Materials and dimensions of items that were welded
.8.4.2.9 Visual examination results

.8.5 Examiners' Qualifications:
.8.5.1 All persons performing visual examinations and evaluating examinations shall be certified according to AWS QC1 or those requirements stated explicitly in ASME B31.1. It is not intended to have a third party inspector perform this service.
.8.5.2 Credentials and certification of all examiners must be submitted and approved prior to an examiner performing the initial examination.

.8.6 Visual Examination Requirements:
.8.6.1 Welds designated for visual examination shall be examined after the weld is completed for cracks, contour and finish, bead reinforcement, undercutting, overlap, size of fillet welds, finished weld appearance, weld size, weld length, dimensional accuracy of weldment, and monitor post weld heat treatment.
.8.6.2 Records of visual examinations must be kept as described in this Section.
.8.6.3 Shop fabricated welds may be examined in the shop prior to arrival at the project site provided all other conditions of this Section are satisfied.

.8.7 Examiner's Scope:
.8.7.1 Visual examinations to be performed by the Contractor may be performed and interpreted by an employee or employees of the Contractor, provided that each individual is certified as specified. As an option, the Contractor may obtain the services of an independent testing agency to perform these examinations.
.8.7.2 If the Contractor elects to utilize the services of an independent testing agency to perform any visual examinations, the following applies:
.8.7.2.1 The qualifications for the personnel of the independent testing agency performing the examinations shall be submitted.
.8.7.2.2 The Contractor shall provide all required access and lighting for the independent testing agency.
.8.7.2.3 The Contractor shall be responsible for all of the independent testing agencies activities, including handling submittals, performing evaluations at the required times, etc.

.8.7.3 A welder who has performed any work with regard to a specific weld shall not perform the visual examination of the same weld.

.9 PIPING TESTS – MAGNETIC PARTICLE (MT)

.9.1 General: The A/E will direct an independent testing agency to examine pipe welds using the magnetic particle method as indicated in the “Nondestructive Testing Requirements Index”, located in this Section. Where MT is designated, butt welds, socket welds, and welded branch connections for sizes NPS 2 and less will be examined per the requirements specified herein on the root and cap passes. Magnetic Particle testing will be paid for by the A/E except for retests for failed welds which shall be paid for by the Contractor.

.9.2 Acceptance Standards: Will be in accordance with Paragraph 136.4.3 of ASME B31.1. The A/E may, at his sole discretion, elect to waive some of the acceptance standards on a case-by-case basis.

.9.3 Procedure:

.9.3.1 Magnetic particle examination will be performed in accordance with Article 7 of Section V of the ASME Boiler and Pressure Vessel Code.

.9.3.2 The procedure will be as described in Paragraph T-721 of Article 7 of Section V of the ASME Boiler and Pressure Vessel Code.

.9.4 Reporting:

.9.4.1 The report of each magnetic particle examination will be submitted to the A/E and the University within 2 working days of the examination by the ITA.

.9.4.2 In addition to the requirements of Paragraph T-761 of Article 7 of Section V of the ASME Boiler and Pressure Vessel Code, each weld report will include the following:

.9.4.2.1 Date of weld examination
.9.4.2.2 Type of examination
.9.4.2.3 Examiner's name
.9.4.2.4 Welders' names including all persons who worked on the weld and their work involved
.9.4.2.5 Pipe system
.9.4.2.6 Weld location
.9.4.2.7 Weld procedure and materials
.9.4.2.8 Materials and dimensions of items that were welded
.9.4.2.9 Magnetic particle examination results

.9.5 Examiner's Qualifications: All persons performing and evaluating magnetic particle examinations will be certified for NDT Level II MT as recognized by the ANST. A Nationally Certified Level III MT technician per ASNT shall be on staff
at the testing laboratory. A Corporate Level III MT without National Certification is not acceptable.

.9.6 Magnetic Particle Examination Requirements:

.9.6.1 The A/E will be responsible for obtaining and paying for the services of the independent testing agency, except for retesting of failed welds which shall be paid by the Contractor. The Contractor is responsible for providing access to the welds for the Independent Testing Agency.

.9.6.2 When a limited number of welds are specified (not 100%), the welds to be examined shall be random. The A/E will designate the specific welds that are to be randomly tested as the job is in progress.

.9.6.3 It is suggested to the Contractor that the Contractor should notify the A/E when welds that require scaffolding are complete so that the Contractor will not have to re-build scaffolding to gain access to the welds.

.9.6.4 Shop fabricated welds will be examined in the field.

.9.7 Failed Welds:

.9.7.1 All welds not passing magnetic particle examination shall be repaired or replaced at no expense to the University or A/E.

.9.7.2 Do not begin to repair or replace the failed weld until the weld report has been submitted to the A/E and University and the A/E gives approval for repairing the weld with the method that the Contractor proposes. Repair shall be performed using the qualified welding procedures applicable to the original weld.

.9.7.3 All failed welds discovered by magnetic particle examination will be re-examined by magnetic particle examination after the weld is repaired or replaced at no additional cost to the University or A/E with the report being submitted to the A/E and the University within 2 working days of the examination which shall reference the repair of the particular weld.

.10 PIPING TESTS - ULTRASONIC EXAMINATION (UT)

.10.1 General: The A/E will direct an independent testing agency to ultrasonically examine pipe welds as indicated in the "Nondestructive Testing Requirements Index", located in this Section. Where Ultrasonic testing (UT) is designated, it will be performed on piping sizes larger than 2 inch NPS. UT will be paid for by the A/E except for retests for failed welds which shall be paid for by the Contractor.

.10.2 Acceptance Standards: Shall be in accordance with Paragraph 136.4.6 of ASME B31.1. The A/E and University may, at their sole discretion, elect to waive some of the acceptance standards on a case by case basis.

.10.3 Procedure:

.10.3.1 Ultrasonic examination will be performed in accordance with Article 5 of Section V of the ASME Boiler and Pressure Vessel Code.

.10.3.2 The procedure will be as described in Paragraph T-593 of Article 5 of Section V of the ASME Boiler and Pressure Vessel Code.
.10.4 Reporting:
   .10.4.1 The report of each ultrasonic examination will be submitted to the A/E and University within 2 working days of the examination.
   .10.4.2 In addition to the requirements of Paragraph T-593 of Article 5 of Section V of the ASME Boiler and Pressure Vessel Code, each weld report will include the following:
      .10.4.2.1 Date of weld examination
      .10.4.2.2 Type of examination
      .10.4.2.3 Examiner's name
      .10.4.2.4 Welders' names including all persons who worked on the weld and their work involved
      .10.4.2.5 Pipe system
      .10.4.2.6 Weld location
      .10.4.2.7 Weld procedure and materials
      .10.4.2.8 Materials and dimensions of items that were welded
      .10.4.2.9 Ultrasonic examination results

.10.5 Examiner's Qualifications: All persons performing and evaluating ultrasonic examinations will be certified for NDT Level II as recognized by the American Society for Nondestructive Testing (ANST).

.10.6 Ultrasonic Examination Requirements:
   .10.6.1 The A/E shall be responsible for obtaining and paying for the services of the independent testing agency, except for retesting of failed welds which shall be paid for by the Contractor. The Contractor is responsible for providing access to the welds for the Independent Testing Agency.
   .10.6.2 When a limited number of welds are specified (not 100%), the welds to be examined shall be random. The A/E will designate the specific welds that are to be randomly tested as the job is in progress.
   .10.6.3 It is suggested to the Contractor that the Contractor should notify the A/E when welds that require scaffolding are complete so that the Contractor will not have to re-build scaffolding to gain access to the welds.
   .10.6.4 Shop fabricated welds will be examined in the field.

.10.7 Failed Welds:
   .10.7.1 All welds not passing ultrasonic examination shall be repaired or replaced at no expense to the University or A/E.
   .10.7.2 Do not begin to repair or replace the failed weld until the weld report has been submitted to the A/E and the A/E gives approval for repairing the weld with the method that the Contractor proposes.
   .10.7.3 All failed welds discovered by ultrasonic examination shall be re-examined by ultrasonic examination after the weld is repaired or replaced at no additional cost to the University with the report being submitted to the A/E and the University within 2 working days.
of the examination which shall reference the repair of the particular weld.

.11 NONDESTRUCTIVE TESTING REQUIREMENTS INDEX: THE NONDESTRUCTIVE TESTING REQUIREMENTS INDEX IS LISTED BELOW: “NR” MEANS “NOT REQUIRED.”

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>LINE DESCRIPTION &amp; DESIGN CONDITIONS</th>
<th>VISUAL</th>
<th>MT</th>
<th>UT</th>
<th>SERVICE GROUP ON DWGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>EQUIPMENT DRAIN, PUMPED</td>
<td>50 PSIG at 212°F Max., from Sump Pump Discharge in Trenches</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>PED</td>
</tr>
<tr>
<td>CONDENSATE, HIGH PRESSURE</td>
<td>200 PSIG at 600°F Max., from HPS to PC System</td>
<td>100%</td>
<td>NR</td>
<td>NR</td>
<td>HPR</td>
</tr>
<tr>
<td>CONDENSATE, PUMPED</td>
<td>200 PSIG at 388°F Max., Returned Condensate from Campus and Manhole Pumps to Plant</td>
<td>100%</td>
<td>NR</td>
<td>NR</td>
<td>PCR</td>
</tr>
<tr>
<td>STEAM, HIGH PRESSURE</td>
<td>200 PSIG at 600°F Max., HPS Campus Distribution</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>HPS</td>
</tr>
<tr>
<td>CHILLED WATER SUPPLY AND RETURN</td>
<td>150 PSIG at 140°F Max., Chilled water from/to chiller plants and buildings</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>CWS &amp; CWR</td>
</tr>
</tbody>
</table>

.12 OPERATING TEST AND FINAL INSPECTION

.12.1 New utility piping systems shall not be placed in service if these Standards are not met or if the design or A/E approved equipment or installation fails these Standards or inspections by the authority having jurisdiction.

.12.2 A structured inspection and review process shall be followed per the Utility Service Connection and Inspection Standards:

https://fod.osu.edu/sites/default/files/utility_service.pdf

Checklists are available from FOD Utilities. Pre in-service checks include cleaning, pressure testing, insulation, painting, and identification.

.12.3 Upon completion of pre-service tests, the work shall be tested by an operating test performed by the University under normal service conditions.

.12.4 Upon completion of each operating test, the Contractor shall correct loose or faulty hangers and shall provide required devices to eliminate sway or vibration of piping.

.13 INSULATION, PAINTING, AND IDENTIFICATION
.13.1 Insulate all piping as indicated in Section 33 63 55 - PIPING INSULATION.
.13.2 Piping identifications shall be in accordance with Section 33 63 50 –
IDENTIFICATION FOR PIPING AND EQUIPMENT.
.13.3 Paint piping systems in accordance with Section 33 63 50 – IDENTIFICATION
FOR PIPING AND EQUIPMENT.
.13.4 Internal Cleaning of Piping: Refer to Part 3-Execution; Section .6 CLEANING,
FLUSHING, INSPECTING.

33 63 10.2 PIPING GROUP 2 – CARBON STEEL - CHILLED WATER SUPPLY AND RETURN
PIPE – CWS and CWR

.1 DESIGN BASIS
.1.1 Working pressure, 100 psig at 140°F.
.1.2 Piping Group 2 – Carbon Steel.

.2 PIPE
.2.1 All pipes shall be ASTM A 106 or ASTM A 53, Grade B, Type S, seamless Pipe
wall thickness shall be as follows:
1" through 24" Schedule 40

.3 JOINTS
.3.1 Joints 2 inches and smaller shall be screwed.
.3.2 Joints 2-1/2 inches and larger shall be butt welded.
.3.3 All sizes shall be flanged where shown on the Contract Drawings or where
required to connect to flanged valves, fittings, or equipment.

.4 STRESS RELIEVING
.4.1 Stress relieving and pre and/or post weld heat treatment is not required.

.5 FABRICATION AND ERECTION
.5.1 Fabrication and erection shall be in accordance with Section 33 63 10 –
COMMON WORK RESULTS FOR PIPING.

.6 TESTING
.6.1 Testing shall be in accordance with Section 33 63 10 – COMMON WORK
RESULTS FOR PIPING.

.7 FLANGES
.7.1 Flanges 24 inches and smaller shall be Class 150 welding neck type in
accordance with ANSI B16.5 and raised faced as required to match the mating
flange. Material shall conform to ASTM A 105. Welding neck flanges shall be
bored to match the same ID as the attached pipe.

.8 FITTINGS
.8.1 Fittings 2 inches and smaller shall be 150 pound screwed banded malleable
iron in accordance with ANSI B16.3. Material shall conform to ASTM A 197.
.8.2 Fittings 2-1/2 inches and larger shall be steel, butt welded type in accordance with ANSI B16.9 and with the same wall thickness as the attached pipe. Material shall conform to ASTM A 234, Grade WPB.

.9 BOLTING MATERIALS
.9.1 Bolting materials shall be mild steel, hexagonal head bolts with heavy hexagonal nuts conforming to ASTM A 307, Grade B.

.10 UNIONS
.10.1 Unions 2 inches and smaller shall be 150 pound malleable iron, brass seat, nut type. Material shall conform to ASTM A 197.
.10.2 Unions 2-1/2 inches and larger shall be made with flanges.

33 63 10.20 PIPING GROUP 3 – CARBON STEEL - HIGH PRESSURE STEAM PIPE - HPS

.1 DESIGN BASIS
.1.1 Design minimum working pressure and temperature: 200 psig and 600°F.
.1.2 Piping Group 3 – Carbon Steel Pipe.

.2 PIPE
.2.1 All pipe through 16 inches shall be seamless carbon steel conforming to ASTM A53 Grade B Type S or ASTM A 106 Grade B Type S. Pipe wall thickness shall be as follows:

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Wall Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 through 16 inches</td>
<td>Schedule 40 (Hard Schedule 40, not “STD”)</td>
</tr>
</tbody>
</table>

.2.2 All threaded pipe nipples shall be Schedule "XSTG" conforming to ASTM A 106, Grade B.

.3 JOINTS
.3.1 Joints 2 inches and smaller shall be socket welded.
.3.2 Joints 2-1/2 inches and larger shall be butt welded.
.3.3 All sizes shall be flanged where shown on the Contract Drawings or where required to connect to flanged valves, fittings, or equipment.

.4 STRESS RELIEVING
.4.1 Stress relieving and pre and/or post weld heat treatment is not required.

.5 FABRICATION AND ERECTION
.5.1 Fabrication and erection shall be in accordance with Section 33 63 10 – COMMON WORK RESULTS FOR PIPING.

.6 TESTING
.6.1 Testing shall be in accordance with Section 33 63 10 – COMMON WORK RESULTS FOR PIPING.

.7 FLANGES
.7.1 Flanges shall be Class 300 welding neck type in accordance with ANSI B16.5 and raised. Material shall conform to ASTM A 105. Welding neck flanges shall be bored to match the same ID as the attached pipe.

.8 FITTINGS
.8.1 Fittings 2 inches and smaller shall be 3000 pound socket-weld in accordance ANSI B16.11. Material shall conform to ASTM A 105.
.8.2 Fittings 2-1/2 inches and larger shall be seamless forged steel, butt-welding type in accordance with ANSI B16.9 and with the same wall thickness as the attached pipe. Material shall conform to ASTM A 234, Grade WPB.

.9 BOLTING MATERIALS
.9.1 Bolting shall consist of a bolt head which requires one nut on the opposite side on the threaded end in accordance with ANSI B1.1, Class 2A. Material shall conform to ASTM A354 Grade BD. Nuts shall be heat-treated, heavy, hexagonal nuts, semi-finished and in accordance with ANSI B18.2.2 and B1.1, Class 2B. Material shall conform to ASTM A 194, Grade 2H.

.10 UNIONS
.10.1 Unions 2 inches and smaller shall be 3000 pound forged steel socket weld with steel to steel seats. Material shall conform to ASTM A 105.
.10.2 Unions 2-1/2 inches and larger shall be made with flanges.

PIPING GROUP 90 – TYPE 304L STAINLESS STEEL PIPE

.1 DESIGN BASIS
.1.1 Working pressure, 408 psig at 600°F

.2 PIPE
.2.1 All pipe shall be seamless stainless steel conforming to ASTM A312 Type TP304L. The wall thickness shall be as follows:
1 through 8 inches Schedule 10S

.2.2 The supplier or fabricator shall submit mill chemical and physical test reports of material.
.2.3 Any pipe delivered for incorporated in the work which shows any signs of improper welding techniques, signs of rust, or other forms of corrosion will be rejected.

.3 JOINTS
.3.1 Joints 2 inches and smaller shall be socket welded.
.3.2 Joints 2-1/2 inches and larger shall be butt welded.
.3.3 All sizes shall be flanged where shown on the Contract Drawings or where required to connect to flanged valves, fittings, or equipment.

.4 STRESS RELIEVING
.4.1 Stress relieving and pre and/or post weld heat treatment is not required.
.5 FABRICATION AND ERECTION
   .5.1 Fabrication and erection shall be in accordance with Section 33 63 10 – COMMON WORK RESULTS FOR PIPING.

.6 TESTING
   .6.1 Testing shall be in accordance with Section 33 63 10 – COMMON WORK RESULTS FOR PIPING.

.7 FLANGES
   .7.1 Flanged joints shall be lap joint style. Material shall conform to ASTM Specification A 182, F304L. Flanges shall be ANSI Class 150, ANSI B16.5.

.8 FITTINGS
   .8.1 2 Inches and Smaller: Fittings shall be socket weld type, Class 3000, in accordance with ANSI B16.11 and of the same thickness as the attached pipe. Material shall conform to ASTM A182, F304L.
   .8.2 2-1/2 Inches and Larger: Fittings shall be stainless steel butt-welded type in accordance with ANSI B16.11 and with the same wall thickness as the attached pipe. Material shall conform to ASTM A 403, Grade WP 304L.

.9 BOLTING MATERIALS
   .9.1 Bolting shall consist of a bolt head which requires one nut on the opposite side on the threaded end in accordance with ANSI B1.1, Class 2A. Bolting materials shall be ASTM A193, Grade B7. Nuts shall be heavy series, hexagon, carbon steel, ASTM A194 Grade 2H, dimensional requirements per ANSI B18.2.2.

.10 UNIONS
   .10.1 Unions 2 inches and smaller shall be 3,000 pound forged stainless steel socket weld with stainless steel seats.
   .10.2 Unions 2-1/2 inches and larger shall be made with flanges.

33 63 10.94 PIPING GROUP 94 – TYPE 316L STAINLESS STEEL - HIGH PRESSURE AND PUMPED CONDENSATE PIPE – HPR AND PCR

.1 DESIGN BASIS
   .1.1 Design minimum working pressure and temperature: 200 psig and 600°F.
   .1.2 Piping Group 94 – Type 316L Stainless Steel.

.2 PIPE
   .2.1 All pipe shall be seamless stainless steel conforming to ASTM A312 Type TP316L. The wall thickness shall be as follows:
      1 through 8 inches Schedule 40S
   .2.2 The supplier or fabricator shall submit mill chemical and physical test reports of material.
.2.3 Any pipe delivered for incorporated in the work which shows any signs of improper welding techniques, signs of rust, or other forms of corrosion will be rejected.

.3 JOINTS
.3.1 Joints 2 inches and smaller shall be socket welded.
.3.2 Joints 2-1/2 inches and larger shall be butt welded.
.3.3 All sizes shall be flanged where shown on the Contract Drawings or where required to connect to flanged valves, fittings, or equipment.

.4 STRESS RELIEVING
.4.1 Stress relieving and pre and/or post weld heat treatment is not required.

.5 FABRICATION AND ERECTION
.5.1 Fabrication and erection shall be in accordance with Section 33 63 10 – COMMON WORK RESULTS FOR PIPING.

.6 TESTING
.6.1 Testing shall be in accordance with Section 33 63 10 – COMMON WORK RESULTS FOR PIPING.

.7 FLANGES
.7.1 Flanged joints shall be weld neck joints. Material shall conform to ASTM Specification A 182, F316L. Flanges shall be ANSI Class 300, ANSI B16.5.

.8 FITTINGS
.8.1 2 Inches and Smaller: Fittings shall be socket weld type, Class 3000, in accordance with ANSI B16.11 and of the same thickness as the attached pipe. Material shall conform to ASTM A182, F316L.
.8.2 2-1/2 Inches and Larger: Fittings shall be stainless steel butt-welded type in accordance with ANSI B16.11 and with the same wall thickness as the attached pipe. Material shall conform to ASTM A 403, Grade WP 316L.

.9 BOLTING MATERIALS
.9.1 Bolting shall consist of a bolt head which requires one nut on the opposite side on the threaded end in accordance with ANSI B1.1, Class 2A. Bolting materials shall be ASTM A193, Grade B7. Nuts shall be heavy series, hexagon, carbon steel, ASTM A194 Grade 2H, dimensional requirements per ANSI B18.2.2.

.10 UNIONS
.10.1 Unions 2 inches and smaller shall be 3,000 pound forged stainless steel socket weld with stainless steel seats.
.10.2 Unions 2-1/2 inches and larger shall be made with flanges.

33 63 13.94 UNDERGROUND CONDENSATE DISTRIBUTION PIPING
PART 1 - GENERAL

2006 Edition, Published January 1, 2006; Division Revision Date: February 7, 2017
.1 RELATED DOCUMENTS
  .1.1 Contract Drawings and General Provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections apply to this Section.

.2 DESCRIPTION OF WORK
  .2.1 All underground condensate lines, as indicated on contract drawings, shall be Class A testable, drainable, and dryable. The system supplier shall have fabricated systems of the composition herein for at least three years. All straight sections, fittings, anchors, and other accessories shall be factory prefabricated to job dimensions and designed to minimize the number of field welds. Each system layout shall be computer analyzed by the piping system manufacturer to determine the stresses on the carrier pipe and anticipated thermal movement of the service pipe. The system design shall be in strict conformance with ASME B31.1, latest edition. Factory trained field technical assistance shall be provided for the critical periods of installation, i.e., unloading, field joint instruction, and testing. The preapproved conduit system shall include all piping and components to a point twelve inches inside the building, or manhole wall.

  .2.2 The system suppliers’ representative shall be responsible for directing the installation and testing of the conduit system. It shall be certified in writing by the supplier that the representative is technically qualified and experienced in the installation of the systems. The supplier’s representative shall be present during the following work phases:

  • Inspection and unloading
  • Inspection of trench prior to laying of conduit
  • Inspection of expansion loops
  • Inspection of joining of system
  • Air test (conduit)
  • Repair of any patchwork
  • Back filling of conduit sections

  .2.3 The contractor shall not perform any of the above stated work in the absence of the system supplier's representative.

  .2.4 The contractor performing the work shall be responsible for the installation of the preapproved system and all other components of the underground condensate conduit systems, including the manholes and the piping equipment in the manholes and buildings. This responsibility shall include all site work and purchase of the preapproved system from the system supplier.

.3 SUBMITTALS
  .3.1 Refer to Division 1 and Common Work Results for Mechanical for administrative and procedural requirements for submittals.

  .3.2 Product Data: Submit manufacturer's technical product data, including installation instructions, and dimensioned drawings for the type of manufactured piping specialty.
.3.3 Shop Drawings: Submit for fabricated specialties, indicating details of fabrication, materials, and method of support. A complete engineering stress analysis indicating all anchors, fittings, dimensions in three axes, thermal movement calculations, maximum anticipated stresses and maximum allowable stresses must be submitted.

.3.4 Maintenance Data: Submit maintenance data and spare parts lists for each type of manufactured piping specialty. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 1.

.3.5 Quality Control Submittals:
   .3.5.1 Submit welders’ certificates specified in Quality Assurance below.
   .3.5.2 Welding procedures

.3.6 Excavation Support and Protection:
   .3.6.1 Prior to starting work, submit for review and approval, calculations, and shop drawings showing each proposed method of supporting adjacent earth and structures; i.e. retention system and other methods of bracing. Include the following:
      .3.6.1.1 Lists of material to be used, including design mixes
      .3.6.1.2 Sequence of operations
      .3.6.1.3 Detailed sections clearly illustrating the scope of work
      .3.6.1.4 Relationship of piles, lagging, walls, and bracing to new and existing structures
      .3.6.1.5 Location of utilities and details of support when required
      .3.6.1.6 Procedures and details of testing

   .3.6.2 Shop drawings and calculations: Prepared by qualified Licensed Professional Engineers registered in the State of Ohio and bearing their seals and signatures.

   .3.6.3 Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of complete projects with project names and addresses, names and addresses of architects and the owners, and other information specified.

   .3.7 Photographs or videotape, sufficiently detailed, of existing conditions of adjoining construction and site improvements that might be misconstrued as damage caused by excavation support and protection systems.

.4 QUALITY ASSURANCE
   .4.1 Welder’s Qualifications: All welders shall be certified in accordance with ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing qualifications.


   .4.3 Excavation Support and Protection:
.4.3.1 Comply with the Publications of the following agencies to the extent referenced and applicable:
- AISC - American Institute of Steel Construction.
- OSHA - Occupational Safety and Health Act.

.4.3.2 Installer Qualifications: Engage an experienced installer to assume engineering responsibility and perform work of this Section who has specialized in installing excavation support and protection systems similar to those required for this Project and with a record of successful in-service performance.

.4.3.3 Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in the State of Ohio and who is experienced in providing engineering services for designing excavation support and protection systems that are similar to those indicated for this Project in material, design, and extent.

.4.3.4 Engineering Responsibility: Engage a qualified professional engineer to prepare or supervise the preparation of data for the excavation support and protection system including drawings and comprehensive engineering analysis that shows the system's compliance with specified requirements.

.4.3.5 Do not install excavation support and protection system until successfully reviewed by AE.

.5 JOB CONDITIONS
.5.1 Before starting work, check and verify governing dimensions and elevations. Survey condition of adjoining surfaces. Photograph existing conditions to record any prior settlement or cracking of structures, pavements, and other deficiencies. Prepare a list of existing damages, verified by dated photographs and signed by the University.

.5.2 Survey adjacent structures and improvements, establishing exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations. Locate datum level used to establish benchmark elevations.

.5.3 Contractor shall schedule a “Direct Buried Underground Condensate Piping Systems” pre-construction meeting with the Project Manager and AE to review installation requirements. The meeting shall take place after all submittals have been approved, but prior to any utility installation/construction.

.6 EXISTING UTILITIES
.6.1 The contract drawings indicate the general location of underground utilities. All utility locations and elevations in the vicinity of work shall be verified by the contractor prior to the start of project work. Test pits shall be conducted in areas where conflicts may occur prior to any excavation, heavy equipment loading, drilling and setting the H-piles is performed so as to avoid damaging or interfering with these existing utilities.
.6.2 Do not interrupt utility services unless permitted in writing by the accountable University representative. Outages to existing utility systems must be planned and scheduled at least two weeks in advance.

.7 DELIVERY, STORAGE, AND HANDLING
.7.1 Provide factory-applied plastic end-caps on each length of pipe and tube, except for concrete, corrugated metal, hub-and-spigot, and clay pipe. Maintain end-caps through shipping, storage and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.

.7.2 Protect stored pipes and tubes. Elevate above grade and enclose with durable, waterproof wrapping. When stored inside, do not exceed structural capacity of the floor.

.7.3 Protect flanges, fittings, and specialties from moisture and dirt by inside storage and enclosure, or by packaging with durable, waterproof wrapping.

PART 2 - PRODUCTS
.1 PIPE MATERIALS AND FITTINGS
.1.1 Systems Designs:
.1.1.1 Pumped Condensate: Maximum operating conditions are 200 PSIG at 388°F. Design conditions for the system shall be 200 PSIG at 388°F.

.1.2 Service Pipe: Condensate piping shall be Type TP316L, schedule 40, seamless stainless steel conforming to ASTM A312. All joints shall be butt-welded for sizes 2-1/2 inches or greater. Where possible, straight sections shall be supplied in 40 foot random lengths with 6 inches of piping exposed at each end for field joint fabrication.

.1.3 Fittings: Fittings 2-1/2 inches and larger shall be steel butt-welding type in accordance with ANSI B 16.9 and with the same wall thickness as the attached pipe. Material shall conform to ASTM A403, Grade WP 316L.

.1.4 Sub-Assemblies: Gland seals, end seals, and direct buried anchors shall be designed and factory prefabricated to prevent the ingress of moisture into the system. All sub-assemblies shall be designed to allow for complete draining and drying of the conduit system.

.1.5 Insulation: Insulation shall be cellular glass for the service pipe and polyurethane for the outer conduit. Insulation of the service pipe at each field welded joint shall be held in place by stainless steel bands with the minimum of two bands and the maximum spacing of 12 inches. The insulation shall have passed the most recent boiling test and other requirements specified in the Federal Agency Guidelines. All condensate piping shall have a minimum insulation thickness of 3 inches.

.1.6 Outer Conduit: The steel conduit casing shall be airtight, pressure testable, smooth wall welded steel conduit.

.1.7 Outer Conduit Insulation and Jacket: Conduit insulation shall be 1 inch thick factory applied foam, meeting ASTM C591. The outer jacket shall be either:
.1.7.1 Fiberglass (FRP), which filament wound directly onto the urethane foam insulation, with minimum wall thickness of 0.125 inches.
Fiberglass field enclosures matching the thickness of the outer jacket shall be used to complete the installation closures. No shrink wrap type will be allowed for closure joints.

.1.7.2 High Density Polyethylene (HDPE) jacket with minimum wall thickness of 0.125 inches. A pressure testable electric-fusion process or heat shrinkable process (recommended by the manufacturer) HDPE field joint closures equal to or greater than in thickness to the outer jacket shall be used to complete the installation closure. No shrink wrap type will be allowed for closure joints.

.1.8 Pipe Supports: All pipes within the inner casing shall be supported continuously around service pipe at not more than 10 foot intervals. These supports shall be designed to allow for continuous airflow and drainage of the conduit in place. The straight supports shall be designed to occupy not more than 10% of the annular air space. Supports shall be of the type where insulation thermally isolates the carrier pipe from the outer conduit. Supports which directly contact both the carrier pipe and the outer casing shall not be allowed. The surface of the insulation shall be protected at the support by a sleeve not less than 12 inches long, fitted with traverse and where required, rotational arresters.

.1.9 Anchors: Prefabricated steel plate anchors shall be factory furnished and installed where shown on plans. A concrete block shall be cast over the plate and conduit and shall be large enough for firm anchorage into undisturbed trench sidewalls and/or bottom. The concrete block is to be at least 30 inches in length and extend a minimum of 9 inches beyond the top and bottom of anchor plate.

.1.10 Expansion Loops, Ells, and Tees: Expansion utilizing prefabricated ELLS without loops is only allowed as defined on the drawings. Expansion loops shall be of proper design in accordance with stress limits indicated by the code for pressure piping ASME B31.1. Loop piping shall be installed in conduit suitable sized to handle indicated pipe movement.

.1.11 Backfill: A 6 inch layer of sand or pea gravel shall be placed and tamped in the trench to provide uniform bedding for the conduit. The entire trench shall be evenly backfilled with a similar material as the bedding in 6 inch compacted layers to a minimum height of 6 inches above the top of the insulated piping system. Bedding and backfill materials shall be as recommended by the manufacturer.


.2 SOIL MATERIALS
.2.1 Refer to Section 31 00 00 – EARTHWORK.

.3 BURIED UTILITY WARNING AND IDENTIFICATION TAPE:
.3.1 Provide detectable aluminum foil plastic backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried
piping. Tape shall be detectable by an electronic detection instrument. Provide tape in rolls, 6 inches minimum width, color; yellow, with warning and identification imprinted in big black letters continuously and repeatedly over entire tape length. Warning and identification shall read “CAUTION BURIED STEAM SYSTEM DISTRIBUTION PIPING BELOW” or similar wording. Use permanent code and letter coloring unaffected by moisture and other substances contained in trench backfill material.

PART 3 - EXECUTION

.1 EXCAVATION FOR UTILITY TRENCHES

.1.1 Excavate trenches to indicated slopes, lines, depths, and invert elevations.

.1.2 Excavate trenches to uniform widths to provide a working clearance on each side of pipelines. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit, unless otherwise indicated.

.1.3 Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove stones and sharp objects to avoid point loading.

.1.4 Where encountering rock or another unyielding bearing surface, carry trench excavation 6 inches below invert elevation to receive sub-base course material.

.2 INSTALLATION

.2.1 The installing contractor shall handle the system in accordance with the directions furnished by the manufacturer and as approved by the engineer.

.3 OUTER CONDUIT JACKET AIR TEST

.3.1 In cases that a HDPE outer jacket is used, the Contractor shall furnish all necessary equipment and labor to perform the air test, including air compressor, gauges, conduit caps, temporary pipe and connections, etc. and complete the test to the satisfaction of the engineer. The field closure joint HDPE outer jacket shall be air tested at 8 PSIG. Testing shall occur in the field after fabrication is complete or as specified in the contract documents. The test pressure shall be held for not less than one hour. The test results shall be provided to the University.

.4 OUTER CONDUIT AIR TEST

.4.1 The Contractor shall furnish all necessary equipment and labor to perform the air test, including air compressor, gauges, conduit caps, temporary pipe and connections, etc. and complete the test to the satisfaction of the engineer. The casing shall be air tested at 8 PSIG. Testing shall occur in the field after fabrication is complete or as specified in the contract documents. The test pressure shall be held for not less than one hour.

.5 SERVICE PIPE FIELD WELD INSPECTION
.5.1 Ultrasonically test one hundred percent (100%) of the full penetration field welds in the steam systems. Testing shall be performed by a qualified independent testing contractor. All fillet and socket welds shall be visual and dye penetrant examined on the completed weld by an individual qualified to perform the examinations.

.5.2 Provide documentation of each inspection of accepted or rejected welds. Provide report results within three working days for satisfactory results and one working day for unsatisfactory tests.

.5.3 Remove weld defects by grinding or chipping and repair or replace weld joints in accordance with approved procedures. Retest all repaired joints.

.5.4 The Supplier’s representative and the University’s representative or Engineer shall be present during testing.

.6 FIELD QUALITY CONTROL

.6.1 Piping Tests: Fill pipeline 24 hours prior to testing and apply test pressure to stabilize system. Use only potable water.

.6.2 Do not proceed until test results on subgrade, fill and backfill layers for previously completed work verify compliance with requirements. Coordinate with the Independent Soil Testing Agency (hired by contractor, but approved by the University) to perform all tests.

.6.2.1 The Independent Soil Testing Agency will perform field in-place density tests in accordance to ASTM D1556 (sand cone method), ASTM D2167 (rubber balloon method), or ASTM D2937 (drive cylinder method), as applicable.

.6.2.1.1 In-place density field tests may also be performed by the nuclear method according to ASTM D2922, provided that calibration curves are periodically checked and adjusted to correlate to tests performed using ASTM D1556. With each density calibration check, check the calibration curves furnished with the moisture gauges according to ASTM D3017.

.6.2.1.2 When in-place density field tests are performed using nuclear methods, make calibration checks of both density and moisture gauges at beginning of work, on each different type of material encountered, and at intervals as directed by the University.

.6.2.2 Trench Backfill: In each compacted initial and final backfill layer, perform at least one field in-place density test for each 150 feet or less of trench, but no fewer than two tests per layer.

.6.3 When subgrades, fills, or backfills are below specified density, scarify and moisten or aerate, or remove and replace soil to the depth required, recompact and retest until required density is obtained. Contractor shall pay for all retesting by the Independent Soil Testing Agency and corrective actions.

.7 VERIFICATION OF FINAL ELEVATIONS
.7.1 Prior to covering the top of the casing with backfill material, but after all temporary supports have been removed and initial backfilling of the conduit systems have been accomplished, the contractor shall measure and record the elevation of the top of the casings in the trench. This measurement shall be checked against the contract drawings. These measurements shall confirm that the conduit system have been installed to the elevations shown on the contract drawings. These measurements shall be certified correct by the Contractor and provided to the University for review prior to covering the casing with backfill material. The preapproved conduit system shall be installed, inspected, and tested in accordance with the contract drawings and specifications, the system supplier's Approved Brochure and any directions given by the system supplier's representative. All work pertaining to the preapproved system shall be performed in the presence of the system supplier's representative.

.8 UTILITY TRENCH BACKFILL

.8.1 Place and compact base course material on rock and other unyielding bearing surfaces and to fill unauthorized excavations.

.8.2 Concrete backfill trenches that extend below or pass under footings and that are excavated within 18 inches of footings. Place concrete to elevation of bottom of footings.

.8.3 Place and compact initial backfill of satisfactory soil material or sub-base material, free of particles larger than 1 inch, to a height of 6 inches over the utility pipe or conduit.

.8.3.1 Carefully compact material under pipe haunches and bring backfill evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of utility system.

.8.3.2 Place backfill and fill materials in layers not more than 6" in loose depth for material compacted by heavy power-operated compaction equipment, and not more than 4" in loose depth for material compacted by hand-operated tampers.

.8.3.3 Compact soil to 95% of its maximum dry density in accordance with ASTM D698.

.8.4 Coordinate backfilling with utilities testing.

.8.5 Fill voids with approved backfill materials as shoring and bracing, and sheeting is removed.

.8.6 Use one bag mix to completely backfill all voids of less than one (1) foot between new and existing utilities.

.8.7 Place and compact final backfill of satisfactory soil material to final subgrade.

.8.8 Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.
.1.1 Contract Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to work of this Section.

.2 DESCRIPTION OF WORK
.2.1 This Section specifies the requirements for the steam blowing of steam piping.

.3 SUBMITTALS
.3.1 Shop Drawings and Product Data: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:
   .3.1.1 Detailed written description of the steam blow procedures. Include the following:
      .3.1.1.1 An estimation of how much piping is going to be temporarily installed and what size
      .3.1.1.2 Estimated time for each steam blow and how many total blows estimated to be required
      .3.1.1.3 Step by step steam blow procedure; Indicate all safety measures and communication and coordination required with the Owner.
      .3.1.1.4 Pressure, flow, and velocity calculations; Indicate inlet pressure from the system, reduced pressure from pressure drop device, and pressures through the system including outlet pressure of system. For all these points, indicate corresponding velocity and Cleaning Force Ratio. Include diagram of the flow pattern to reference calculation points.
      .3.1.1.5 Acceptance criteria for each type of blow.
   .3.2 Drawings of the following:
      .3.2.1 Process flow diagrams depicting the steam blow traveling through piping to be blown and through the temporary piping.
      .3.2.2 Isometric drawings depicting the piping to be steam blown. Include the temporary piping leading to the outside exhaust noise reduction system for the steam blows.
   .3.3 Maximum noise levels that will be emitted by the steam blow process.
   .3.4 Steam blow service company's qualifications as described in Paragraph Quality Assurance below.

.4 QUALITY ASSURANCE
.4.1 A steam target blow shall be considered for all new steam piping, 4 inches NPS and above, to remove general construction debris, organic materials, weld slag, rust and mill scale.
.4.2 The risk of equipment damage downstream from newly installed steam pipe shall be assessed to determine if a steam blow is required or other steps shall be specified to protect equipment.
.4.3 Qualifications for Steam Blow Service Company
.4.3.1 Only firms experienced in performing steam blows in noise sensitive areas for projects similar to the requirements specified for this Project shall be considered.

.4.3.2 The proposed service company that will perform the steam blows shall submit a list of projects where they have performed steam blows in noise-sensitive areas for projects of similar size to this project. The list shall include a brief description of the scope of work for each project, including the size of equipment blown, the facility name and location, and a contact name and telephone number for each facility. The name of a Contractor will not be acceptable. For each project, provide a brief description of the noise sensitive issues, what was done to satisfy the requirements, and the general results of the noise sensitive issues. Failure to provide qualifications in this format will result in a total rejection of the proposed service company.

.4.3.3 The qualifications of the proposed steam blow service will be reviewed by the Engineer.

.4.4 Regulatory Requirements: All temporary piping systems and design shall be in accordance with ASME B31.1 Power Piping Code.

PART 2 - PRODUCTS
.1 GENERAL
.1.1 Products provided under this Section are temporary. The Contractor and the service company shall ensure that all products are safe to use for the service and that no harm will be done to equipment which exists or will remain.

.1.2 Temporary products used under this Section can be re-used in this Contract provided items remain properly identified at all times.

PART 3 - EXECUTION
.1 SCOPE OF SERVICE FOR STEAM BLOWS
.1.1 General:

.1.1.1 The Contractor shall obtain and pay for the service of a company to perform the steam blow services.

.1.1.2 All steam blows shall occur before each line is placed in service for the first time.

.1.2 Steam Blow Service Company Responsibilities:

.1.2.1 The steam blow service company shall design a system to perform steam blowing that satisfies the requirements listed, erect and provide temporary piping and mufflers, and oversee the steam blow procedure.

.1.2.2 The steam blow service company shall provide all required temperature and pressure gauges, hoses and valves. They shall also provide any device used to reduce the pressure (if necessary) to obtain a CFR as specified.

.1.2.3 Fully coordinating with University requirements for phasing.
.1.2.4 Clear communication with operating personnel for the operation of the University personnel.
.1.2.5 Submitting a written plan and procedure for performing steam blow operations.
.1.2.6 Conducting steam blow operations in a safe manner.
.1.2.7 Performing and submitting an ASME B31.1 thermal stress analysis of the vent piping system from the last permanent anchor to the vent silencer which shall be anchored.

.1.3 Contractor Responsibilities: The Contractor shall be fully responsible for all other associated support to the steam blow service company including providing manpower and covering the costs of the following:

.1.3.1 Provide temporary services required for steam blowing including service water piping, drain piping, and any other piping or components.
.1.3.2 Craft labor and supervision for system preparation, unloading steam blow service company equipment, installing vent piping and equipment, operating valves, support during steam blow service, and disassembly and reloading of piping and equipment
.1.3.3 Any connections required for vent or drain piping.
.1.3.4 Modifications and repairs to permanent fixtures such as handrails or openings in wall for vent piping if required
.1.3.5 Posting of safety warnings and barriers
.1.3.6 Temporary insulation of vent piping to protect personnel from hot vent piping
.1.3.7 Radio communication with control room operators
.1.3.8 Reviewing all of the steam blow service company's procedures to ensure that the conditions of this specification are satisfied
.1.3.9 Field verification of temporary equipment/piping layout drawings
.1.3.10 Temporary pipe supports of all associated piping systems
.1.3.11 All other support and materials required to perform steam blowing
.1.3.12 Submitting a written plan and procedure for performing steam blow operations
.1.3.13 Ensuring steam blow operations are conducted in a safe manner
.1.3.14 Opening all steam trap drip leg vents prior to steam blow and closing them after steam blow is closed

.2 STEAM TARGET BLOW
.2.1 Perform steam target blow for all new steam piping, 4 inches NPS and above, to remove general construction debris, gross debris, organic materials, weld slag, rust, and mill scale. Scope shall cover all piping in Bid Package 1, Bid Package 2, and Bid Package 3, from McCracken Power Plant to the South Campus Central Chiller Plant.
.2.2 Procedure and Acceptance Criteria:
.2.2.1 Steam blowing may be performed after hydrostatic testing is performed.
.2.2.2 Remove all meters and instrumentation taps into lines prior to steam blowing. If required by the steam blow process, provide other temporary means to measure steam flow during the steam blow.

.2.2.3 The University will only allow the usage of up to 45,000 PPH of steam (approximately 180 PSIG at 580°F with maximum conditions being 200 PSIG at 600°F). Provide an orifice plate or similar flow-restricting device such as a globe valve upstream of the pipe segment to be blown to limit flow as described below. Submit calculations to support this requirement.

.2.2.4 Blow each pipe segment a minimum of three separate times with cool down periods between to allow the inside temperature of the pipe to drop by 150°F (may be as much as 4 hours) to cause thermal cycling of piping. This is to facilitate the release of weld slag and other bonded debris. Thermal cycling may be performed prior to the commencement of steam blowing.

.2.2.5 The mass velocity head developed during these blows must meet a Cleaning Force Ratio (CFR) of 1.0 or greater where CFR = \((\frac{Q_{sb}^2 \times V_{sb}}{Q_{co}^2 \times V_{co}})\) where \(Q_{sb}\) = steam flow during steam blow (lb/hr), \(V_{sb}\) = specific volume during steam blow (ft³/lb), \(Q_{co}\) = steam flow during maximum continuous operation (lb/hr), and \(V_{co}\) = specific volume during maximum continuous operation. For these calculations, \(V_{co} = 3.08 \text{ ft}^3/\text{lb}\). For 16” NPS pipe, \(Q_{co} = 300,000\) lb/hr, for 14” NPS pipe, \(Q_{co} = 225,000\) lb/hr, and for 12” NPS pipe, \(Q_{co} = 185,000\) lb/hr. Operating at reduced pressure will use less steam and therefore waste less make-up water so this is preferred. The CFR shall be greater than 1.0 for the beginning of the pipe to the end. Try to limit velocities through the permanent piping at the end of the segments to no more than 1,000 ft/sec.

.2.2.6 The first two blows shall last for 15 minutes after the CFR has achieved 1.0 or greater. During the third blow, insert a polished brass target in the vent steam path, and blow at CFR 1.0 or greater for a minimum of 15 minutes. The cleanliness level is passed and the blow can end when there are no impacts larger than 0.8 mm diameter and fewer than 10 impacts with a diameter of 0.3 mm to 0.8 mm. Turn over brass targets to Owner.

.2.2.7 No permanent valves shall be used to throttle the flow upstream or downstream of the pipe segment being blown.

.2.3 Other:

.2.3.1 The steam blows shall be witnessed by the University and A/E.

.2.3.2 The steam blows shall not be conducted when the ambient air temperature is less than 50°F because of the campus demand for steam. All line steam blow activities shall be scheduled with University personnel. The scheduling of live steam blow activities is dependent on campus steam demand and steam availability.
2.3.3 The exhaust end of the line(s) being blow shall be muffled and quenched. Providing the piping is the responsibility of the Contractor.

2.3.4 Steam discharge shall not produce shock waves or air borne particulate which could settle on parked cars, people, buildings, etc. This includes very small particulate which may soil clothing, buildings, cars, etc.

2.3.5 The arrangement of the temporary piping shall be designed in accordance with ASME B31.1. The piping arrangement and steam blow shall not cause the stress levels in any permanent or temporary piping component to exceed the allowable levels per ASME B31.1.

2.3.6 Any low points created as a result of the temporary piping arrangement shall have manual drains installed for proper drainage during the blow. If the drains are installed in permanent piping they shall be installed in accordance with the permanent piping standards, and shall remain. If they are temporary, to be removed after the steam blow, they may be of suitable temporary construction, such as threaded brass or bronze valves.

2.3.7 Modifications to any permanent fixtures or systems to accommodate the steam blow shall be repaired and/or replaced at the completion of the event to the satisfaction of the University and Engineer.

2.3.8 The Contractor shall provide barricades, warning tapes, and signage as necessary to secure the immediate area during the steam blows.

2.3.9 The Contractor and his cleaning sub-contractor shall provide all necessary temporary piping, valves, mufflers, etc. needed to accomplish the steam blows safely and within the guidelines of this specification.

3 NOISE ISSUES

3.1 General: The steam distribution system is located in a noise sensitive campus community. Noise generated from all steam blow procedures shall be in accordance with the criteria listed herein.

3.2 Noise Criteria: Noise levels due to the steam blow shall not exceed 95 dB at a distance of 50 feet from the steam vent point. Provide a silencer at the end of the steam blow vent. Ensure that it is anchored and will be secure during the steam blows. City water is available for quenching the exhaust flow to minimize noise and reduce the velocity of the flow into the silencer, however, the Contractor has to provide a temporary water meter and backflow preventer, and has to provide the hoses needed to get the water where it needs to go. In addition, the Contractor has to coordinate with the University for the availability of water during the steam blow activities to not draw down campus pressure.

3.3 Hours of Steam Blow: The hours of steam blowing shall be restricted to times approved by the University. No steam blowing shall occur on holidays.
Further restrictions may be applied by the University. Coordinate timing of testing with University.

.3.4 The Contractor shall request permission in writing to the University to perform steam blow operations a minimum of 7 days prior to the proposed start of steam blow operations. The request shall include a description of the operations and activities, services and pipe sections affected and the proposed date, time and duration of operations. Steam blow operations shall commence only after the approval of the University.

33 63 20 METERS AND GAUGES

PART 1 - GENERAL

.1 RELATED DOCUMENTS

.1.1 Contract Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

.1.2 Requirements of the following Specification Sections apply to this Section:

.1.2.1 Section 33 63 10 - COMMON WORK RESULTS FOR PIPING

.1.2.2 Section 33 63 35 – VALVES

.2 DESCRIPTION OF WORK

.2.1 This Section provides the specification for pressure gauges.

.2.2 All devices supplied, whether free-standing or provided as part of a packaged equipment unit, shall satisfy the requirements of this Section.

.3 SUBMITTALS

.3.1 Shop Drawings and Product Data: All submittals of this Section shall also be incorporated into the operations and Maintenance Manual, including ISA forms. In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:

.3.1.1 Pressure Gauges: Provide manufacturer's catalog cut sheets for each type of pressure gauge with range, accuracy, materials, and accessories marked clearly.

.3.2 Operation and Maintenance Manuals: In accordance with Section 01 78 00 – CLOSEOUT SUBMITTALS, submit the following:

.3.2.2 General maintenance data for all devices including calibration and troubleshooting

.4 DELIVERY, STORAGE, AND HANDLING

.4.1 Store thermometers and pressure gauges in a dry location, away from the weather, dust, and debris.

.4.2 Retain shipping flange protective covers and protective coatings during storage.

.4.3 Inspect items immediately upon arrival and report any irregularities or damage immediately to the manufacturer/supplier and A/E.

.5 QUALITY ASSURANCE
Comply with applicable portions of American Society of Mechanical Engineers (ASME) and Instrument Society of America (ISA) standards pertaining to construction and installation of gauges and meters.

Conform to ASME B31.1 for all installations.

Certification: Provide gauges whose accuracies are certified by the manufacturer for the specified operating conditions.

Single-source Responsibility: Obtain each category of pressure gauges from one source and by a single manufacturer.

PART 2 - PRODUCTS

PRESSURE GAUGES

Type: ASME B40.1, Grade A, Type 316 stainless steel, phosphor bronze bourdon-tube pressure gauge, with bottom stem mounted connection.

Case: Phenol with glass lens. Diameter shall be 3-1/2”.

Connector: Steel with 1/2 inch male NPT.

Scale: White coated aluminum background with permanently marked black etchings.

Range: Units shall appear in PSIG units. For HPS service, range shall be 0 to 300 PSIG. For PC service, range shall be 0 to 150 PSIG.

Accuracy: Per ASME B40.1, accuracy Grade A.

PRESSURE GAUGE ACCESSORIES

Isolation Valves: For all pressure gauges in the HPS system, provide 1/2 inch NPS shutoff valve, Class 800 valves suitable for 200 PSIG, 600°F operating steam conditions. Valves shall have a socket welded connection on one end and a threaded connection on the other. Valves shall be located minimum 2 inches outside of insulation. Basis of Design: Velan C032064C-13TY

Syphon: On water systems operating above 120° Fahrenheit and for all steam systems, provide fabricated coil syphon or "pig tail" constructed as specified for the specific piping system in Section 33 63 10 – COMMON WORK RESULTS FOR PIPING.

Snubbers: Do not provide for this project.

PART 3 - EXECUTION

GENERAL

Location and orientation of all temperature and pressure gauges shall be coordinated with the A/E prior to installation.

PRESSURE GAUGE INSTALLATION

Install pressure gauges in pipe coupling or tee as required. Provide shutoff valve, snubber, and/or syphon as specified. Locate pressure gauge in most readable position.

Install where indicated in the Contract Documents.

Isolation valve shall be installed with the threaded end towards the pressure gauge.
.3 ADJUSTING AND CLEANING
.3.1 Calibrate gauge according to manufacturer's written instructions, after installation.
.3.2 Adjusting: Adjust faces of gauges to proper angle for best visibility.
.3.3 Cleaning: Clean windows of meters and gauges and factory-finished surfaces. Replace cracked and broken windows and repair scratched and marred surfaces with manufacturer's touchup paint.

.4 PROCESS CONNECTIONS
.4.1 Contractor shall provide all process connections in piping systems to accommodate gauge installation. Process connection type shall be selected by the Contractor to match the actual gauge provided.

33 63 25 PIPING SPECIALTIES

PART 1 - GENERAL
.1 RELATED DOCUMENTS
.1.1 Contract Drawings and general provisions of Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.
.1.2 Requirements of the following Specification Sections apply to this Section:
   .1.2.1 Section 33 63 05 - GENERAL PIPING PROVISIONS
   .1.2.2 Section 33 63 10 - COMMON WORK RESULTS FOR PIPING
   .1.2.3 Section 33 63 20 - METERS AND GAUGES
   .1.2.4 Section 33 63 35 - VALVES
   .1.2.5 Section 33 63 40 - HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT
   .1.2.6 Section 33 63 45 - GASKETS
   .1.2.7 Section 33 63 50 – IDENTIFICATION FOR PIPING AND EQUIPMENT
   .1.2.8 Section 33 63 55 - PIPING INSULATION

.2 DESCRIPTION OF WORK
.2.1 This Section provides the specification for pipe specialties. Specialties include steam traps, dirt pockets/drip legs, strainers, automatic air vents, pipe sleeves, and pipe sleeve seals.
.2.2 Provide pipe sleeves where piping passes through manhole walls (where detailed), vault walls/roofs, tunnel walls/roofs, metal gratings, trench covers, roofs, and concrete floor.
.2.3 Provide steam traps at all low points in the steam piping system where condensate can collect, as designated on the Contract Drawings. The Contractor shall notify the A/E of low points that are created in the piping system so that a steam trap station can be added. The Contractor shall avoid such low points as physical space limits.

.3 SUBMITTALS
.3.1 Shop Drawings and Product Data: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:
   .3.1.1 Steam Traps: Manufacturer's product data including:
.3.1.1.1 Type
.3.1.1.2 Materials of construction with drawing and design rating
.3.1.1.3 Performance based on specified differential pressure and size

.3.1.2 Steam Trap Valve Station: Manufacturer’s product data including:
.3.1.2.1 Type
.3.1.2.2 Materials of construction with drawing and design rating

.3.1.3 Strainers: Manufacturer’s product data including:
.3.1.3.1 Drawing showing type and dimensions of strainer
.3.1.3.2 Materials of construction for body and mesh
.3.1.3.3 Design rating
.3.1.3.4 Mesh size and pressure drop versus flow curve

.3.1.4 Pipe sleeve schedule indicating system location and size of pipe sleeve.

.3.1.5 Manufacturer’s product data for all materials to be used.

.3.2 Operation and Maintenance Manuals: In accordance with Section 01 78 00 – CLOSEOUT SUBMITTALS, submit the following:
.3.2.1 Maintenance data and spare parts list for:
.3.2.1.1 Steam traps
.3.2.1.2 Steam trap valve stations
.3.2.1.3 Strainers

.4 QUALITY ASSURANCE
.4.1 Comply with the following for steam piping and accessories:
.4.1.1 ANSI/ASME B31.1: Power Piping
.4.1.2 ANSI/ASME Boiler and Pressure Vessel Code: Section VIII, Division 1 - Unfired Pressure Vessels
.4.1.3 MSS - Manufacturers Standardization Society
.4.1.4 UL Listed: Provide UL listed fire separation assemblies
.4.1.5 NFPA: National Fire Protection Association Codes and Standards

PART 2 - PRODUCTS
.1 STEAM TRAPS
.1.1 General
.1.1.1 Refer to the Contract Drawings for details of the steam trap stations which include the drip leg, drip leg valve, steam trap, and all steam trap related items.
.1.1.2 Provide steam condensate traps at locations indicated on the Contract Drawings and of type as indicated in the "Steam Trap Schedule" listed in the Contract Drawings. The capacity of the steam trap provided shall satisfy the design flow listed on the "Steam Trap Schedule" for both the operating and maximum conditions of pressure, differential pressure, and steam temperature. Connection sizes of traps are provided as a basis of design; however, actual sizes are dependent upon the actual selection of the steam trap.
.1.3 Steam trap sizing selection and location is based on the piping layout as presented in the Contract Drawings. The Contractor is responsible for informing the A/E of any piping layout changes which could affect the sizing, selection, and location of the steam traps.

.1.4 Steam traps shall be provided at all low points in the steam piping system where condensate can collect, upstream of isolation valves and a maximum spacing of one per every 500 lineal feet of steam pipe.

.1.2 Steam Main Distribution – HPS

.1.2.1 Service: For HPS steam mains. The normal operating conditions are 185 PSIG at 585°F. The maximum operating conditions are 200 PSIG at 600°F. Traps shall be designed for service where the discharge of the trap is sub-cooled condensate water between 140 to 210°F.

.1.2.2 Performance: Refer to "Steam Trap Schedule" listed in Contract Drawings. The trap shall be rated for maximum back pressure of 99 percent of inlet pressure.

.1.2.3 Construction:

.1.2.3.1 General: Traps shall be thermodynamic style. All components shall be designed for maximum allowable steam pressure of 300 psig, 625°F, with maximum operating pressure of 300 psig.

.1.2.3.2 Body and Cover: Stainless steel

.1.2.3.3 Disc: Stainless steel

.1.2.3.4 Cap: Stainless steel

.1.2.4 Connections: Size of connection shall depend on the flow requirements. Type of connection shall be universal connector.

.1.2.5 Acceptable Manufacturers: Spirax Sarco or Armstrong. The strainer specified below shall be provided by the steam trap manufacturer and must satisfy the specification below.

.1.2.6 Basis of Design: Armstrong CD-3300.

.2 STEAM TRAP VALVE STATIONS

.2.1 Service: For HPS steam mains. The normal operating conditions are 185 PSIG at 585°F. The maximum operating conditions are 200 PSIG at 600°F.

.2.2 Description: Refer to Steam Trap Station with two isolation valves, integral strainer with blowdown valve, test valve, and steam trap connection.

.2.3 Construction:

.2.3.1 General: All components shall be designed for maximum allowable steam pressure of 300 psig, 625°F.

.2.3.2 For valve selection see BDS 33 63 35.3, Valve Group 3

.2.3.3 Strainer Screen: Stainless steel

.2.4 Connections: 3/4-inch socket welded connections for pipe; Universal trap connection for steam trap.
.2.5 Acceptable Manufacturers: Shall be provided by the steam trap manufacturer.
.2.6 Basis of Design: Armstrong TVS Connector.

.3 STRAINERS - STEAM TRAP SERVICE
.3.1 Strainers for steam service shall be "Y" type, unless otherwise indicated on Contract Drawings. Strainers for steam traps stations shall be in accordance with this specification.
.3.2 Provide a screen blowdown valve for each strainer. The valve shall be the full size of the blow-off tap. Provide shut-off valve in accordance with Section 33 63 35 - VALVES. Provide nipple with cap downstream of valve in accordance with the pipe system specification as specified in Section 33 63 10 - COMMON WORK RESULTS FOR PIPING. Select the length of the nipple connecting the blow-off valve to the strainer basket connection so that the blow-off valve is clear of the insulation.
.3.3 Provide strainer screen with a minimum net free area of 2-1/2 times the cross-sectional area of the entering pipe.
.3.4 All strainer screens shall be 1/8 inch thick Type 304 or 316 stainless steel with 3/64-inch mesh perforations unless otherwise required by the valve or device which it protects.

.4 PIPE SLEEVES
.4.1 For concrete or masonry interior and exterior walls and floors, partitions, and fire-rated walls (Where Detailed)
  .4.1.1 Fabricate sleeves or floor from Schedule 40 steel pipe in length to match finished wall or floor thickness. Provide a continuous 2 inch wide x 1/4 inch thick steel anchor plate and water stop weld to sleeve.
  .4.1.2 For pipes 8 inches NPS diameter and smaller, make sleeve inside diameter a minimum of 2 inches larger than the outside diameter of the pipe insulation. For pipes larger than 8 inch NPS, make sleeve inside diameter a minimum of 3 inches larger than the outside diameter of the pipe insulation. Coordinate with the calculations made by the requirements of Section 33 63 40 - HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT which shall calculate thermal movements of piping. Provide a greater clearance where dictated by these calculations.
  .4.1.3 Sleeves shall be hot-dipped galvanized.
  .4.1.4 Where the service pipe insulation is combustible the pipe shall be un-insulated where passing through fire-rated walls and partitions. For service pipes with non-combustible insulation systems the insulation shall extend through the wall.

.4.2 For Metal Grating and Trench Covers Penetrations
  .4.2.1 All grating penetrations shall be banded with 1-1/4 inch wide by 1/4 inch thick steel bands welded to all of the cut grating bars or plate.
.4.2.2 Opening inside the band shall be the diameter of the pipe or the insulation plus a minimum of 2 inches. Coordinate with the calculations made by the requirements of section 33 63 40 - HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT which shall calculate the thermal movements of piping. Provide a greater clearance where dictated by these calculations.

.4.3 Mechanical Type (Synthetic Rubber) - Watertight Pipe Sleeves
   .4.3.1 General: Provide for all piping penetrations through exterior walls to below ground areas.
   .4.3.2 Description: The pipe to wall penetration closures shall be "Link-Seal" as manufactured by Thunderline Corporation - Belleville, Michigan or equal. Seals shall be high temperature rated for 400°F. Seals shall be modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening. 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 nut. After the seal assembly is positioned in the sleeve, tightening of the bolts shall cause the rubber sealing elements to expand and provide an absolutely water-tight seal between the pipe and wall opening. The seal shall be constructed so as to provide electrical insulation between the pipe and wall, thus reducing cathodic reaction between these two members. Material shall be silicone and shall be rated for sustained temperature of 325°F.

.4.4 Fire Rated Sleeve Seals
   .4.4.1 Provide UL listed fire rated pipe sleeve seals and assemblies at fire rated partitions. Install fire rated sleeve seals in accordance with the manufacturer’s instructions and the listing requirements.
   .4.4.2 Fire rating shall be as required for partition rating but not less than 1-1/2 Hours.

.4.5 Non-Rated and Non Watertight Penetration Pipe Sleeves
   .4.5.1 Openings and sleeve for piping shall be large enough to allow lateral thermal movement of the piping. The calculations made by the requirements of Section 33 63 40 - HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT shall indicate the minimum required clearance.
   .4.5.2 If it is observed for any new piping system that the pipe insulation (or pipe wall, if there is no insulation) is touching the pipe sleeve when the pipe is heated, the Contractor shall provide a larger pipe sleeve at no additional cost to the University.

PART 3 - EXECUTION
.1 INSTALLATION - GENERAL
.1.1 Install steam specialties in accordance with manufacturer's instructions and as shown on the Contract Drawings.

.2 INSTALLATION - STEAM TRAPS
   .2.1 Provide all steam trap accessories in accordance with the details on the Contract Drawings.
   .2.2 Provide drip legs with sizes indicated on Contract Drawings.
   .2.3 Install steam traps at an elevation with respect to the drip leg in accordance with the manufacturer's instructions to insure hydraulic head during start-up.
   .2.4 Install steam traps at all low points in the steam piping system where condensate can collect, upstream of isolation valves and a maximum spacing of one (1) per every 500 lineal feet of steam pipe.

.3 INSTALLATION OF STRAINERS
   .3.1 Install strainers where indicated and at places not indicated but where required by a manufacturer's instruction to protect his equipment.
   .3.2 Install steam strainers horizontally on their side with screen chamber at the 3 or 9 o'clock position. Install all other strainers horizontally with the screen chamber at the 6 o'clock position. Provide blowdown drain with valve and cap. Install strainers vertically only when required and when the direction of flow is down.

.4 INSULATION, PAINTING AND, IDENTIFICATION OF STEAM SPECIALTIES
   .4.1 Insulate all pipe specialties in accordance with Section 33 63 55 - PIPING INSULATION. Do not insulate moving parts unless insulation sleeves are provided. Do not insulate steam traps.
   .4.2 Provide steam trap identification tags in accordance with Section 33 63 50 – IDENTIFICATION FOR PIPING AND EQUIPMENT.

.5 INSTALLATION OF PIPE SLEEVES
   .5.1 Extend and partition sleeves through and cut flush with each surface, unless otherwise indicated or specified.
   .5.2 Locate piping in sleeve to allow for movement. Do not allow steel sleeves to touch copper piping at any time.
   .5.3 After piping has been installed (and insulated if required), fill the annular spaces between piping and sleeves with materials as specified in this Section.
   .5.4 Sleeves shall be fabricated and hot dipped galvanized, cold galvanizing coating shall be applied for any field touchup repairs.
   .5.5 Fill all voids between the sleeve and the rough wall opening with non-shrinking non-metallic epoxy grout as specified in Section 03 30 00 - CAST-IN-PLACE CONCRETE.
   .5.6 Terminate floor and trench cover sleeves at 1/2 inch above the finished floor or cover.

.6 INSTALLATION OF PIPE SLEEVE SEALS
   .6.1 For Pipe Sleeves Receiving Non-Fire-Rated Seals (Watertight Pipe Sleeves)
.6.1.1 Provide and install mechanical type rubber link type as detailed and as manufactured by Thunderline Corporation or equivalent.

.6.1.2 Size the link seal as recommended by the manufacturer and as required for the intended service.

.6.1.3 The link seal shall be installed so that tightening bolts are accessible for maintenance.

.6.1.4 For insulated piping systems provide a 6-inch long removable portion in front of the tightening bolts for maintenance. Do not extend insulation through the sleeve.

.6.1.5 Pack the void between the pipe and the sleeve with oakum and caulk on the non-servicing side of the sleeve.

.6.2 Provide UL listed fire rated pipe sleeve seals and assemblies at fire rated partitions. Install fire rated sleeve seals in accordance with the manufacturer’s instructions and the listing requirements.

33 63 30 PIPE EXPANSION JOINTS

PART 1 - GENERAL

.1 RELATED DOCUMENTS

.1.1 Contact Drawings and general provisions of the Contract, including the General and Supplementary Conditions and Division 1 Specification Section, apply to this Section.

.1.2 Requirements of the following specification Sections apply to this Section.

.1.2.1 Section 33 63 05 - GENERAL PIPING PROVISIONS

.1.2.2 Section 33 63 10 - COMMON WORK RESULTS FOR PIPING

.1.2.3 Section 33 63 40 - HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT

.1.2.4 Section 33 63 45 - GASKETS

.1.2.5 Section 33 63 50 – IDENTIFICATION FOR PIPING AND EQUIPMENT

.1.2.6 Section 33 63 55 – PIPING INSULATION

.1.2.7 Section 33 63 35 – VALVES

.2 DESCRIPTION OF WORK

.2.1 This Section includes pipe expansion joints and expansion joint insulation blankets for mechanical piping systems.

.3 SUBMITTALS

.3.1 Shop Drawings and Product Data: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:

.3.1.1 Product data for each type of pipe expansion joint specified. Provide design data and materials description.

.3.1.2 Pipe expansion joint schedule showing manufacturer’s figure number, size, location, and features for each required expansion joint. Indicate country of fabrication and ISO 9001 registry, if applicable. Provide calculations of each joint per EJMA 9th edition standard including stresses, cycle life, joint spring rates, etc.
.3.1.3 Assembly - type shop drawings for each pipe expansion joint, indicating dimensions, weights, required clearances, pipe alignment tolerances and methods of component assembly.

.3.1.4 Assembly drawing of insulation blankets

.3.1.5 Individual expansion joint piping configuration diagrams indicating basic piping configuration between anchors, pipe anchor spacing requirements, guide spacing and guide pipe travel requirements.

.3.1.6 Maintenance data for each type pipe expansion joint specified to include in the "Operating and Maintenance Manuals" specified in Section 01 78 00 – CLOSEOUT SUBMITTALS.

.4 QUALITY ASSURANCE

.4.1 All materials provided shall be designed, fabricated, installed, and tested in accordance with ASME B31.1.

.4.2 All expansion joints shall be designed and installed in accordance with the 2008 9th edition of Expansion Joint Manufacturer's Association (EJMA) Standards.

.4.3 Expansion joint shall be fabricated and assembled in the United States or Canada, or the expansion joints must be manufactured by an ISO 9001 registered corporation. No expansion joints shall be provided where materials are fabricated or assembled in China including Taiwan, regardless of ISO 9001 registry.

.5 DELIVERY, STORAGE, AND HANDLING

.5.1 Handle expansion joints with great care. Adhere to the requirements of the manufacturer.

.5.2 Do not break the shipping tabs off the expansion joint until it is installed and all piping to the adjacent anchors including the anchors are completed.

PART 2 - PRODUCTS

.1 EXTERNALLY PRESSURIZED EXPANSION JOINTS (METAL-BELLOWS, PACKLESS TYPE)

.1.1 Type: Provide packless bellows expansion joints of externally pressurized design where designated for thermal expansion.

.1.2 Steam Service:

.1.2.1 Design: Expansion joints shall be rated for 200 PSIG, 600°F steam service. Joints shall be designed for 1,000 full pressure/temperature cycles to the 200 psig, 600°F steam rating. Provide axial movement as indicated in the table on the drawings. Non-axial movement shall be minimal due to the internal/external guides of the joint itself and the guides of the piping system. Each joint must be hydrostatically tested by the manufacturer prior to shipping at 350 PSIG for a minimum of 10 minutes.

.1.2.2 Materials: Bellows shall be constructed of ASTM A240 Grade 321 stainless steel, of uniform curvilinear shape without circumferential welds, and with not more than one longitudinal weld for each 10 inches of pipe diameter. Bellows shall be multi-ply construction. Provide carbon steel internal and external guide rings per ASTM A36.
to maintain alignment of the expanding pipe. Weld bellows to internal and external guide rings via stainless steel collars. Do not weld bellows to the guide rings at the root or crest radii. Provide external housing and internal liner of expansion joint rated for the design conditions and constructed of seamless ASTM A53 Grade B or ASTM A106 Grade B carbon steel to limit bellows movement and prevent flow induced vibration. Vent internal guide rings to reduce the effects of sudden pressure changes. Provide a base for all expansion joints that is designed to serve as an intermediate anchor. Provide a 3000-LB, forged steel, ASTM A105, 2-inch socket welded half coupling with a forged steel pipe plug on the cover at the 6 o'clock position to serve as a steam trap/liquid drain. Provide a lifting lug.

.1.3 Pumped Condensate Service:
.1.3.1 Design: Expansion joints shall be rated for 200 PSIG, 388°F steam service and liquid service of 200 PSIG at 387°F. Joints shall be designed for 1,000 full pressure/temperature cycles to the 200 PSIG, 388°F steam rating. Provide axial movement as indicated in the table on the drawings. Non-axial movement shall be minimal due to the internal/external guides of the joint itself and the guides of the piping system. Each joint must be hydrostatically tested by the manufacturer prior to shipping at 350 PSIG for a minimum of 10 minutes.

.1.3.2 Materials: All wetted parts shall be stainless steel to resist corrosion. Bellows shall be constructed of ASTM A240 Grade 321 stainless steel, of uniform curvilinear shape without circumferential welds, and with not more than one longitudinal weld for each 10 inches of pipe diameter. Bellows shall be multi-ply construction. Provide stainless steel internal and external guide rings to maintain alignment of the expanding pipe. Weld bellows to internal and external guide rings via stainless steel collars. Do not weld bellows to the guide rings at the root or crest radii. Provide external housing and internal liner of expansion joint rated for the design conditions and constructed of Type TP316L seamless stainless steel conforming to ASTM A312 to limit bellows movement and prevent flow induced vibration. Vent internal guide rings to reduce the effects of sudden pressure changes. Provide a base for all expansion joints that is designed to serve as an intermediate anchor and vertical support. Provide a 3000-LB, forged steel, ASTM A105, 1/2-inch socket welded half-coupling with a forged steel pipe plug on the cover at the 6 o'clock position to serve as a liquid drain. Provide a lifting lug.

.1.4 Connections: Expansion joints shall have butt weld ends, regardless of size.
.1.5 Acceptable Manufacturers: Provide expansion joints from Hyspan, Microflex, Pathway Bellows, or Senior Flexonics.
.1.6 Blanket: Insulation/weather covers shall be provided for each expansion joint as specified in this Section.

.1.7 Warranty: Expansion Joints shall be provided with a five year minimum warranty against leaks for material defects which shall cover the material replacement. Repair of joint is not acceptable.

.1.8 Nameplate: Provide a weatherproof, temperature proof, metal nameplate on the exterior of each expansion joint with all of the following information etched or depressed into the metal: manufacturer, model number, serial number, year fabricated, maximum pressure and temperature rating, design compression and extension of expansion joint, and maximum design full pressure/temperature cycles of the expansion joint.

.2 INSULATION BLANKETS

.2.1 General: Provide an insulation jacket for each expansion joint provided. The insulation jacket shall be removable and reusable and shall be designed to expand and contract as necessary with the expansion joint and connected pipe. The contractor shall verify clearance requirements for insulation jackets for expansion joints located in restricted locations including pipe trenches.

.2.2 Design

.2.2.1 Provide non-porous inner and outer jackets rated for flooding conditions, constructed of minimum 20 ounce per square yard PTFE Teflon film laminated/impregnated Nomex woven cloth. Blanket construction shall be a double woven stitch with a minimum of 7 stitches per inch. No raw cut jacket edges shall be exposed.

.2.2.2 Insulation shall be minimum 5-inch thick fiberglass needled mat with minimum 11 lbs/ft density. All materials shall be rated for service of 600°F. Outer jacket wall temperature shall be under 120°F. Submit proof of outer temperature assuming wet conditions.

.2.2.3 Type: Provide different blanket style to accommodate features of each joint:

.2.2.3.1 Externally Pressurized Bellows Style: Blanket design shall encase the unit to be insulated and provide a minimum 4 inch overlap extension over insulation of adjacent piping at cold conditions. Coordinate requirements for support base mounting conditions for floor mounted and steel rack mounted expansion joints.

.2.2.4 To accommodate leaks and detect their origins, blanket pieces shall have either a low point drain grommet or a mating seam at the low point which will allow water to seep through.

.2.2.5 Provide means of prevention of shifting of insulation filler.

.2.2.6 Provide lacing twists made of durable noncorrosive, non-rotting material for fastening blankets. Velcro is not acceptable. Assembly shall allow removal and installation with no tools required.
.1.1 Dimensions and End Connections: The Contractor is responsible for ensuring that the expansion joints provide conform to the dimensions required by the piping, anchor and pipe guide configuration. Expansion joint end connections shall be butt welded. Welding shall conform to ASME and AWS and examined in accordance with specifications section 33 63 10 – “Common Work Results for Piping”

.1.2 Install pipe expansion joints according to manufacturer’s written instructions.

.1.3 Align expansion joints to avoid end-loading and torsional stress. Metal-bellows expansion joints cannot accept any torsional loading. All expansion joints shall be provided with a base that shall be utilized for vertical support and for installation assistance, leveling shims or leveling bolts with nuts on the underside of the base shall be utilized for leveling and aligning the unit during installation. After alignment, high density calcium silicate insulation shall be inserted between the base and mounting steel or grout between the base and the floor. If a pipe anchor is adjacent to the expansion joint in accordance with the manufacturer’s requirements and unless indicated otherwise, the expansion joint support base shall not have tighten nuts or be otherwise permanently fixed or secured to the mounting steel, floor or other parts of the structure.

.1.4 Provide insulation/weather cover which protects joints from moisture. Clean inside of expansion joints thoroughly before putting joints into service.

.1.5 Do not break shipping band until expansion joint is installed and system is complete from anchor to anchor. If shipping band is broken prematurely, consult Associate and manufacturer immediately.

.1.6 Stretching of expansion joints to correct for piping misalignment or to accommodate available end-to-end spacing is not allowed.

.1.7 Laser align piping during welding and when aligning all supports, guides, and anchors. Ensure straight alignment so expansion joint will not bind. Follow all directions by expansion joint manufacturer for guide locations, except if a manufacturer states that the first guide closest to the expansion joint (within 4 pipe diameters) is not required, provide anyway.

.2 EXPANSION JOINT TESTING

.2.1 Contractor shall hydrostatically test piping system with joints in place after the shipping bands are broken and the entire piping system is connected as one system.

.2.2 Under no instance shall new expansion joints be hydrostatically tested, steam blown or put in any kind of service without the entire piping system being connected as one system, including all anchors and guides installed and completed.

.2.3 Water utilized for hydrostatic test must be at room temperature when hydrostatic test is performed.

.3 PIPE ALIGNMENT GUIDE INSTALLATION

.3.1 Install pipe alignment guides on piping as indicated on contract drawings. Pipe alignment guides shall be provided as indicated on the drawings and in accordance with the Expansion Joint Manufacturer’s requirements. If the
Expansion Joint Manufacturer’s required installation conditions do not exist, the Contractor shall alert the Associate and the Expansion Joint Manufacturer. Any damage resulting from pipe alignment guides not being located in accordance with the Expansion Joint Manufacturer’s requirements shall be the responsibility of the Contractor.

3.2 Secure pipe alignment guides to tunnel structures as indicated on the contract drawings.

4 PIPE ANCHOR INSTALLATION

4.1 Install pipe anchors at locations indicated on the drawings and in accordance with pipe anchor details indicated on the drawings. Comply with the Expansion Joint Manufacturer’s requirements and recommendations for pipe anchor locations and placement. Notify the Associate of pipe anchor installation conditions that do not conform to the locations indicated on the drawings and the Expansion Joint Manufacturer’s requirements or recommendations.

4.2 Fabricate and install anchors by welding steel shapes, plates, and bars to piping and securing to structure. Coordinate requirements for pipe anchor - concrete cast-in and embedded structural elements with the concrete work. Comply with ASME B31.1 and with AWS D1.1.

4.3 Provide grout for pipe anchors in accordance with 33 63 05 – GENERAL PIPING PROVISIONS.

4.4 For hot dipped galvanized pipe anchors provide cold galvanizing repair coating at field welds and for touch-up of damaged galvanized surfaces.

33 63 33 STEAM ENERGY DISTRIBUTION METERING

PART 1 GENERAL

1 APPLICATIONS:

1.1 The main objective of this design standard is to outline the requirements of a steam meter, to measure the consumption of steam supply in total pounds (lbs) and total British Thermal Units (BTU) in the buildings owned by The Ohio State University, and to communicate this consumption locally and to the campus-wide Energy Metering & Monitoring system (InStep eDNA server). The steam meter shall include the instantaneous mass flow rate in pounds per hour (lbs/hr) and totalized mass consumption in pounds (lbs), as well as instantaneous energy flow rate in British Thermal Units per hour (BTU/hr) and totalized energy delivered in British Thermal Units (BTU), with steam pressure and steam temperature compensation.

1.2 The steam meter, elements and devices shall meet custody transfer measurement requirements as indicated in Part 2 – PRODUCTS AND Part 3 - EXECUTION of this Section. Custody transfer measurement furnishes quantity and quality information which can be used as the basis for a change in ownership and/or a change in responsibility for materials, e.g., billing for rate of energy demand plus totalized energy transfer.

1.3 Products: Describes the general requirements for the totalizing steam meter, primary element, a flow computer, secondary element, and an RTD temperature sensor/transmitter.
.2 DEFINITIONS:
.2.1 High Pressure Steam: Steam pressures higher than 70 psig.
.2.2 Medium Pressure Steam: Steam Pressures between 15 psig and 70 psig.
.2.3 Low Pressure Steam: Steam pressures below 15 psig.

.3 DOCUMENTATION
.3.1 Data sheets, wiring diagrams, catalog literature, installation instructions, and Operations & Maintenance data must be sent to The Ohio State University Utilities for prior review and approval, to include the primary element flow sensor, secondary element(s) (transmitters, multivariable transmitter, etc.), RTD temperature sensor/transmitter, and flow computer. Instrument sheets as requested in ISA S20 Standard must be submitted.
.3.2 Interconnections and drawings for installation of the primary, secondary, and tertiary elements of the corresponding devices shall be submitted for review and approval prior to installation. P&ID’s shall be furnished in accordance to ISA S5.
.3.3 Provide flow computer program setup parameters as written hard copy and as Windows based electronic file.
.3.4 Certificates for the conformance of the steam meter according to engineering procedures and practices, and standards, shall be provided. Temperature and pressure compensation, coefficients, linear regressions, constants, equations, methodologies and basis of calculations to establish the steam flow rates shall also be provided for review.
.3.5 Certificates of calibration for the steam meter with air or any other gas available in the calibration facility, as well as a certificate of calibration conformance for the transmitters in accordance to NIST shall be provided.

PART 2 PRODUCTS
.1 GENERAL
.1.1 The selection of the steam meter shall be based on the following parameters and recommendations to guarantee that the accuracy of the steam meter station stays within the ±1% of the actual reading from 5% to 100% of the maximum rated flow, and the repeatability within ± 0.5%.
.1.2 The supply pressure could vary between 120 psig and 200 psig, whereas the temperature changes between 370°F and 600°F.
.1.3 The mass flow rate shall be computed in lbs/hour and the energy flow rate shall be computed in BTU/hr; both shall be temperature and pressure compensated. The steam meter shall register the mass flow rate with no less than 30 to 1 turn down based on actual flow conditions.
.1.4 Steam meters and associated piping shall be sized for steam velocities between 5 fps and 100 fps unless otherwise specified by the meter manufacturer.
.1.5 The pressure drop through the primary element, sensor, shall not be greater than 200 inches w.g.c. for the maximum mass flow rate.
.1.6 The flow computer shall provide loop powered 4-20 mA inputs for the temperature and pressure compensated mass flow rate in lbs/hour and
energy flow rate in BTU/hr. The flow computer shall totalize the mass flow rate, the energy flow rate, and shall be equipped with a MODBUS TCP/IP RTU communications port or MODBUS RTU RS-485 over AWG-18 twisted pair shielded cable to another meter in the same location. Prior to flow computer approval, the flow computer must be submitted by the Contractor for testing by The Ohio State University Utilities to prove interoperability with the campus-wide Energy Metering & Monitoring system (InStep eDNA server). Cat-6 shielded cable and conduit shall be installed between the flow computer or group of flow computers connected by twisted pair and the nearest building network switch.

.1.7 The flow computer shall be supplied with two isolated outputs that permit external system, e.g. Building Automation Systems, to monitor selected meter parameters.

.1.8 All primary and secondary electronic elements shall support an ambient temperature equal to or greater than 150°F.

.2 PRIMARY ELEMENT, FLOW SENSOR

.2.1 A Variable Area flow sensor either non-spring loaded or spring loaded or an ultrasonic shall be used as the primary element of the steam meter. The material of the components of the flow sensor must be 316 stainless steel or material approved by OSU Utilities. The nominal size of the sensor shall match the size of the pipe where the flow sensor will be installed. The primary element shall comply with standard codes, ISO, ASME.

.2.2 For those cases that apply, the flow sensor shall be installed in a wafer or lug type arrangement, constructed of 316 stainless steel, or approved material, rated for 200 psig and 660°F. If the primary flow element is longer than its flange-to-flange dimension, then a spool piece shall be included of sufficient length such as to permit the removal of the primary flow element with spool piece, and eliminate disassembly of any downstream or upstream piping when servicing the element.

.2.3 Calculations, equations and/or methodology used to determine the size of the flow sensor shall be supplied to OSU Utilities for acceptance. Where applicable, Reynolds Number dependent equations shall be checked for maximum and minimum mass flow rates.

.3 SECONDARY ELEMENT, TRANSMITTER(S)

.3.1 The output shall be 4-20mA with digital signal preferable with HART protocol. The accuracy shall be at least ±0.1% of span, 4 to 20mA, and ±0.07% of span, digital. Drift less than ±0.1% of URL over at least 8,000 hours.

.3.2 Range limits for the differential pressure measurement shall be 0 to 200 inches of H_2O with a minimum transmitter pressure rating of 300 psi. Range limits for absolute pressure shall be 0 to 300 psia. The transmitter shall be energized with a 24-VDC source or a 120-VAC source for flow computers. The differential pressure transmitter shall be mounted below the flow element using 316 stainless steel tubing.
.3.3 Programming shall be accomplished via a Windows-based software package or from the keypad of the flow computer without the need to open the cover; thus maintaining the NEMA 4 integrity of the enclosure.

.3.4 Standard LCD indicator with backlight shall be included with the flow computer.

.3.5 The flow computer shall provide precise and reliable measurement of absolute/gauge and differential pressures, sensor and electronics temperatures, and process temperature from an external transmitter/RTD combination. It shall calculate densities and specific enthalpies according to the Steam Tables ASME 1997, and mass flow rates for the actual pressure and in line temperature. Parameters and measurements shall be stored in non-volatile memory to avoid data loss during power failure. Data shall be restored from internal memory upon restoration of power.

.3.6 A 316 stainless steel 3-valve manifold to mount the pressure differential transmitter shall be supplied. Drain/vent material and isolation valves shall be 316 stainless steel and furnished.

.4 PROCESS CONNECTIONS AND PIPING

.4.1 All steam service piping shall comply with the requirements of ASME 31.1 Power Piping Code.

.4.2 Sensor connections that are normally NPT 1/4-inch shall be adapted to 1/2-inch.

.4.3 Sensor connections shall be minimum 1/2-inch, 316 stainless steel, heavy duty, schedule 80 pipe or 1/2-inch diameter 316 stainless steel tubing with compression fittings.

.4.4 Pipe sealants for threaded connections shall be rated for a minimum of 600°F.

.4.5 Process shutoff valves shall be supplied for all sensor connections, minimum 1/2-inch, class 600, 316 stainless steel, and full port gate style with graphite packing, Velan or approved equal.

.4.6 All pressure-sensing devices shall have a condensate loop (i.e. pigtail).

.5 RTD TEMPERATURE SENSOR/TRANSMITTER

.5.1 Furnish a spring loaded Dual Element 100 ohm platinum RTD temperature sensor assembly. The accuracy shall be ±0.5% at 32°F utilizing a three-wire single element with aluminum waterproof head, 316 stainless steel nipple-union-nipple extension. The length shall be determined by the piping system where the meter will be installed.

.5.2 The temperature process input range shall be 20°F to 800°F.

.5.3 The thermo-well shall be 316 stainless steel, long enough for the size of the process pipe with a 4-inch lagging allowance, and provided with a 3/4-inch NPT process connection. The well finish shall be 15Ra maximum, electropolish finish.

.6 STEAM METER MANUFACTURERS AND MODELS

.6.1 Spirax/Sarco ILVA flow sensor with Steam Flow Computer, including pressure transmitter, temperature sensor and transmitter, differential pressure transmitter and accessories including but not limited to flow straighteners.
.6.2 GE Panameterics Transient Time Ultrasonic steam flow meter, including flow computer, and pressure and temperature transmitters for flow compensation.

.6.3 McCrometer V-Cone flow sensor with flow computer, including pressure transmitter, temperature sensor and transmitter, differential pressure transmitter and accessories. Acceptable in limited applications where the turndown of the steam flow is relatively low, 10 to 1.

.6.4 Kessler-Ellis Products (KEP) flow computer shall be supplied.

.6.5 Other models and manufacturers require submittal by the A/E and approval by The Ohio State University Utilities before including in the Design Development Documents.

.6.6 All meters will be considered for approval on the basis of life cycle cost analysis by the A/E.

.7 DIFFERENTIAL PRESSURE AND PRESSURE TRANSMITTERS - MANUFACTURERS

.7.1 Rosemount

.7.2 Honeywell

.7.3 Siemens

.8 MANUFACTURERS

.8.1 RTDs shall be specified as Burns Engineering Series 200

.8.2 Temperature Transmitters shall be specified as HART SensorTec model Q4, PR Electronics Model 5335A, or Rosemount model 248.

PART 3 EXECUTION

.1 CERTIFICATIONS – CALIBRATION AND CALCUALTIONS

.1.1 A third-party conformance certificate for the calibration of the steam meter shall be provided.

.1.2 A certified calculation, for the maximum and minimum mass flow rates at 185 psig and 540°F shall be supplied.

.1.3 Calibration of the transmitter(s) shall be accomplished following NIST standards. A certification of conformance shall be submitted.

.2 COMMUNICATION

.2.1 Meter data in the form of total consumption, mass flow rate, energy flow rate, and a meter diagnostic must be communicated over the university Ethernet network back to the InStep eDNA server. Consumption will be in billable units, klbs of steam and kBTUs of steam. Flow rate will be in klbs/hr of steam. Meter diagnostic will be in the form of Normal or Failure. MODBUS data registers shall be provided, at a minimum, for instantaneous mass flow rate, energy flow rate, totalized mass and energy values, temperature, pressure, and differential pressure.

Meters will utilize a combination of MODBUS RTU over RS-485 and MODBUS over Ethernet. Provide a B&B Model MESR901 RS-485 to Modbus TCP/IP converter for flow computers without built in Modbus TCP/IP.

.3 WARRANTY
3.1 The supplier/manufacturer of the above specified equipment shall guarantee for twenty four (24) months from equipment startup or thirty (30) months from date of shipment, whichever occurs first, that the equipment shall be free from defects in design, workmanship or materials.

3.2 In the event a component fails to perform as specified or is proven defective in service during the warranty period, the manufacturer shall promptly repair or replace the defective part at no cost.

3.3 The manufacturer or contractor shall furnish OSU Utilities and Energy Services and Sustainability group with an installation, operation and maintenance manual for the steam meter and all its components, in both hard copy and electronic media including a program manual for the flow computer.

4 INSTALLATION

4.1 Follow manufacturer’s guidelines and submit installation drawings to OSU FOD Utilities and Energy Services for review and approval prior to installation.

4.2 Outages to existing steam systems for meter installation must be planned and scheduled at least two weeks in advance. See outage procedure: https://ap.osu.edu/sites/default/files/utility_outage_procedures.docx

4.3 The Contractor shall obtain assistance from FOD in following the manufacturer’s installation specifications such as but not limited to location of the meter components, Ethernet connection, electrical connections, local disconnect, enclosure type, and all other applicable issues. Power shall be obtained from a dedicated 20 Amp circuit in the nearest local building electrical panel.

4.4 The pipe diameter shall be known and shall never be reduced to install the steam meter.

4.5 Steam meters shall be installed with the manufacturer’s recommended straight run of pipe upstream and downstream of the meter.

4.6 Work performed without the assistance of the manufacturer’s technical erection supervisor and/or OSU Utilities shall adhere to dimensional requirements, assembly methods, and installation procedures specified herein and in the manufacturer’s instruction manuals and drawings.

4.7 The Contractor shall comply with all erection and installation methods, techniques, sequence, and procedures requested by the manufacturer’s representative and/or OSU Utilities.

4.8 Where manufacturer’s written instructions differ significantly from those proposed by the manufacturer’s representative, OSU Utilities shall determine the method used.

4.9 The steam meter shall be aligned with the direction of the flow in a horizontal line.

4.10 Gaskets shall be installed in proper alignment, free of tears and wrinkles. Bolted connections shall be tightened per gasket manufacturer’s torque and sequence requirements to provide a uniform tight seal to insure uniform stress over the entire gasket area.

4.11 All conduit and conduit connections shall be sealed connections and meet the design and installation standards applicable for the installation area.
.4.12 Installation services shall include all conduit and wiring to provide a fully functional meter and communication wiring to the building Ethernet switch. Termination of Ethernet communication cable at the building Ethernet switch shall be by OSU.

.4.13 Panel addressing shall be assigned by OSU Utilities.

.4.14 All meters and ancillary equipment shall be installed in such a manner as to provide access for routine inspections, maintenance, and a means of removal.

.4.15 The flow computer readout/display shall be located between 5 feet and 6 feet above finished floor level.

.4.16 All meters shall be supported independent from the piping systems.

.4.17 Structural steel supports and miscellaneous steel required for supporting and/or anchoring meters and piping furnished under this standard shall be provided and installed in accordance with Division 5.

.4.18 All anchors and structural steel supports shall be built to template and reinforced as required for loads imposed on them.

.4.19 Equipment and pipe internals shall be cleaned and inspected prior to placing in service.

.5 TRAINING

.5.1 The supplier/manufacturer shall train OSU Utilities and Energy Services and Sustainability personnel to program, calibrate, operate and maintain the above-mentioned devices for at least 3 hours. Training shall be scheduled within two weeks of completion of the installation.

.6 INSPECTION AND COMMISSIONING

.6.1 A representative of OSU Utilities will inspect the installation and performance of the steam meter for acceptance and approval before commissioning. OSU Utilities reserves the right to witness factory testing and calibration.

.6.2 Provide for review of required closeout documentation.

.6.3 Provide for review loop sheets with point to point wiring diagrams in AutoCAD .dwg format.

.6.4 Document and provide for review all electrical power sources with breaker and panel numbers.

.6.5 Provide for review all calibration data sheets.

.6.6 Download or load programming setup parameters.

.6.7 OSU Utilities shall fill impulse lines with distilled water, if applicable.

.6.8 The integrity and polarity of all terminations shall be checked and verified.

.6.9 All piping connections must pass a service test.

.6.10 Final system checks and closeout shall be performed.

.6.11 Steam service will not be reinstated by OSU Utilities until installation of the steam meter is inspected by OSU Utilities and found to meet the requirements of the steam meter manufacturer and these design and installation standards.

33 63 35 VALVES

PART 1 - GENERAL

.1 RELATED DOCUMENTS
.1.1 Requirements of the following (OSU Building Design Standards) apply to this
Section:
  .1.1.1 Section 33 63 10 – COMMON WORK RESULTS FOR PIPING
  .1.1.2 Section 33 63 25 – PIPING SPECIALTIES
  .1.1.3 Section 33 63 40 – HANGERS AND SUPPORTS FOR PIPING AND
  EQUIPMENT

.2 DESCRIPTION OF WORK
  .2.1 The A/E shall specify that valves furnished as part of factory-fabricated
  equipment shall conform to the requirements of this Section unless otherwise
  stated.
  .2.2 The A/E shall note that strainers and other special valves are specified in
  Section 33 63 25 – PIPING SPECIALTIES.

.3 SUBMITTALS
  .3.1 Shop Drawings and Product Data: The A/E shall specify that the contractor
  shall submit the following:
    .3.1.1 Manufacturer's technical product data, including installation
    instructions, for each type of valve. Include pressure drop curve or
    chart for each type and size of valve.
    .3.1.2 Submit valve schedule showing manufacturer's figure number for
    corresponding valve symbol used to specify valves on this
    specification. List all valve sizes to be supplied for each valve
    symbol.
    .3.1.3 Manufacturer's assembly-type (exploded view) shop drawings for
    each type of valve and valve actuator indicating dimensions,
    weights, materials, and methods of assembly of components.
    .3.1.4 Technical data for electric valve actuators that indicate all features
    specified.
    .3.1.5 Manufacturer's technical product data indicating the service rating
    of each valve type. In addition, this information shall indicate the
    maximum hydrostatic test pressure that the valve can take when
    only one side of the valve is being pressurized. The indicated
    hydrostatic pressure shall be good for not only the structural
    integrity of the valve, but should also take into consideration its
    continued effectiveness for providing tight shut-off service as a
    valve without requiring any modifications or maintenance.
    .3.1.6 List country of manufacturer, fabrication, and assembly for all valves
    and valve components.
    .3.1.7 Submit ISO 9001 and Independent Test reports, if applicable, per
    Quality Assurance paragraph below.

.4 QUALITY ASSURANCE
  .4.1 Manufacturers Standardization Society of the Valve and Fittings Industry
  (MSS) Compliance: Comply with the various MSS Standard Practices
  referenced.
  .4.2 Country of Fabrication – A/E shall specify the following:

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.4.2.1 All valves and valve components not manufactured, fabricated, and/or assembled in the United States of America or Canada must be manufactured, fabricated, and/or assembled by an ISO 9001 registered corporation.

.4.2.2 The contractor shall submit ISO 9001 registration certificates for all corporations where valves and valve components are not manufactured, fabricated, and/or assembled in the United States or Canada.

.4.2.3 For all valves and valve components not fabricated in the United States or Canada, the contractor shall submit an independent test report for all materials to be provided.

.4.2.4 No valves or valve components manufactured, fabricated, and/or assembled in China including Taiwan are permitted.

.5 DELIVERY, STORAGE, AND HANDLING

.5.1 Preparation for Transport; A/E shall specify the following:

.5.1.1 Contractor shall ensure valves are dry and internally protected against rust and corrosion.

.5.1.2 Contractor shall protect valve ends against damage to threads, flange faces, and weld-end preps.

.5.1.3 Set valves in best position for handling. Set globe and gate valves closed to prevent rattling; set ball and plug valves open to minimize exposure of functional surfaces; set butterfly valves closed or slightly open; and block swing check valves in either closed or open position.

.5.2 Storage: A/E shall specify the following:

.5.2.1 Contractor shall not remove valve end protectors unless necessary for inspection; then reinstall for storage.

.5.2.2 Contractor shall protect valves from weather. Store valves indoors. Maintain valve temperature higher than the ambient dew point temperature. Outdoor storage of valves shall not be permitted.

.5.3 Handling: A/E shall specify that the contractor shall rig valves to avoid damage to exposed valve parts. Do not use handwheels and stems as lifting or rigging points.

PART 2 - PRODUCTS

.1 VALVE FEATURES

.1.1 General: Provide valves with features indicated and, where not otherwise indicated, provide proper valve features as determined by the manufacturer for installation requirements. Comply with ASME B31.1.

.1.2 Valve Design: A/E shall specify valves with outside screw and yoke (OS&Y) stems. If non-rising stem valves are needed due to operational constraints, Utilities Division shall verify the constraints, shall review the submittals of the installation, and shall approve the installation of a non-rising stem valve.
.1.3 Pressure and Temperature Ratings: As specified according to the individual valve specifications.

.1.4 Sizes: Same size as upstream pipe, unless otherwise indicated.

.1.5 Operators: A/E shall specify the following special operator features:

.1.5.1 Handwheels fastened to valve stem, for valves other than quarter turn.

.1.5.2 Lever handles, on quarter-turn valves 3 inches and smaller, except for plug valves. Provide plug valves with square heads. For valves greater than 3-inch, provide gear operator with handwheel.

.1.5.3 Chain-wheel operators, for all valves installed 6 feet or higher above finished floor. Extend chains to an elevation of 5 feet above finished floor.

.1.6 Extended Stems: Where insulation is indicated or specified, A/E shall specify that the contractor shall provide extended stems arranged to receive insulation.

.1.7 By-pass and Drain Connections: Specify and design valved by-passes. The A/E shall indicate locations on the Contract Drawings. A/E shall specify and have the contractor comply with MSS SP-45 bypass and drain connections.

.1.8 Specify neck extensions and right angle drives where indicated and where required for access to the operator.

.1.9 Hot Tap Valves: The A/E shall design for hot taps into existing mains that will remain energized up to the piping system design pressure where a hot tap is shown and designed for in the Contract Drawings. This procedure is also known as wet tapping. For these instances, specify that the valve shall be a full port valve to satisfy the requirements of the hot tap machine and provide a true area pipe tap, and shall satisfy the requirements of the specification of the valve group. All hot taps shall be approved by OSU Utilities.

.2 VALVE IDENTIFICATION SYSTEM DESCRIPTION

.2.1 General: The A/E shall establish a system which identifies the specific valves for each piping system being designed in the Contract Drawings. The specific valve specification is linked by the service number as depicted in the "Valve Index" listed in this Section.

.2.2 Valves shall be identified on the Contract Drawings by symbol. Size is indicated by the upstream size.

.2.3 Valves are specified in this Section according to the "Valve Index". In general, the following is a description of the format:

.2.3.1 The first symbol, consisting of one or more numerals, indicates the valve group specification that applies to this valve.

.2.3.2 The second symbol, consisting of one or more letters, indicates the type of valve in accordance with the following listing:

- GB = Globe Valve
- BF = Butterfly Valve
- BL = Ball Valve
- CK = Check Valve
- GT = Gate Valve
• AG = Angle-Stop Globe Valve

2.3.3 The third symbol consists of two numerals. The first numeral indicates the size group; the second numeral, when it is zero, indicates that the valve is standard type. Where the second numeral is greater than zero, it indicates modifications as described in the valve specifications herein.

2.3.4 The fifth symbol, consisting of a letter, indicates the type of connection to the valve as follows:
- F = Flanged Ends
- S = Screwed Ends
- W = Weld Ends, Butt, or Socket

2.3.5 For example: For a 10-inch high pressure steam (HPS) shutoff valve, refer to 3BF21W which indicates a valve of Valve Group 3, Butterfly Type, Non-Standard, and with butt weld ends. Refer to Section 33 63 35.3 - VALVE GROUP 3 for the specification of this valve.

2.4 Note to the A/E: There may be some instances where it is desirable to substitute an item, such as a valve or gasket at a particular location, in place of the one specified in the groups listed in the Index. In that event, the item shall be clearly indicated and specified on the Contract Drawings, and such an indication is to take precedence over the item specified in the valve group specifications. All other terms of that group specification are to be observed.

3.3 VALVE INDEX: THE FOLLOWING PAGES CONTAIN THE "VALVE INDEX"
3.3.1 CONDENSATE, HIGH PRESSURE (Valve Group 3)
3.3.1.1 Abbreviation: HPR
3.3.1.2 Description: From HPS to PC System
3.3.1.3 Maximum Design Conditions:
- Pressure: 200 PSIG
- Temperature: 600°F
3.3.1.4 Normal Operating Conditions:
- Pressure: 185 PSIG
- Temperature: 585°F
3.3.1.5 2 Inches and Smaller:
- Shutoff: 3GT15W
- Throttling: None
- Check: 3CK11W

3.3.2 CONDENSATE, PUMPED (Valve Group 10)
3.3.2.1 Abbreviation: PCR
3.3.2.2 Description: Returned Condensate from Campus and Manhole Pumps to Plant
3.3.2.3 Maximum Design Conditions:
- Pressure: 200 PSIG
- Temperature: 388°F
3.3.2.4 Normal Operating Conditions:
- Pressure: 50 PSIG
• Temperature: 180°F
  .3.2.5 inches and smaller:
  • Shutoff: 10GT11W
  • Throttling: None
  • Check: 10CK10W
  .3.2.6 2-1/2 inches and larger:
  • Shutoff: 10GT20F
  • Throttling: None
  • Check: 10CK20F

.3.3 steam, high pressure (valve group 3)
  .3.3.1 abbreviation: HPS
  .3.3.2 description: HPS campus distribution
  .3.3.3 maximum design conditions:
  • Pressure: 200 PSIG
  • Temperature: 600°F
  .3.3.4 Normal operating conditions:
  • Pressure: 185 PSIG
  • Temperature: 585°F
  .3.3.5 inches and smaller:
  • Shutoff: 3GT10W
  • Throttling (Warm-up By-pass Service): 3AG10W
  • Check: None
  .3.3.6 2-1/2 inches and larger:
  • Shutoff: 3GT20W
  • Throttling: None
  • Check: None

.3.4 chilled water, chilled water supply & return (valve group 2)
  .3.4.1 abbreviation: CWS, CWR
  .3.4.2 description: CWS and CWR
  .3.4.3 maximum design conditions:
  • Pressure: 100 PSIG
  • Temperature: 140°F
  .3.4.4 Normal operating conditions:
  • Pressure: 100 PSIG
  • Temperature: 42°F
  .3.4.5 2” and smaller:
  • Shutoff: 2BL12S
  • Check: 2CK11S
  .3.4.6 2-1/2” and larger:
  • Shutoff: 2BF23F
  • Check: 2CK20F

.4 chainwheels
.4.1 Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   .4.1.1 Babbitt Steam Specialty Co
   .4.1.2 Roto Hammer Industries
   .4.1.3 Trumbull Industries

.4.2 Description: Lockable valve actuation assembly with sprocket rim, brackets, and chain.
   .4.2.1 Brackets: Type, number, size, and fasteners required to mount actuator on valve.
   .4.2.2 Attachment: For connection to butterfly valve stems.
   .4.2.3 Sprocket Rim with Chain Guides: Ductile or cast iron, of type and size required for valve. Include zinc coating.
   .4.2.4 Chain: Hot-dip, galvanized steel, Brass, or Stainless steel, of size required to fit sprocket rim.

PART 3 - EXECUTION
.1 EXAMINATION – The A/E shall specify in the contract documents the following items as they relate to Examination:
   .1.1 Examine valve interior through the end ports for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks used to prevent disc movement during shipping and handling.
   .1.2 Actuate valve through an open-close and close-open cycle. Examine functionally significant features, such as guides and seats made accessible by such actuation. Following examination, return the valve closure member to the shipping position.
   .1.3 Examine threads on both the valve and the mating pipe for form (i.e., out-of-round or local indentation) and cleanliness.
   .1.4 Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage. In cases where higher rated raised face steel flanges are mated to lower rated flat face cast iron flanges, remove raised face from steel flange before bolting together.
   .1.5 Prior to valve installation, examine the piping for cleanliness, freedom from foreign materials, and proper alignment.

.2 VALVE INSTALLATIONS – The A/E shall specify in the contract documents the following items as they relate to Valve Installations:
   .2.1 General Application: The contractor shall refer to the Contract Drawings and piping system specification sections for specific valve applications and arrangements.
   .2.2 Locate valves for easy access and provide separate support where necessary.
   .2.3 Contractor shall install valves and unions for each fixture and item of equipment arranged to allow equipment removal without system shutdown. Unions are not required on flanged devices.
.2.4 The A/E shall design, and the contractor shall install a three-valve bypass around each control valve and throttling valve. Required locations shall be located on the Contract Drawings.

.2.5 The A/E shall design so that the stems of valves in horizontal lines shall be pointed up (vertical). If this is not practical, the stem may be pointed in a horizontal position with prior approval from the A/E and OSU Utilities. Valves shall not be installed with stems pointed down. All valves shall have a readily accessible location. The Contractor shall be responsible to determine valve stem locations on field-routed piping prior to fabrication of the piping. When welding valves to piping, the Contractor shall insure that the valves are in the open position and shall take extreme care not to overheat and damage the seat area. All valves shall be installed in accordance with the manufacturer’s instruction manual. Any valves damaged during installation shall be replaced with new, identical valves at the Contractor’s expense.

.2.6 The Contractor shall install valves in a position to allow full stem movement.

.2.7 Installation of Swing Check Valves: Install for proper direction of flow and in horizontal position or vertical position with flow direction upwards, and with hinge pin level.

.2.8 Insulation: Where insulation is indicated for the service, insulation of valves shall be in accordance with Section 33 63 55 – PIPING INSULATION. Where required, the contractor shall provide valves with extended stems, arranged in manner to receive insulation.

.3 FLANGED CONNECTIONS – The A/E shall specify in the contract documents the following items as they relate to Flanged Connections:

.3.1 The contractor shall align flange surfaces parallel and level.

.3.2 The contractor shall assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads including anti-seize compound on bolts. Anti-seize compound shall be rated for temperatures to 600°F. Tighten bolts gradually and uniformly with a torque wrench.

.3.3 In cases where higher-rated steel raised face flanges mate to lower-rated cast iron flat face flanges, the contractor shall remove the raised face from the steel flange before bolting together.

.3.4 A/E shall specify gaskets according to the piping system and as specified in Section 33 63 45 - GASKETS.

.4 ADJUSTING, CLEANING, PAINTING AND IDENTIFICATION

.4.1 Valve Adjustment: After piping systems have been tested and put into service, but before final testing, adjusting, and balancing, the A/E, OSU Utilities, and the contractor shall inspect each valve for possible leaks. Specify that the contractor shall adjust or replace packing to stop leaks. Specify that if a valve continues to leak that it shall be replaced.

.4.2 Cleaning: Specify that the contractor shall clean mill scale, grease, and protective coatings from exterior of valves and prepare valves to receive finish painting or insulation.
DIVISION 33 – UTILITIES

33 63 35.2 VALVE GROUP 2: CHILLED WATER SUPPLY AND RETURN

.1 ANGLE VALVES
   Not Used

.2 GATE VALVES
   Not Used

.3 GLOBE VALVES
   Not Used

.4 CHECK VALVES
   .4.1 SYMBOL: 2CK11S - 2 Inches and Smaller:
      .4.1.1 Type: Horizontal swing check valve, screwed cover
      .4.1.2 Class: 150 pound or greater screwed end
      .4.1.3 Body and cover: ASTM B61 or B62
      .4.1.4 Disc: Bronze
      .4.1.5 Seat: Bronze
      .4.1.6 API 594 Trim: 15
      .4.1.7 Standard: MSS SP-80
   .4.2 SYMBOL: 2CK20F - 2-1/2 Inches and Larger:
      .4.2.1 Type: Horizontal swing check valve, bolted cover
      .4.2.2 Class: ANSI 150 flanged.
      .4.2.3 Body and cover: ASTM A216, Grade WCB or ASTM A105
      .4.2.4 Disc: 13 CR
      .4.2.5 Seat: 13 CR
      .4.2.6 API 594 Trim: 1
      .4.2.7 Standard: ANSI B16.34

.5 BALL VALVES
   .5.1 SYMBOL: 2BL12S – 2 Inches and Smaller:
      .5.1.1 Type: Lever operated ball valve
      .5.1.2 Class: 275 pound WOG or greater screwed end
      .5.1.3 Body: ASTM B61 or B62
      .5.1.4 Ball: Bronze
      .5.1.5 Seat: Replaceable Teflon
      .5.1.6 Standard: MSS SP-80

.6 BUTTERFLY VALVES
   .6.1 SYMBOL: 2BF23F – 2-1/2 Inches and Larger:
      .6.1.1 Type: Single flange high performance butterfly valve suitable for bidirectional dead-end service at rated pressure without use of downstream flange
      .6.1.2 Class: ANSI 150 lug type flanged.
      .6.1.3 Body: ASTM A216, Grade WCB or ASTM A105
      .6.1.4 Disc: 316 Stainless Steel
      .6.1.5 Seat: Reinforced R-PTFE
      .6.1.6 Shaft: Stainless Steel (X4CrNiMo 16-5); offset from seat plane
.6.1.7 Shaft seal: Graphite
.6.1.8 Standard: MSS SP-68
.6.1.9 Actuator: Gear operator with highly visible position indicator, memory stop and lockable hand wheel

33 63 35.3 VALVE GROUP 3: HIGH PRESSURE STEAM

.1 ANGLE VALVES
  .1.1 Symbol: 3AG10W – 2 Inches and Smaller:
  .1.1.1 Type: Globe style valve with a "Y" style or 45-degree angle body, designed for high steam pressure drop application for by-pass service. Valve shall be in-line repairable.
  .1.1.2 Class: 600 pound or greater socket weld
  .1.1.3 Body and bonnet: ASTM A216, Grade WCB or ASTM A105
  .1.1.4 Disc: HF Stellite
  .1.1.5 Seat: HF Stellite
  .1.1.6 API 600 Trim: 5
  .1.1.7 Shaft: Stainless steel
  .1.1.8 Packing: Graphite
  .1.1.9 Standard: ANSI B16.34

.2 GATE VALVES
  .2.1 Symbol: 3GT10W - 2 Inches and Smaller:
  .2.1.1 Type: Full port gate valve, vertical bolted bonnet, outside screw and yoke, rising stem, solid wedge disc
  .2.1.2 Class: 600 pound or greater socket weld
  .2.1.3 Body and bonnet: ASTM A216, Grade WCB or ASTM A105
  .2.1.4 Disc: HF Stellite
  .2.1.5 Seat: HF Stellite
  .2.1.6 API 600 Trim: 5
  .2.1.7 Shaft: Stainless steel
  .2.1.8 Packing: Graphite
  .2.1.9 Standard: ANSI B16.34

  .2.2 Symbol 3GT15W – 2 Inches and Smaller:
  .2.2.1 Type: Full port gate valve, vertical bolted bonnet, outside screw and yoke, rising stem, solid wedge disc
  .2.2.2 Class: 600 pound or greater socket weld
  .2.2.3 Body and bonnet: ASTM A351/A744, Grade CF3M Type 316L or ASTM A182, Grade F316L
  .2.2.4 Disc: 13 CR or HF stellite
  .2.2.5 Seat: HF Stellite
  .2.2.6 API 600 Trim: 8
  .2.2.7 Shaft: Stainless steel
  .2.2.8 Packing: Graphite
  .2.2.9 Standard: ANSI B16.34

  .2.3 Symbol 3GT20W - 2-1/2 Inches and Larger:
.2.3.1 Type: Gate valve, vertical bolted bonnet, outside screw and yoke, rising stem, flexible or solid wedge disc
.2.3.2 Class: 300 pound or greater butt weld
.2.3.3 Body and bonnet: ASTM A216, Grade WCB or ASTM A105
.2.3.4 Disc: HF Stellite
.2.3.5 Seat: HF Stellite
.2.3.6 API 600 Trim: 5
.2.3.7 Shaft: 13 CR
.2.3.8 Packing: Graphite
.2.3.9 Standard: ANSI B16.34
.2.3.10 Actuator: Where noted on the contract drawings, provide an enclosed gear operator

3 GLOBE VALVES
Not Used

4 CHECK VALVES
.4.1 Symbol: 3CK11W - 2 Inches and Smaller:
.4.1.1 Type: Vertical lift check valve, bolted cover
.4.1.2 Class: 600 pound or greater socket weld
.4.1.3 Body and bonnet: ASTM A351/A744, Grade CF3M Type 316L or ASTM A182, Grade F316L
.4.1.4 Disc: 13 CR or HF Stellite
.4.1.5 Seat: HF Stellite
.4.1.6 Trim: 8
.4.1.7 Standard: ANSI B16.34

5 BALL VALVES
.5.1 Symbol: 3BL15W - 2 Inches and Smaller:
.5.1.1 Type: Ball valve, designed shut-off service, in-line repairable, top-entry. Valve shall have capability of being welded into line without disassembly. Configuration shall be regular port. Operation of the valve shall automatically wipe the ball clean. The valve shall be blow-out proof, and shall be fully-guided to reduce side thrust effect. Tightness rate shall be per ASME Class V at 200 PSIG at 600°F. Valve shall be Velan “Securaseal” Type T or approved equivalent.
.5.1.2 Class: 600 pound socket weld ends
.5.1.3 Body and bonnet: 316 stainless steel, Grade CF8M
.5.1.4 Ball: 316SS/HC
.5.1.5 Seat: 316SS/Stellite
.5.1.6 Packing and back-up seal: Graphite
.5.1.7 Stem: Stainless steel

6 BUTTERFLY VALVES
.6.1 Symbol 3BF21W - 2-1/2 Inches and Larger:
.6.1.1 Type: High performance butterfly style, rotary valve, suitable for bidirectional dead-end service at rated pressure without the use of
downstream flange. The disk movement relative to the shaft rotation shall be triple offset design. Valve shall be Adams MAK-6 or approved equivalent.

.6.1.2 Class: 600 pound, butt weld ends
.6.1.3 Body: Carbon steel body conforming to ASTM A216, Type WCB. The hardened bearing with bearing seal shall be retained in the body.
.6.1.4 Disc: Retainer screws, disk, and plate shall be stainless steel.
.6.1.5 Seat: Stellite or similar hard-surfaced metal. Seats shall be resilient, non-flexing laminate metal seal composite of stainless steel and graphite retained such that centering movement is permitted.
.6.1.6 Shaft: Blow-out proof, 17-4 PH stainless, and single piece construction
.6.1.7 Shaft Seal: Graphite with multiple-stud packing gland followers for adjustability utilizing Belleville style washers
.6.1.8 Standard: API 607
.6.1.9 Actuator: Position indicator for sizes 2-1/2 through 24 inches. Provide right angle gear operator with 2-inch AWWA nut, with loose steel hand wheel or chain wheel attachment for remote "tee" handle operation as shown on drawings. Valve actuator shall be provided with self-locking gears. Provide stem housing to allow for minimum of 5 inches of insulation.

33 63 35.10 VALVE GROUP 10: CONDENSATE RETURN

.1 GATE VALVES
.1.1 Symbol: 10GT11W - 2 Inches and Smaller:
.1.1.1 Type: Gate valve, vertical bolted bonnet, outside screw and yoke, rising stem, solid wedge disc
.1.1.2 Class: 600 pound or greater socket weld
.1.1.3 Body and bonnet: ASTM A351/A744, Grade CF3M Type 316L or ASTM A182, Grade F316L
.1.1.4 Disc: 13 CR or HF Stellite
.1.1.5 Seat: HF Stellite
.1.1.6 API 600 Trim: 8
.1.1.7 Shaft: Stainless steel
.1.1.8 Packing: Graphite
.1.1.9 Standard: ANSI B16.34

.1.2 Symbol 10GT20F - 2-1/2 Inches and Larger:
.1.2.1 Type: Gate valve, vertical bolted bonnet, outside screw and yoke, rising stem, flexible or solid wedge disc
.1.2.2 Class: ANSI 300 flanged
.1.2.3 Body and bonnet: ASTM A351/A744, Grade CF3M Type 316L or ASTM A182, Grade F316L
.1.2.4 Disc: HF Stellite
.1.2.5 Seat: HF Stellite
.1.2.6 API 600 Trim: 5
.1.2.7 Shaft: 13 CR
.1.2.8 Packing: Graphite
.1.2.9 Standard: ANSI B16.34
.1.2.10 Actuator: Where noted on the contract drawings, provide an enclosed gear operator.

.2 CHECK VALVES
.2.1 Symbol: 10CK10W - 2 Inches and Smaller:
  .2.1.1 Type: Horizontal swing check valve, bolted cover. Vertical check valves are to be used only upon approval of OSU Utilities and must be lift check type.
  .2.1.2 Class: 600 pound or greater socket weld
  .2.1.3 Body and bonnet: ASTM A351/A744, Grade CF3M Type 316L or ASTM A182, Grade F316L
  .2.1.4 Disc: 13 CR or HF Stellite
  .2.1.5 Seat: 13 CR or HF Stellite
  .2.1.6 API 594 Trim: 1
  .2.1.7 Standard: ANSI B16.34

.2.2 Symbol: 10CK20F - 2-1/2 Inches and Larger:
  .2.2.1 Type: Horizontal swing check valve, bolted cover. Vertical check valves are to be used only upon approval of OSU Utilities and must be lift check type.
  .2.2.2 Class: ANSI 300 flanged
  .2.2.3 Body and bonnet: ASTM A351/A744, Grade CF3M Type 316L or ASTM A182, Grade F316L
  .2.2.4 Disc: 13 CR or HF Stellite
  .2.2.5 Seat: 13 CR or HF Stellite
  .2.2.6 API 594 Trim: 1
  .2.2.7 Standard: ANSI B16.34

.3 BALL VALVES
.3.1 Symbol: 10BL11W – 2 Inches and Smaller:
  .3.1.1 Type: Rated for steam service at 200 PSIG, 600°F conditions; two-piece construction, with stainless steel body, regular port, 316 SS ball and stem, replaceable seats and seals rated for temperature, blowout proof stem, vinyl-covered steel handle, socket weld ends and extended stem for insulated piping. Packing shall be graphite.

.4 BUTTERFLY VALVES
Not Used

33 63 40 HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT

PART 1 - GENERAL
.1 RELATED DOCUMENTS
.1.1 Contract Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
.1.2 Requirements of the following Division 33 Sections apply to this Section for the installation package only:
  .1.2.1 Section 33 63 05 – GENERAL PIPING PROVISIONS
  .1.2.2 Section 33 63 10 – COMMON WORK RESULTS FOR PIPING
  .1.2.3 Section 33 63 25 – PIPING SPECIALTIES
  .1.2.4 Section 33 63 35 – VALVES
  .1.2.5 Section 33 63 55 – PIPING INSULATION

.2 DESCRIPTION OF WORK

.2.1 This Section provides the specification for the installation of owner furnished pre-insulated supports and is included in the pre-purchase specification package for reference only. Additionally, this Section provides the specification for providing all non-insulated pipe hangers and supports. Only the pre-insulated supports for steam and condensate are being pre-purchased by OSU. The Contractor shall provide all other anchors and supports necessary for a fully functional system. This includes all ASME B31.1 piping systems. The A/E has performed an ASME B31.1 thermal stress analysis on the high pressure steam and pumped condensate piping systems for this project. The Contractor shall provide the pipe supports, hangers and anchors as detailed in the Contract Drawings and shall provide all supports for these systems to satisfy ASME B31.1 requirements of supporting the weight of the piping systems and to accommodate lateral and axial travel in the piping system associated with thermal pipe expansion and contraction. For all other piping systems, the Contractor shall design and provide pipe support systems to satisfy ASME B31.1 code requirements for all design conditions such as dead loads (weight of pipe, insulation, etc.), thermal loads (due to thermal expansion), and other loads (earthquake, etc.).

.2.2 The Contractor shall design and provide an engineered pipe hanger system for all pipe systems of this project as specified in this Section.

.2.3 This Section provides the specification for the following components:
  .2.3.1 Horizontal-piping hangers and supports
  .2.3.2 Vertical-piping clamps
  .2.3.3 Hanger-rod attachments
  .2.3.4 Saddles and shields
  .2.3.5 Miscellaneous materials
  .2.3.6 Pipe alignment guides
  .2.3.7 Pipe slides and rollers
  .2.3.8 Anchors

.2.4 Supports and anchors furnished as part of factory-fabricated equipment are specified as part of equipment assembly in other Division 33 Sections.

.3 SUBMITTALS

.3.1 Shop Drawings, Product Data, and Quality Assurance Submittals: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:
.3.1.1 Pipe hanger and support schedule for the pipe systems, including isometric drawings of the piping system. Schedule shall list all pipe supports.

.3.1.2 Product data, including installation instructions for each type of hanger and support component. This information shall consist of copies of the manufacturer's catalog data for the items provided in the pipe hanger assembly drawings and shall indicate dimensions, materials of construction, maximum recommended load if applicable, any operating instructions, approximate weight, and MSS SP-69 approval. Together with the pipe system isometric drawings and the manufacturer's catalog data, the assembly of the complete system should be clearly identifiable.

.3.1.3 Shop drawings of hangers, anchors, guides and slides to include hanger, pipe slides and guides data indicating the pipe service, location in the piping system, size, lateral and axial travel and vertical and lateral forces.

.3.1.4 Product data for high temperature sealant.

.4 QUALITY ASSURANCE

.4.1 For all pipe support related welding performed on site, qualify welding processes and welding operators in accordance with AWS D1.1 and ASME Boiler Pressure Vessel Code Section IX. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

.4.2 MSS Standard Compliance

.4.2.1 Provide pipe hangers and supports of which materials, design, and manufacture comply with MSS SP-58.

.4.2.2 Select and apply pipe hangers and supports, complying with MSS SP-69.

.4.2.3 Fabricate and install pipe hangers and supports, complying with MSS SP-89.

.4.2.4 Terminology used in this Section is defined in MSS SP-90.

.4.3 All hangers and supports shall comply with seismic design requirements. Seismic requirements are stated on the drawings and are not stated in this specification. You must get the drawings to conform to this specification.

.5 DELIVERY, STORAGE, AND HANDLING

.5.1 Packaging, marking, shipping, receiving, and storage shall be performed per the recommendations of Paragraph 9 of MSS SP-89.

.6 APPLICABLE PUBLICATIONS

.6.1 The publications listed below form a part of this Specification to the extent referenced. The publications are referenced in the text by basic designation only.

.6.2 American Society of Mechanical Engineers (ASME)

.6.2.1 B31.1 Power Piping Code
.6.2.2 BPVC Boiler Pressure Vessel Code
.6.2.3 BPVC Section IX Welding and Brazing Qualifications
.6.3 American Society for Testing and Materials (ASTM)
   .6.3.1 ASTM A36 Carbon Structural Steel
   .6.3.2 ASTM C150 Portland Cement
   .6.3.3 ASTM C404 Aggregates for Masonry Grout
.6.4 American Welding Society (AWS)
   .6.4.1 AWS D1.1 Structural Welding Code - Steel
.6.5 Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS)
   .6.5.1 SP-58 Pipe Hangers and Supports - Materials, Design, and Manufacturer
   .6.5.2 SP-69 Pipe Hangers and Supports - Selection and Application
   .6.5.3 SP-89 Pipe Hangers and Supports - Fabrication and Installation Practices
   .6.5.4 SP-90 Guidelines on Terminology for Pipe Hangers and Supports

PART 2 - PRODUCTS
.1 GENERAL
   .1.1 The Contractor shall provide all necessary pipe slides, pipe guides, hangers, beam clamps, hanger rods, turnbuckles, bracing, rolls, plates, brackets, saddles, and other accessories necessary to support the pipes from the trench structures. Drilling, welding, cutting, and other operations required to attach the piping to such structures shall be part of the Contract. Channels, angles, beams, and other structural steel items indicated and necessary to attach or brace pipe supports to the structure and used solely for that purpose shall be furnished by the Contractor and the cost thereof included in the Contract.
   .1.2 All pipe lines shall be provided with complete hanger and support assemblies. Included but not limited to shall be the pipe hanger, load-bearing insulation inserts, saddles, shields, hardware, washers, nuts, turnbuckles, rods, strap, clip angles, beam clamps, through bolts, ceiling plates and grout. Pipe hangers for all pipe lines shall comply with MSS SP-58, SP-69, and SP-89.
   .1.3 Pipe lines to be supported include all new piping and tubing, existing piping that requires temporary supporting due to structural related work, and existing piping where required due to new piping connecting to existing piping.

.2 HANGER DESIGN SERVICES
   .2.1 The A/E has provided a pipe support design for the high pressure steam and pumped condensate piping as described in .2 - DESCRIPTION OF WORK Section .2.1. The Contractor shall design an engineered pipe hanger system for all other pipe systems of this Contract. A detailed analysis is not required to be submitted, however, the Contractor shall perform calculations to the detail necessary to demonstrate that the pipe support system is adequate for the service. For all pipe hangers, supports, anchors, guides, etc., the Contractor shall submit pipe system isometric drawings. Provide proposed equipment manufacturer, manufacturer's model number and size,
construction, finish, quantities and/or lengths. Indicate pipe group, line size, insulation thickness.

.2.2 The Contractor shall provide engineering and design services and submit calculations and analysis for any deviation or modification to the pipe support systems designed by the A/E.

.2.3 The design conditions utilized to generate the hanger system design shall be taken from the piping system specification in Section 33 63 10 – COMMON WORK RESULTS FOR PIPING.

.2.4 Piping Connecting to Existing Systems

.2.4.1 The Contractor shall be responsible for verifying that existing supports are acceptable where tie-ins to existing piping occur. The Contractor shall consider all additional material required as part of this Contract.

.2.4.2 In order to perform calculations of the movement and support of the piping systems, it is recognized that the Contractor will have to identify existing piping and supports not currently shown on the Contract Drawings.

.3 GENERAL DESIGN GUIDELINES

.3.1 All supports and parts shall conform to the latest requirements of the ASME Code for Pressure Piping B31.1, and MSS SP-58, MSS SP-69, and MSS SP-89, except as supplemented or modified by the requirements of this Section.

.3.2 Designs generally accepted as exemplifying good engineering practice, using stock or production parts, shall be utilized wherever possible.

.3.3 Weight balance calculations shall be made to determine the required supporting force at each hanger location and the pipe weight load at each equipment connection.

.3.4 Pipe hangers shall be capable of supporting the pipe in all conditions of operation. They shall allow free expansion and contraction while providing continuous support of the piping and prevent excessive stress resulting from transferred weight or force being introduced into the pipe or connected specialties and equipment.

.3.5 Hanger Rods and Supports

.3.5.1 All rigid rod hangers shall provide a means of vertical adjustment after erection.

.3.5.2 Hanger rods shall be subject to tensile loading only. At hanger locations where lateral or axial movement is anticipated, suitable linkage shall be provided to permit swing.

.3.5.3 Where horizontal piping movements are such that hanger rod angularity is greater than or equal to 4 degrees from the cold to hot position of the pipe, the hanger pipe and structural attachments shall be designed and positioned in such manner that the rod is vertical in the hot and cold position.

.3.5.4 Hanger components shall not be used for purposes other than for which they were designed. They shall not be used for rigging and erection purposes.
.3.6 Pipe Anchors, Guides and Bracing Requirements

.3.6.1 All pipe anchors and guides shall be of welded steel construction designed with a safety factor of not less than five.

.3.6.2 The Contract Drawings for this project indicate the location of all anticipated anchors, guides, and braces required to control excessive forces and moments on equipment, over stressing of pipe material, and/or extreme mal-positioning and misalignment of supports or expansion joints caused by thermal expansion and contraction.

.3.6.3 The Contractor shall recognize the necessity and provide anchors, guides, and sway braces to prevent extreme mal-positioning and misalignment pipe supports, over stressing of pipe, and/or excessive forces and moments on equipment caused by hydraulic surge in the lines associated with normal operation and hydrostatic testing. These anchors, guides, and braces are not indicated on the Contract Drawings; the Contractor shall anticipate that such are necessary and shall allow for same in his contract; the Contractor shall also provide these items as necessary in the design of pipe support systems for piping systems included in the Contractor’s scope of piping systems support designs.

.3.6.4 After flushing and startup of all pipe lines, each shall be observed to locate excessive movement and then shall be guided or anchored by the Contractor at this time.

.3.6.5 Where the piping system is subject to shock loads, such as seismic disturbances or thrusts imposed by the actuation of safety valves or hydrostatic testing hanger design shall include provisions for rigid restraints or shock absorbing devices of approved design, such as Anvil Fig. 200 or approved equal shock and sway suppressor.

.3.6.6 Supports, guides, and anchors shall be so designed that excessive heat will not be transmitted to the supporting steel. The temperature of supporting parts shall be based on a temperature gradient of 100°F per inch distance from the outside surface of the pipe.

.3.7 Thin-wall Stainless Steel Lines: Ceiling hung thin-wall stainless steel pipes shall be supported by pre-insulated clamp type hangers and rollers with a stainless steel bearing plate or shield secured in place between the hanger or roller and the pipe. The bearing plate or shield shall be a minimum 12-inches long, cover a minimum of 1/2 of the pipe circumference, and be made 1/8-inch thick stainless steel bent to fit the pipe insulation. The maximum spacing of pipe hangers on thin wall stainless steel lines shall be no more than:

.3.7.1 1/2 inch through 1-1/4 inch = 8 feet
.3.7.2 1-1/2 inch through 4 inch = 10 feet
.3.7.3 5 inch and larger = 12 feet

.3.8 Finishes: All hangers and support assemblies, associated accessories and hardware shall have factory galvanized finish.
.4 HORIZONTAL-PIPING HANGERS AND SUPPORTS
   .4.1 Hangers shall be so spaced as to prevent sag and permit proper drainage. Hanger spacing shall be in accordance with MSS SP-69 except where indicated on the drawing and specified herein. Provide a hanger at elbows (within 2 feet) and terminations.
   .4.2 Horizontal pipe attachments shall be selected in accordance with Table 1 of MSS SP-69. Selection of components must strictly adhere to the allowable temperature ranges listed and the presence of insulation.
   .4.3 Pipe Clamps: Double-bolt pipe clamps when used on insulated pipe shall match the insulated pipe outer diameter. High density insulation inserts matching the pipe insulation shall be provided.
   .4.4 Clevis Hangers
      .4.4.1 Clevis hangers used on uninsulated lines shall match the pipe outer diameter. Clevis hangers used on insulated pipes shall be so sized that the inner diameter of the hanger matches the outer diameter of the piping insulation.

   .4.5 Brackets used for supporting piping shall be of welded steel construction with a design safety factor of not less than five.

.5 PIPING AND SUPPORTS, ROUTING AND LOCATION
   .5.1 Piping and conduits shall be run parallel with the lines of the structure, unless otherwise shown or noted on the Contract Drawings. The different service pipes, valves, and fittings shall be so installed that after the covering is applied there will not be less than one inch clear space between the finished covering and other work and between the finished coverings of parallel adjacent pipes. Hangers and supports on different service lines, running parallel with each other and parallel to the lines of the structure. Where conflicts between the trades result, they shall be resolved by the Contractor to the A/E's satisfaction and at no expense to the University.

.6 VERTICAL-PIPING CLAMPS
   .6.1 Provide Factory-fabricated vertical-piping clamps complying with MSS SP-58 selected by Contractor to suit vertical piping systems in accordance with MSS SP-69 and manufacturer's published product information. Select size of vertical piping clamps to exactly fit pipe size of bare pipe. Provide copper-plated clamps for copper-piping systems.

.7 HANGER-Rod ATTACHMENTS
   .7.1 Provide factory-fabricated hanger-rod attachments complying with MSS SP-58 as indicated on the drawings to suit pipe hangers and structure attachments in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacturer for each pipe support application. Select size of hanger-rod attachments to suit hanger rods and pipe support load. Provide copper-plated hanger-rod attachments for copper-piping systems.
.8 STRUCTURE ATTACHMENTS
   .8.1 Provide factory-fabricated structure attachments complying with MSS SP-58 as indicated on the drawings to suit substrate conditions in accordance with MSS SP-69 and manufacturer’s published product information. Provide copper-plated building attachments for copper-piping systems.

.9 SADDLES AND SHIELDS
   .9.1 As required for the pipe support load and the load bearing capacity of the insulation. Comply with MS SP 58 and MSS SP-69 type 40.

.10 MISCELLANEOUS MATERIALS
   .10.1 Steel Plates, Shapes and Bars: Provide products complying with ASTM A 36.
   .10.2 Cement Grout: Portland Cement (ASTM C 150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C 404, Size No. 2). Mix at a ratio of 1.0 part cement to 3.0 parts sand, by volume, with minimum amount of water required for placement and hydration. Refer to Section 33 63 05 – GENERAL PIPING PROVISIONS. Pipe anchors shall utilize a high temperature rated grout mix.
   .10.3 Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required; weld steel in accordance with AWS standards.

.11 PIPE SLIDES AND GUIDES
   .11.1 Pipe Slides and Guides: The A/E shall specify that the Contractor shall review carefully the insulation type, materials, and movements and submittal requirements in order to meet the design intent. Specify that units shall be rated for temperature for each service – steam and condensate to 600°F, pumped equipment drain to 212°F and chilled water to 120°F. Specify that all steel clamps and steel shapes components shall be ASTM A36 hot-dipped galvanized. Slide pads shall be graphite rated to 2000 PSI with a 0.1 coefficient of friction, bonded and secured to backing plates with recessed set screws. Hardware shall be ASTM A307 or B7 plated bolts, studs, and nuts. Structural insulation inserts shall be high density/high compressive strength Marinite P. Insulation shall be calcium silicate with moisture repellent on steam and condensate pipe services in buildings, tunnels and manholes and shall be high density/high compressive strength Cellular Glass on steam and condensate pipe services in trenches. (A/E refer to Section 33 63 55 – PIPING INSULATION for insulation thickness). Specify and design that the pipe slides and guides shall be selected for the anticipated lateral and axial travel and vertical and lateral forces at each pipe support location. Specify and design that the pipe slides and guides shall be designed and constructed in accordance with ASME B31.1 and MSS-SP 58 and have a design safety factor of 5.
   .11.2 Identification: Specify that the Contractor shall, for each support and base plate, clearly identify with the pipe support designation. Each support and base plate shall have markings that identify the axial and lateral positions of
the support in the cold position. This must be installed and coordinated in the field with the A/E’s thermal stress analysis and design documents.

.12 HARDWARE FOR PRE-INSULATED SUPPORTS
12.1 The contractor shall provide the levering nut, expansion anchor, expansion anchor nut, washer, and grout pad for each support.

.13 HIGH TEMPERATURE SEALANT
13.1 Provide high temperature, one part, silicone rubber sealant. Sealant shall be rated to 500°F for continuous operation. Basis of design: Tremco Trempro 644.

PART 3 - EXECUTION
.1 GENERAL
.1.1 Specifications of this part apply to the execution of contractor provided and owner furnished supports.

.2 RECEIPT OF PRE-PURCHASED SUPPORTS
.2.1 Contractor shall remove pre-purchased supports from the delivery vehicle on or near the jobsite.

.3 INSPECTION
.3.1 The installation, adjustment, and inspection of all hangers systems shall be performed by the Contractor in accordance with Paragraph 10 of MSS SP-89.
.3.2 During renovation and installation of equipment, the Contractor shall be responsible for the temporary support of all piping systems where necessary due to the phasing of construction. Temporary support systems shall be in accordance with the requirements of this Section.

.4 PREPARATION
.4.1 Proceed with installation of permanent hangers, supports, and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including, but not limited to, proper placement of inserts, anchors and other building structural attachments.
.4.2 Prior to installation of hangers, supports, anchors and associated work but after the pipe hanger submittal has been reviewed by the A/E, the Installer shall meet at project site with Contractor, installer of each component of associated work, installers of other work requiring coordination with work of this Section, and A/E for purpose of reviewing material selections and procedures to be followed in performing the work in compliance with this Section.

.5 INSTALLATION OF HANGERS AND SUPPORTS
.5.1 General: Install hangers, supports, clamps and attachments to support piping properly from building structure; comply with MSS SP-69 and SP-89. Install supports with maximum spacing complying with MSS SP-69 and to permit
normal pitch of pipe with deflection and bending stress maintained at a minimum.

.5.2 During the hydrostatic testing of any line with spring hangers designed for fluids lighter than water, travel stops or locks must be installed on the hangers or temporary solid rod supports must be provided during the entire time the line is filled with water to support its additional weight and thereby prevent overloading the springs. When tests are completed, the stops, locks, or solid rods must be removed and the hanger springs set for their cold loads.

.5.3 On the first occasion that any line is brought to operating temperature, the Contractor shall immediately reset each spring hanger to its hot load position and lock the adjusting nut or screw.

.5.4 Install building attachments to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping.

.5.5 Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping.

.5.6 Install hangers and supports to allow controlled movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends and similar units.

.5.7 Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.

.5.8 Seal the connection between each pre-insulated support and the adjoining insulation with high temperature silicone sealant.

.6 INSTALLATION OF ANCHORS

.6.1 Install anchors at proper locations to prevent stresses from exceeding those permitted by ASME B31.1 and to prevent transfer of loading and stresses to connected equipment.

.6.2 Fabricate and install anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.1 and with AWS Standards D1.1.

.7 METAL FABRICATION

.7.1 Cut, drill, and fit miscellaneous metal fabrications for pipe anchors and equipment supports. Install and align fabricated anchors in indicated locations.

.7.2 Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

.7.3 Field Welding: Comply with AWS D1.1 for procedures of manual shielded metal-arc welding, appearance and quality of welds made, methods used in correcting welding work, and the following:

.7.3.1 Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
.7.3.2 Obtain fusion without undercut or overlap.
.7.3.3 Remove welding flux immediately.
.7.3.4 Finish welds at exposed connections so that no roughness shows after finishing and so that contours welded surfaces to match adjacent contours.

.8 ADJUSTING
.8.1 Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve proper slope of pipe.
.8.2 Touch-Up and Cleaning: Clean and touch-up all field welds, bolted connections, and abraded areas of the shop finish on all support components with cold galvanizing repair.
.8.3 Refer to Section 33 63 05 – GENERAL PIPING PROVISIONS.

33 63 45 GASKETS
PART 1 - GENERAL
.1 RELATED DOCUMENTS
.1.1 Contract Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.
.1.2 Requirements of the following Specification Sections apply to this Section:
  .1.2.1 Section 33 63 05 – GENERAL PIPING PROVISIONS
  .1.2.2 Section 33 63 10 – COMMON WORK RESULTS FOR PIPING
  .1.2.3 All related specific piping specification Sections.

.2 DESCRIPTION OF WORK
.2.1 The extent and type of gaskets required by this Section shall be as indicated on the Contract Drawings and/or specified in other Division 48 Electrical Sections.

.3 SUBMITTALS
.3.1 Product Data: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:
  .3.1.1 Manufacturer's technical product data, including materials of construction, thickness, pressure and temperature rating, manufacturer's model number, and storage requirements.

.4 DELIVERY AND STORAGE
.4.1 Transport, Storage, and Handling:
  .4.1.1 Keep gaskets in dry area protected from weather.
  .4.1.2 Do not prepare gaskets until ready for installation.
  .4.1.3 Do not reuse gaskets.

PART 2 - PRODUCTS
.1 Gasket Identification System: a system has been established which identifies the specific gasket for each service identified in the contract drawings. The specific
gasket group is linked by the service number as listed in the "Piping, Gasket, and Service Group Index", which appears in Section 33 63 10 – COMMON WORK RESULTS FOR PIPING. An example is also presented in that section.

2.2 GASKET GROUPS

2.1 Gasket Group HP: Gaskets shall be spirally wound, Type 304 stainless steel with non-asbestos filler material and carbon steel outer ring. Gaskets shall be 1/16-inch thick and conform to the flange face on which they are used. Acceptable products from acceptable manufacturers include: Flexitallic Style CG with Flexicarb filler and 316L winding, manufactured by Flexitallic Inc., or approved equivalent.

2.2 Gasket Group HPB: Gaskets shall be spirally wound, Type 316L stainless steel with non-asbestos filler material and carbon steel outer ring. Gaskets shall be 1/8 inch thick and conform to the flange face on which they are used. Acceptable products from acceptable manufacturers include: Flexitallic Style CG with Flexite Super filler, manufactured by Flexitallic Inc., or approved equivalent.

PART 3 - EXECUTION

3 INSTALLATION

3.1 Match flanges within piping system and at connections with valves and equipment where specified.

3.2 Clean flange faces and install gaskets.

3.3 Tighten bolts to provide uniform compression of gaskets.

33 63 50 IDENTIFICATION FOR PIPING AND EQUIPMENT

PART 1 - GENERAL

1 RELATED DOCUMENTS

1.1 Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

2 DESCRIPTION OF WORK

2.1 Piping identification shall be provided for all new work in accordance with the requirements of this Specification Section.

2.2 Types of identification devices specified in this Section include the following:

2.2.1 Pipe Contents and Identification Markers

2.2.2 Equipment Identification

2.2.3 Brass Valve Tags

2.3 Piping identification furnished as part of factory-fabricated equipment is specified as part of equipment assembly in other Division 33 Sections.

3 SUBMITTALS

3.1 Product Data and Samples: In accordance with Section 01 33 00 - SUBMITTAL PROCEDURES, submit the following:
.3.1.1 Manufacturers’ technical product data and installation instructions for each type of identification device specified; Include a list of all piping systems indicating a proposed nomenclature.

.3.1.2 Samples of each color, lettering style, and other graphic representation required for Pipe contents and identification markers.

.4 QUALITY ASSURANCE
   .4.1 Codes and Standards:
       .4.1.1 ANSI Standards: Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

.5 SEQUENCING AND SCHEDULING
   .5.1 Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
   .5.2 Install identifying devices before installing concealment.

PART 2 - PRODUCTS
.1 PIPING IDENTIFICATION MATERIALS
   .1.1 General: Provide manufacturer’s standard products of categories and types required for each application as referenced in other Division 33 Sections. For each identification type, provide all tags from same manufacturer with same text, style, color, shape, and other identification features.

.2 PIPE CONTENTS AND IDENTIFICATION MARKERS
   .2.1 Description: The Contractor shall provide pipe markers or painted stenciled identification on all pipe systems as described below. Pipe markers and stencils shall indicate line contents, direction of flow, and that insulation is asbestos free. Line contents shall match service. Obtain approval from A/E for identification of each service.
   .2.2 Material: Fade-resistant, non-ferrous metal material. Snap-on or strap-on type. All markers shall have a minimum service temperature of -40°F to 175°F and be rated for outdoor service.
   .2.3 Arrangement: For external diameters (including insulation) equal to or greater than 3 inch, provide stencils. For external diameters (including insulation) equal to or greater than 1-1/2 inch and less than 3 inches, rectangular pipe contents indication marker shall contain only one line of text and appear on both sides of the pipe with a flow direction arrow roll wrapping 360 degrees around at both ends of the pipe contents indication marker. For external diameters less than 1-1/2 inch, provide full-band marker extending 360 degrees around pipe. The working of each marker shall be spelled out in the direction of the travel of the pipe.
   .2.4 Colors: For steam, condensate, and other related systems, stencil shall be orange letters and arrows. “Asbestos Free” stencils shall have a blue background with white letters. See Part 3 – EXECUTION, Sections .3 and .4 for painting considerations.
   .2.5 Text Height: Content minimum text height shall be as follows:
Overall OD
Including Insulation  Min. Letter Size
3/4 to 1-1/4 inch  1/2 inch
1-1/2 to 2 inches  3/4 inch
2-1/2 to 6 inches  1-1/4 inches
8 to 10 inches  2-1/2 inches
Over 10 inches  3-1/2 inches

.3  EQUIPMENT IDENTIFICATION
.3.1  All equipment shall have a manufacturer’s data tag. When this tag has been
removed, painted over, or rendered illegible, the Contractor shall provide new
tags. Tags shall be brass plates on which operational data plus information
regarding areas or other equipment served is stamped. Permanently attach
tags to the equipment in locations where they can easily be read.

.4  BRASS IDENTIFICATION TAGS
.4.1  Description: For the purpose of identifying valves. Provide on each valve a
brass identification tag. OSU shall provide a schedule of valve tags to the
Contractor.
.4.2  Lettering: Symbol letters and numerals shall be not less than 1/2 inch high,
shall be deeply impressed into the metal tag, and shall be Black filled.
.4.3  Size and Shape: Rectangular, minimum 1-1/2 inch high by 1-1/2 inch wide by
0.040 inch thick.
.4.4  Fastening: For valves, attach through punched hole on side of tag to valve
body or yoke, not the valve handwheel, with Monel wire.

PART 3 - EXECUTION
.1  GENERAL INSTALLATION REQUIREMENTS
.1.1  Coordination: Where identification is to be applied to surfaces which require
insulation, painting, or other covering or finish, install identification after
completion of covering and painting. In addition, provide pipe markers only
after each line has been complete, erected, purged, tested, and/or painted.

.2  PIPE SYSTEM IDENTIFICATION
.2.1  General: Provide pipe markers on every system including pipe contents and
flow direction. Provide "Asbestos Free" insulation markers for all pipe that is
insulated under this contract. Locations of all markers shall be subject to final
approval by the A/E.
.2.2  Location:
  2.2.1  Location: Locate pipe markers in a conspicuous manner at a
minimum of every 40 feet as follows:
  •  Upstream and downstream each isolation valve, control valve
  and pressure regulating station
  •  Near each valve station and control device
  •  Near each branch or change of direction
  •  On both sides where pipe passes through walls, floors, or
  ceilings within 4 feet of the barrier
• Near major equipment origination and termination points
• Near the inside and outside of concealed points
• In each Manhole and Valve Vault
• At elevation changes

2.2.2 Where pipes run parallel to each other, identify each pipe in the same general location.

.3 PAINTING COLOR SCHEME
.3.1 All piping systems shall receive an aluminum jacket so no paint is required for piping insulation systems.

.4 ADJUSTING AND CLEANING
.4.1 Painting and Insulating: Do not paint or insulate over any identification tags. Tags shall be installed after all painting is completed or shall be covered during painting.

33 63 55 PIPING INSULATION
PART 1 - GENERAL
.1 RELATED DOCUMENTS:
.1.1 Contract Drawings and General Provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections apply to this Section.
.1.2 Requirements of the following Specification Sections apply to this Section:
  .1.2.1 Section 33 63 10 – COMMON WORK RESULTS FOR PIPING
  .1.2.2 Section 33 63 25 – PIPING SPECIALTIES
  .1.2.3 Section 33 63 35 – VALVES
  .1.2.4 Section 33 63 40 – HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT
  .1.2.5 Section 33 63 50 – IDENTIFICATION FOR PIPING AND EQUIPMENT

.2 DESCRIPTION OF WORK
.2.1 Scope: Extent of the piping system and equipment required to be insulated by this Section is indicated in this Section, on the Contract Drawings, and other Division 33 Sections.
.2.2 Types: Types of piping insulation systems specified in this Section include the following:
  2.2.1 Pipe insulation
  2.2.2 Equipment insulation
  2.2.3 Insulation jackets
  2.2.4 Insulation accessories

.3 QUALITY ASSURANCE
.3.1 Codes and Standards: Provide insulation conforming to the following standards:
.3.1.1 American Society for Testing and Materials (ASTM): Manufacture and test insulation in accordance with the ASTM standards, including:

- ASTM B 209 Aluminum Alloys
- ASTM C 195 Mineral Fiber Thermal Insulating Cement
- ASTM C 196 Expanded or Exfoliated Vermiculite Thermal Insulating Cement
- ASTM C 302 Test Method for Density of Preformed Pipe Covering-Type Thermal Insulation
- ASTM C 335 Test Method for Steady-State Heat Transfer Properties of Horizontal Pipe Insulation
- ASTM C 356 Test Method for Linear Shrinkage of Preformed High Temperature Thermal Insulation Subjected to Soaking Heat
- ASTM C 411 Test Method for Hot Surface Performance of High Temperature Thermal Insulation
- ASTM C 449 Mineral Fiber Hydraulic - Setting Thermal Insulating and Finishing Cement
- ASTM C 534 Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
- ASTM C 547 Mineral Fiber Preformed Pipe Insulation
- ASTM C 553 Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
- ASTM C 612 Mineral Fiber Block and Board Thermal Insulation
- ASTM C 795 Thermal Insulation for Use in Contact with Austenitic Stainless Steel
- ASTM C 921 Practice for Determining Properties of Jacketing Materials for Thermal Insulation
- ASTM D 579 Greige Woven Glass Fabrics
- ASTM E 84 Test Method for Surface Burning Characteristics of Building Materials
- ASTM C591 Pre-Formed Polyurethane Pipe Insulation

.3.1.2 National Fire Protection Association (NFPA): Manufacture insulation in accordance with the following NFPA standards:


.3.1.3 Underwriter's Laboratory Inc.

.3.2 Do not provide materials with flame proofing treatments subject to deterioration due to the effects of moisture or high humidity, where applicable.

.3.3 Flame/Smoke Rating: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame spread index specified herein, and smoke developed index specified herein, as tested by ASTM E 84 (NFPA 255) method. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories Inc., label or listing, or satisfactory certified test report from an approved testing laboratory to prove that fire hazard ratings for materials proposed for use do not exceed those specified.

.3.4 The work shall be done only by mechanics thoroughly experienced in pipe insulation, and the quality of workmanship shall be the best attainable.

.4 SUBMITTALS

.4.1 Shop Drawings, Product Data, and Samples: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:

.4.1.1 Manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, K value, flame spread and smoke developed ratings, thickness, and furnished accessories for each mechanical system requiring insulation. Furnish necessary test data certified by an independent testing laboratory. Provide manufacturer's certification that insulation or any other materials provided shall not accelerate stress corrosion of stainless steel pipe per ASTM C795.

.4.1.2 Submit manufacturer's sample of each piping insulation type required, and of each duct and equipment insulation type required. Affix label to sample completely describing product.

.4.1.3 Insulation application schedule indicating equipment or piping systems sizes, insulation material, thickness, insulation vapor barriers, jackets, types of insulated fittings, accessories, and methods for each insulated system.

.5 DELIVERY, STORAGE, AND HANDLING

.5.1 Delivery: Deliver insulation, coverings, cements, adhesives, and coating to the site in containers with manufacturer's stamp or label affixed showing fire hazard indexes of products.

.5.2 Storage and Handling: Protect insulation against dirt, water, chemical, and mechanical damage. Do not install damaged or wet insulation; remove from project site.

.5.3 Outside storage of insulating materials is prohibited.

.5.4 Insulating materials and accessory materials shall be packed in shipping containers so constructed as to ensure safe delivery of the materials in a satisfactory condition. The shipping containers shall be legibly marked with the name of the manufacturer, material, size, type, thickness, density, and quality contained in each container.
.5.5 The Contractor shall provide a storage area for weather protection of all insulation materials and accessory materials after their arrival at the job site.

.5.6 Installed insulation which has not been weather-proofed shall be protected from inclement weather by approved waterproof sheeting installed by the Contractor. Any wet or damaged insulation shall be removed and replaced by the Contractor at no additional cost.

PART 2 - PRODUCTS

.1 INSULATION GENERAL REQUIREMENTS

.1.1 General: Provide insulation conforming to the referenced publications and the specified temperature ranges and approved manufacturers products.

.2 INSULATION IDENTIFICATION SYSTEM

.2.1 A system has been established which identifies the specific insulation type, insulation thickness, and insulation finish for each service indicated in the Contract Drawings. The specific insulation type, insulation thickness, and insulation finish is linked by the service number as listed in the "Piping Insulation Service Group Index" which appears in this Section. In addition, the insulation group only is listed in the "Piping, Gasket, Insulation, and Service Group Index" in Section 33 63 10 – COMMON WORK RESULTS FOR PIPING. See that Section for an example.

.2.2 Where insulation is scheduled for a pipe system below, insulation is required regardless of whether or not the letter designation for the insulation group is specifically called out on the pipe line description in the Contract Drawings. In some cases, a different amount of Insulation may be required for a piping line than what is specified in the indexes. In these cases, the required insulation group will be changed and called out on the pipeline description on the Contract Drawings and its corresponding thickness shall prevail.

.3 PIPING INSULATION SERVICE GROUP INDEX:

.3.1 PIPING INSULATION SERVICE GROUP INDEX – FOR PIPING LOCATED IN TRENCHES AND STEAM AND CONDENSATE MANHOLES

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>LINE DESCRIPTION</th>
<th>INSULATION GROUP</th>
<th>INSULATION FINISH</th>
<th>SERVICE GROUP ON DWGS</th>
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<tr>
<td>EQUIPMENT</td>
<td>50 PSIG at 212°F Max.</td>
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<td>N/A</td>
<td>PED</td>
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<td>Sump Pump Discharge in Trenches</td>
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<td></td>
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<tr>
<td>CONDENSATE, HIGH PRESSURE</td>
<td>200 PSIG at 600°F Max., from HPS to PC System</td>
<td>E</td>
<td>AA</td>
<td>HPR</td>
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<tr>
<td>CONDENSATE, PUMPED</td>
<td>200 PSIG at 388°F Max., Returned Condensate from Campus and Manhole Pumps to Plant</td>
<td>C</td>
<td>AA</td>
<td>PCR</td>
</tr>
<tr>
<td>SERVICE</td>
<td>LINE DESCRIPTION</td>
<td>INSULATION GROUP</td>
<td>INSULATION FINISH</td>
<td>SERVICE GROUP ON DWGS</td>
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<tr>
<td>EQUIPMENT DRAIN, PUMPED</td>
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<tr>
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<td>200 PSIG at 600°F Max., from HPS to PC System</td>
<td>J</td>
<td>CC</td>
<td>HPR</td>
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<tr>
<td>CONDENSATE, PUMPED</td>
<td>200 PSIG at 388°F Max., Returned Condensate from Campus and Manhole Pumps to Plant</td>
<td>H</td>
<td>CC</td>
<td>PCR</td>
</tr>
<tr>
<td>STEAM, HIGH PRESSURE</td>
<td>200 PSIG at 600°F Max., HPS Campus Distribution</td>
<td>J</td>
<td>CC</td>
<td>HPS</td>
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<tr>
<td>CHILLED WATER</td>
<td>150 PSIG at 140°F Max., CWS &amp; CWR Campus Distribution</td>
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<td>AA</td>
<td>CWS &amp; CWR</td>
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.4 INSULATION THICKNESS SCHEDULE: Nominal insulation thickness shall be as follows:

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<th>Insulation Group</th>
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<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
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</tbody>
</table>
.5 PIPE INSULATION GROUP SPECIFICATIONS

.5.1 General: Provide pipe insulation as specified below as dictated by the "Piping Insulation Service Group Index". Provide removable/reusable blankets in accordance with Insulation Group "R".

.5.2 Groups "A" Through "E" - Pipe Insulation:

.5.2.1 Insulation shall be 100 percent rigid cellular glass, totally inorganic, with no binder. Absorption of moisture shall be 0.2% or less per ASTM C240. Water-vapor permeability shall be 0 perm-in per ASTM E96. Average compressive strength shall be 90 psi ASTM C165. Average density shall be 7.5 lb per cubic foot per ASTM C303. Maximum service temperature shall be 900°F. Thermal conductivity shall be no greater than 0.29 Btu-in/hr-Ft² - °F at mean temperature of 75°F per ASTM C177 and C518. The insulation shall conform to ASTM E84 (5 Flame, 0 Smoke). Linear expansion shall be 3 inches per 100 linear feet at 600°F. Insulation shall be fabricated in half sections wherever possible. For large diameter piping where half sections are not practical, curved side wall segments are preferred. Provide double layer system with staggered joints for all systems where pipe temperature is listed as 400°F or greater.

.5.2.2 Fittings and valves shall be insulated with the same insulation system and built-up to the same thickness as the insulation for the adjoining pipe in accordance with insulation manufacturer's instructions.

.5.2.3 Provide insulation from one of the following manufacturers and product trade names:

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Trade Name of Approved Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pittsburgh Corning</td>
<td>FOAMGLAS</td>
</tr>
</tbody>
</table>

.5.2.4 Provide insulation with thickness as specified in Paragraph "Insulation Thickness Schedule".

.5.2.5 Pipe surfaces shall be clean and dry prior to insulating. Insulation may be temporarily held in place with stainless steel wire or fiber reinforced tape overlapped a minimum of 6 inches prior to the insulation finish being installed. The tape and/or wire may remain on the insulation beneath the insulation finish.

.5.2.6 The finish shall be as designated in "Piping Insulation Service Group Index" and specified in this Section.

.5.3 Insulation from inorganic silicate (calcium or sodium) or expanded perlite specifications can be referenced in BDS 40 07 00. Division 40 of the OSU BDS has not been published, therefore, the project A/E shall contact OSU Utilities' project lead for specific insulation details.
.5.4 Pipe Insulation from glass fiber specifications can be referenced in BDS 40 07 00. Division 40 of the OSU BDS has not been published, therefore, the project A/E shall contact OSU Utilities’ project lead for specific insulation details.

.5.5 Group “P” – Pipe Insulation:

.5.5.1 Pipe insulation on steam and condensate may be this type where pipes are close together which may present interference with the standard specified insulation type and thicknesses. Insulation thicknesses may not be reduced where potential interferences exist and therefore this insulation thickness must be considered. Potential interferences are called out on the drawings. If other potential interferences exist, notify the University and the Engineer for approval prior to using this insulation system.

.5.5.2 Insulation shall be Aspen Aerogels, Inc. Pyrogel XT with minimum 11 lb/ft density with k value of 0.26 Btu-in/hr – ft² –°F at a mean temperature of 330°F. Thickness shall be 2” for 16” HPS, 1 1/2” for 12” HPS, 1” for 10” HPS, 3/4” for 8” PCR, 1/2” for 6” and 4” PCR.

.5.5.3 Fittings and valves shall be insulated with same insulation and built up to the same thickness.

.5.5.4 Provide an aluminum jacket with aluminum bands as specified for other systems in this section.

.5.6 Group “R” – Removable/Reusable Insulation

.5.6.1 Insulating material shall be tailor-made removable/reusable blankets. The blankets shall be made with a high temperature fiberglass mat without the use of chemical binders and suitable for temperatures up to 1200°F.

.6 PIPE INSULATION FINISH SPECIFICATIONS

.6.1 General: Provide pipe insulation finish as specified below and where stated in the “Piping Insulation Service Group Index”.

.6.2 Group "AA" - Insulation Finish

.6.2.1 Steam, High Pressure Condensate, and Pumped Condensate Piping: Provide PITT WRAP jacketing system suitable for 200°F that requires heat fused seal.

.6.2.2 Provide an aluminum jacket over the PITT WRAP as specified below.

.6.2.2.1 Apply directly over the insulation an aluminum weatherproof jacket. This jacket shall be manufactured from aluminum alloy 5005 or 3003 half hard, not less than 0.016-inch thick, fabricated with 3/16-inch corrugations running lengthwise of pipeline. The aluminum shall be factory attached to a moisture barrier of kraft paper treated for this service.

.6.2.2.2 All joints shall be made rain or drip proof. Longitudinal joints shall be located on the side of the pipe with the open edge of the lap turned down to shed water. Circumferential joints on pipes that do not have enough slope to get a good shingle effect to keep water out of the joint shall have the
inside end of the lap beaded or sealed with a permanently elastic mastic type sealant designed for this service.

.6.2.2.3 The aluminum jacket shall be secured by aluminum straps 1/2-inch wide by 0.020-inch thick. The straps shall be placed on 12-inch centers (maximum). Each circumferential joint shall have a strap at the midpoint of the lap.

.6.2.2.4 On long radius bends, the aluminum jacket shall be in sections cut on the miter, overlapped, and forming a neat snug fit, using sufficient bands and fasteners to hold jacket properly in place.

.6.2.2.5 All 30-inch diameter and smaller insulated elbows shall be protected with a prefabricated elbow jacket. The jacket shall be manufactured of high purity 0.024-inch aluminum with a suitable moisture barrier on the interior of the jacket to prevent decomposition of the aluminum. The prefabricated elbow jacket shall be applied directly over the insulated fitting.

.6.2.2.6 All insulation on fittings, flanges, valves, and other irregular shaped items on which the aluminum jacket cannot be neatly applied shall be finished as follows:

- Over the smooth insulation surface and cloth reinforcing as described below, apply the mastic in two or more coats at a sufficient rate to provide a dry film thickness of 1/8 inch.
- The mastic shall be applied by trowel or spray. The exact application conditions, procedures and recoat time shall be as recommended by the mastic manufacturer.
- Reinforcing shall consist of a No. 10 mesh nylon or Dynel cloth. Flat surfaces shall be secured to the insulated structure on 18-inch centers maximum.
- The mastic shall be gray or metallic gray vinyl VI-CRYL, CP-10 or CP-11 manufactured by Childers Products Company, or WC-1 manufactured by Vimasco Corporation.
- Upon completion of the work, the Contractor shall furnish the A/E a certificate stating that the mastic has been applied in the same manner as specified or approved by its manufacturer.

.6.3 Group "CC" - Insulation Finish

.6.3.1 Insulation jacket shall be weatherproof aluminum. The jacket shall be manufactured from aluminum alloy 5005 or 3003 half hard, not less than 0.016-inch thick, fabricated with 3/16-inch corrugations running lengthwise of pipeline. The aluminum shall be factory attached to a moisture barrier of kraft paper treated for this service.

.6.3.2 All joints shall be made rain or drip proof. Longitudinal joints shall be located on the side of the pipe with the open edge of the lap turned down to shed water. Circumferential joints on pipes that do not have enough slope to get a good shingle effect to keep water...
out of the joint shall have the inside end of the lap beaded or sealed with a permanently elastic mastic type sealant designed for this service.

6.3.3 The aluminum jacket shall be secured by aluminum straps 1/2 inch-wide by 0.020-inch thick. The straps shall be placed on 12-inch centers (maximum). Each circumferential joint shall have a strap at the midpoint of the lap.

6.3.4 Provide mastic for all insulation on fittings, flanges, valves, and other irregular shaped items on which the aluminum jacket cannot be neatly applied.

PART 3 - EXECUTION

1 GENERAL INSULATION INSTALLATION

1.1 General: Install insulation material with smooth and even surfaces. Unless otherwise specified, install insulation materials, accessories, and finishes in accordance with the manufacturer's published recommendations.

1.2 Fire Precaution: Care shall be exercised by the Contractor that no cutting, welding, or open flames are permitted in the areas where flammable mastics or other materials are used. The precaution period shall extend until the material has cured sufficiently so that no further fire hazard exists.

1.3 Insulation Release: Before insulation is applied to any piping or equipment, the Contractor shall obtain from the Engineers a written release stating that the item is ready for insulation.

1.4 Manufacturer's Recommendations: All materials specified herein shall be installed in full accordance with the manufacturer's recommendations for the best performance and durability of his product, notwithstanding any requirements or omissions herein with respect to preparation of equipment before insulating or method of application.

1.5 Expansion Joints in Insulation: Where necessary, the Contractor shall furnish suitable expansion joints in the insulation to prevent cracking or wrinkling due to expansion and contraction of the surface being insulated.

1.6 Surface Condition: Do not apply insulation materials until all surfaces to be covered are clean and dry, all foreign materials, such as rust, scale, and dirt have been removed, and surfaces have been painted. Insulation shall be clean and dry when installed and during the application of any finish.

1.7 Moisture and Vapor Seal: Provide a complete moisture and vapor seal wherever insulation terminates against metal hangers, anchors and other projections through insulation on cold surfaces for which a vapor seal is specified.

1.8 Asbestos Containing Material:

1.8.1 No Contractor, Subcontractor, or Supplier shall furnish any asbestos containing material.

1.8.2 Provide "Asbestos Free" identification labels for insulated piping and equipment as specified in Section 33 63 50 – IDENTIFICATION FOR PIPING AND EQUIPMENT.
.2 INSULATION FOR PIPING
  .2.1 General: Installation
    .2.1.1 All sectional pipe insulation shall be applied with staggered girth joints tightly butted together as recommended by the insulation manufacturer. Each section of insulation is to be held in place with separate loops of 16 gauge annealed stainless steel wire placed not more than 12 inches on center.
    .2.1.2 Insulation shall not be applied to any flanged, machined, or welded surfaces until they have passed all field tests, including hydrostatic, and have been released for insulation.
  .2.2 Insulation of Valves, Flanges, Fittings, Etc.
    .2.2.1 High maintenance items such as control valves, some flanged valves, flanged joints, strainers and similar type items located in insulated lines shall be insulated with removable/reusable blankets. The Contractor shall insulate all high maintenance items as directed by the A/E with removable/reusable blankets in accordance with Insulation Group “R” of this Section.
    .2.2.2 In all insulated lines, with the exception of the high maintenance items which are insulated with blankets, the valve bodies, fittings, and flanges shall be insulated with the same material and the same thickness as the pipe insulation using mitered pipe insulation and/or block insulation securely cemented together. All flange insulation shall be the removable type, but not the replaceable type.
  .2.3 Gaps and Terminations: Neatly terminate all insulation at each end of unions and at other points where required and seal. Fill gaps occurring at hangers with insulating cement and finish flush with the adjoining pipe insulation as specified for fittings.
  .2.4 Butt pipe insulation against pipe hanger insulation inserts. For cold piping apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3 inch wide vapor barrier tape or band.

.3 PAINTING AND IDENTIFICATION
  .3.1 Aluminum jackets shall not be painted. Paint all glass canvas jacket insulated surfaces Section 33 63 50 – IDENTIFICATION FOR PIPING AND EQUIPMENT.
  .3.2 Provide identification labels and tags for all piping systems and equipment as specified in Section 33 63 50 – IDENTIFICATION FOR PIPING AND EQUIPMENT.
  .3.3 Do not insulate or paint over factory attached nameplate labels on equipment, valves, and other devices.

33 70 00.

ELECTRICAL UTILITIES METERING

PART 1 GENERAL

.1 APPLICATIONS:
  .1.1 The objective of this design standard is to outline the requirements of electric meters.
The permanent building meters in buildings on the Columbus campus utilized by The Ohio State University shall communicate this consumption to a local display and to the campus-wide Energy Metering & Monitoring system (InStep eDNA server). The electric meter shall include the instantaneous kilowatt rate.

A meter with system display is required for each Main and Distribution feeder circuit. The metering device and its display may be mounted on the Feeder Breaker or its associated Metering compartment. Additional duplicate metering shall be displayed on the Substation main control boards associated with the Main Transformers and their MV transformer Secondary feeders and report its information back to the campus distribution monitoring system, (ION Enterprise).

The electric meter, elements and devices shall meet custody transfer measurement requirements. Custody transfer measurement furnishes quantity and quality information which can be used as the basis for a change in ownership and/or a change in responsibility for materials, e.g., billing for rate of energy demand plus totalized energy transfer.

All Primary System Meters, potential and current transformers shall be of utility acceptable quality and accuracy, and shall be considered the property of OSU Utilities, within Facilities Operations and Development once placed in service. An engraved name plate displaying potential transformer primary and secondary voltage ratings and current transformer primary and secondary current ratings shall be installed below the meter.

If complete meter setup cannot be done from the front panel, any required software, cables, and keys shall be provided to OSU Utilities, within Facilities Operations and Development.

As a standard feature on all secondary metering, with the exception of temporary construction meters, a 4-pole GE PK-2 panel-mounted test block and 4 pole current test plug shall be installed flush on switchgear for portable test metering connection and use by OSU Utilities personnel. Current transformer poles shall have shorting auxiliary contacts and all CT wiring shall be on shorting type terminal blocks. (See Figure 5 for typical connection diagram).

If the meter used for kWh reading does not have a meter serial number on the front of the display, then an engraved name plate shall be installed below the meter displaying the meter serial number.

PART 2 PRODUCTS
1 Distribution Metering – Revenue
   1.1 Feeder/Distribution metering serves the dual purpose of providing instantaneous values of feeder operating conditions and provides trending, logging and historical data for planning and operations use over a secure OSU Utilities data acquisition network.
      1.1.1 The monitor shall provide the following information:
      1.1.2 Voltage (kiloVolts) - phase to neutral and phase to phase ABC
.1.1.3 Current (kiloAmps)- line and neutral (residual) ABCN
.1.1.4 Kilowatts (kW)
.1.1.5 Kilo-vars (kVAR)
.1.1.6 Kilo-voltamperes (kVA)
.1.1.7 Voltage maximum and averages over 15 min intervals
.1.1.8 Current Maximum and averages over 15 min intervals
.1.1.9 Kilowatt maximum demand based on 15 minute intervals
.1.1.10 Kilo-voltampere maximum demand based on 15 minute intervals
.1.1.11 Power Factor
.1.1.12 Transient waveform capture
.1.1.13 Power Quality measurements, logging and trending

.1.2 Permanent Building/System Metering – Revenue
.1.2.1 The monitor shall provide the following information:
   .1.2.1.1 Voltage – phase to neutral and phase to ABC
   .1.2.1.2 Amps – present reading and 15 minute maximum demand ABCN
   .1.2.1.3 Kilowatt-hours
   .1.2.1.4 Kilowatt maximum demand base on 15 minute intervals
   .1.2.1.5 Power Factor, Kilo VAR, Kilo VAR Hour, KVA

   .1.2.2 Avoid metering schemes that are only capable of measuring partial loads connected to the distribution system or electrical apparatus being monitored. Specify that a meter shall be installed to measure electrical load from the distribution system, including, but not limited to fire pumps.

   .1.2.3 Primary Service (customer) metering shall be performed by metering installed on the low voltage side of the Primary Transformer, before or after the Secondary main feeder circuit breaker or fused disconnect.

.1.3 Construction Metering – Revenue
The prime construction contractor shall provide one kW-hr meter suitable to record the total electrical consumption of the construction site. The contractor is responsible for the proper connection and installation of the meter and associated sources of current and potential. OSU Utilities, within Facilities Operations and Development supports an application process that the Contractor must follow as indicated herein

   .1.3.1 Meters shall be maintained accessible to and will be read by University Personnel. Failure to place a proper functioning meter into service prior to drawing electrical load will result in electrical usage charges that are estimated by the University based on the greater of the first full month of properly metered service or an estimate by OSU Utilities, within Facilities Operations and Development of likely usage based on worst case connected load for the period, whichever is greater. OSU Utilities, within Facilities Operations and Development reserves the right to refuse new
electrical service to any site not metered in accordance with design standards. Dysfunctional metering installation/systems are subject to estimated billing and back charges.

.2 CERTIFICATIONS
  .2.1 All devices shall be certified to be used the way it is being applied meeting all local and governing building codes.
  .2.2 Provide “Certificate of Compliance and Calibration” for each meter, which provides test tracing back to (NIST).
  .2.3 Provide IEC 60687 Class 0.5S and ANSI 12.20 Class 0.5 accuracy.

.3 COMMUNICATIONS
  .3.1 Distribution Metering
    .3.1.1 Each individual kW-hr meter specified must have communications capability. The communications shall be MODBUS RTU via a combination of serial RS-485 over 18 AWGA twisted pair and TCP/IP Ethernet over single mode fiber to medium voltage gear, to satisfy the information flow requirements to the OSU Utilities’ ION Enterprise meter data collection system. The final design configuration shall be determined by the OSU Utilities, within the Facilities Operations and Development.

  .3.2 Permanent Building/System Metering
    .3.2.1 Each individual kW-hr meter specified must have communications capability. The communications shall be MODBUS RTU via a combination of serial RS-485 over 18 AWGA twisted pair and TCP/IP Ethernet over CAT6 cable to the campus-wide Energy Metering & Monitoring system (InStep eDNA server). The final design configuration shall be determined by OSU Utilities, within Facilities Operations and Development.

.4 WARRANTY TERMS
  .4.1 THE SUPPLIER/MANUFACTURER OF THE ABOVE SPECIFIED EQUIPMENT shall guarantee for twenty four (24) months from equipment startup or thirty (30) months from date of shipment, whichever occurs first, that the equipment shall be free from defects in design, workmanship or materials.
  .4.2 In the event a component fails to perform as specified or is proven defective in service during the warranty period, the contractor shall promptly repair or replace the defective part at no cost to the University.
  .4.3 The manufacturer or contractor shall furnish OSU Utilities, within Facilities Operations and Development, with an installation, operation and maintenance manual for the electric meter and all of its components.

.5 ELECTRIC METER MANUFACTURERS AND MODELS
  .5.1 Low voltage building meters
.5.1.1 Schneider Electric, PowerLogic model ION6200 Enhanced 2 Series meter or IQ 150 meter with fused control transformer. (See Figure 5).

.5.1.2 Other models and manufacturers require submittal by the A/E and approval by The Ohio State University Utilities before including in the Design Development Documents.

.5.2 Medium voltage metering

.5.2.1 Schneider Electric, PowerLogic model ION7600 series meter with fused control transformer or with its power supplied from the meter potential transformer fused secondary. The 125 VDC power supply is the preferred option if a reliable DC source is available. Meter shall use Ethernet over single mode fiber for communications.

.5.2.2 Other models and manufacturers require submittal by the A/E and approval by The Ohio State University Utilities before including in the Design Development Documents.

.6 SHORTING BLOCKS

.6.1 A 4-pole GE PK-2 panel-mounted test plug.

.6.2 Other models and manufacturers require submittal by the A/E and approval by The Ohio State University Utilities before including in the Design Development Documents.

PART 3 EXECUTION

.1 INSTALLATION

.1.1 Follow manufacturer’s guidelines and submit installation drawings to OSU Utilities for review and approval prior to installation.

.1.2 The Contractor shall give OSU Utilities 10 University working days notification by calling Service2Facilities at 614-292-HELP prior to the installation of the electric meter for assistance in following the manufacturer’s installation specifications such as but not limited to location of the meter components, Ethernet connection, electrical connections, local disconnect, enclosure type, and all other applicable issues.

.1.3 Work performed without the assistance of the manufacturer’s technical erection supervisor and/or OSU Utilities shall adhere to dimensional requirements, assembly methods, and installation procedures specified herein and in the manufacturer’s instruction manuals and drawings.

.1.4 The Contractor shall comply with all erection and installation methods, techniques, sequence, and procedures requested by the manufacturer’s representative and/or OSU Utilities.

.1.5 Where manufacturer’s written instructions differ significantly from those proposed by the manufacturer’s representative, OSU Utilities shall determine the method used.

.1.6 All conduit and conduit connections shall meet the design and installation standards applicable for the installation area.
.1.7 Installation services shall include all conduit and wiring to provide a fully functional meter and communication wiring to the building Ethernet switch. Connection of Ethernet communication cable at the building Ethernet switch shall be coordinated through OSU Utilities. If necessary, Cat-6 shielded cable or single mode fiber and conduit shall be installed between the electric meter and the nearest building network switch.

.1.8 Panel/Meter IP and MODBUS addressing shall be assigned by OSU Utilities.

.1.9 MODBUS data registers shall be provided, at a minimum, for instantaneous kW rate, and totalized value.

.1.10 All meters and ancillary equipment shall be installed in such a manner as to provide access for routine inspections, maintenance, and a means of removal.

.1.11 All anchors and structural steel supports shall be built to template and reinforced as required for loads imposed on them.

.1.12 The height of the meter display shall be five feet (5.0') from the finished floor or 4-½ feet from the floor elevation to the center of the meter if mounted on a vertical panel or cabinet. If mounted in switchgear, the meter display should be mounted at a height that facilitates meter access and viewing.

.2 TRAINING

.2.1 The supplier/manufacturer shall train OSU Utilities personnel to program, calibrate, operate and maintain the above-mentioned devices for at least 3 hours. Training shall be scheduled within two weeks of completion of the installation.

.3 INSPECTION AND COMMISSIONING

.3.1 A representative of OSU Utilities will inspect the installation and performance of the electric meter for acceptance and approval before commissioning. OSU Utilities reserves the right to witness factory testing and calibration.

.3.2 Provide for review of required closeout documentation.

.3.3 Provide for review, of wiring schematics with point to point wiring diagrams in AutoCAD.dwg format.

.3.4 Document and provide for review, all electrical power sources with breaker and panel numbers.

.3.5 Electric meters shall be commissioned and a commissioning record document shall be issued identifying each meter by its serial number and location and confirming its correct installation and function.

.3.6 Electric meter commissioning shall be a joint effort between the project’s Contractor, A/E and/or Commissioning Agent, and The Ohio State University. Electrical service will not be connected or reinstated by OSU Utilities until installation of the electric meter is inspected by OSU Utilities and found to meet the requirements of the electric meter manufacturer and these design and installation standards.
.1.1 Bulk electrical power is delivered to the University at 138,000 Volts. The University transforms this power down to 13.6 kV at the main substation(s) bus(es), which in turn then distributes it to Primary feeder pairs that traverse the campus. See Figure 1 for overall MV Distribution system layout and nomenclature. All permanent buildings, and building complexes, and construction temporary power are provided with service drops from both circuits of a feeder pair through one or more primary switches. These switches allow the buildings to be switched between primary feeders when feeders need to be de-energized for construction work, maintenance, or due to failure. Each building or building complex has one or more transformers fed from the primary switches through a variety of switch and secondary feeder arrangements designed to suit the specific needs of the buildings. See Figure 2 for typical Primary Service arrangements.

.1.2 Primary service is generally restricted to significant 3 phase loads. The number of primary services on any given feeder pairs must be limited for reliability reasons and to insure that circuit feeders can be quickly isolated and restored after experiencing a circuit failure. Preference is given to providing primary service switches that can separately switch multiple building loads from one primary service tap.

.1.3 Buildings are assigned a normal and an alternate feed. This assignment may be changed by UTHVS to meet the needs of the High Voltage system. The alternate feed is not a “Back-up” feed. Circuits are routinely removed from service to accommodate construction needs, maintenance and repair of cable and switches. The practice of assigning a “Regular” and “Backup” building feed is generally prohibited. Certain campus circuit pairs have designated “third feeders”. In such instances, some buildings fed from the circuit pair will have an assigned “Regular” feed and a “Backup” from the associated third feeder.

.1.4 Some of the larger buildings or building complexes are equipped with third feeders and a set of two Primary Select switches. This design allows a “Switched Primary” feeder pair to be run throughout the building or building complex. This arrangement provides extra switching flexibility and greater failure tolerance.

.1.5 Some Feeder pairs have a set of two Primary select switches feeding branch circuits with a switched pair of feeders. This feature is provided to reduce switching time and aid in location of system faults. See Figures 2 and 3.

.1.6 Third Feeders have been added to the MV Distribution system to increase feeder capacity and improve system reliability and availability. See Figure 3.

.1.7 The addition of Dual Primary Select switches with switched primary pairs along with the third feeders will ultimately increase Feeder Protection selectivity and support automation of the Campus electrical distribution system while reducing the time it takes to locate, isolate and transfer campus loads in the case of feeder failure.

.2 Columbus Campus Primary voltage: The available underground primary distribution voltage is 13.2 kV volt 3-wire, 3-phase, 60-cycle. This system is a solidly grounded Wye system.
Regional Campuses Primary voltage: While the University strives to maintain a level of consistency between regional campuses, each campus is unique. Consult the UTHVS or TSG for specifics of the power distribution systems at Regional Campuses.

### MEDIUM VOLTAGE DISTRIBUTION SYSTEM

#### EXTERIOR UNDERGROUND RACEWAYS:

1. **All underground cables of any classification shall be installed in approved duct raceway systems. The number and size of conduits depend on the service classification and are designed to meet the electrical system and facility needs. See Figure 4 for typical Primary duct bank configurations.**

2. **Direct burial of underground cables is prohibited.**

3. **Cold bending of PVC conduits is prohibited.**

4. **New raceway installations shall be designed for future capacity addition.**

5. **Additional spare ducts shall be included as required by the University to afford spare ducts for failure or circuit additions. Duct banks that are intended to carry Primary circuits shall be provided with enough spare ducts to accommodate a minimum of one additional circuit pair. Duct banks intended to carry lateral building feeder taps shall be designed with a minimum of one spare duct per duct bank.**

6. **Raceway ducts within duct banks for Primary cables shall be schedule 40 PVC conduit. PVC conduit shall be adapted to rigid steel conduit beginning at ten feet (10’) before entrance to outside of building foundations.**

7. **PVC conduit shall be adapted to rigid steel conduit beginning at ten feet (10’) before entrance into manholes. This requirement may be waived with the written approval of Utilities UTHVS in specific instances where adequate structural integrity can be demonstrated and where the duct bank design uses the added reinforcement and is four or more 6” ducts high by two wide. Raceways shall be encased in concrete as Primary duct bank.**

#### PRIMARY DUCT BANKS

1. **Raceways for primary electric shall be encased in a reinforced concrete (3” minimum cover) envelope. The standard size for primary electric ducts shall be 6 inches for Primary mains, and 5 inches for Primary building laterals and Primary load ways.**

2. **Ducts for Primary mains shall be placed on 9 1/2 inch centers for 3-inch spacing between power ducts. Ducts for Primary laterals and Primary load ways shall be in duct banks with power ducts placed on 8 1/2 inch centers for 3-inch spacing between power ducts. Primary mains shall contain a minimum of six 6-inch diameter schedule 40 PVC power ducts and two concentrically located 2-inch diameter schedule 40 PVC ducts provided for ancillary use. Primary laterals and Primary load ways shall contain a minimum of four 5-inch diameter schedule 40 PVC power ducts and one concentrically located 2-inch diameter schedule 40 PVC conduit provided for ancillary use. Carlon Snap-Loc Spacers, or approved equivalent, supported on concrete or ceramic blocks shall be placed at eight (8) ft intervals. See Figure 4 for duct bank details.**

3. **Ducts shall be installed below the frost line at a minimum thirty (30) inches below finished grade and shall be sloped to drain into manholes.**
.2.4 Multiple parallel duct bank installations shall observe a minimum horizontal spacing of two (2) feet of soil, thermally conductive sand or compacted 304 aggregate. This provision does not apply to duct bank crossings with an acute angle of greater than 30 degrees.

.2.5 Two longitudinal steel reinforcing bars with a minimum of 18 inch overlap shall be used for each layer of duct in all duct banks. In instances where the duct bank crosses a roadway or high vehicle traffic area, two additional steel reinforcing bars shall be provided at the top and bottom of the bank to assist in distributing the load. Ducts shall be bundled and tie-wired to assure integrity of the duct array during pour. Concrete shall encase the duct bank installation a minimum of 3-inches on all sides. Provide one (1) #5 steel reinforcing bar for each conduit in the duct bank). Tie off the reinforcing bars to the plastic supports holding the conduit in place. Allow for a minimum of 2" of concrete over the reinforcing. Concrete envelopes shall extend through foundation and manhole walls designed so that the envelope becomes a structural member providing support for bridging the area that has been excavated and back filled for foundation or manhole walls. Encasement concrete shall be City of Columbus CMS 499 Class C, 4000 psi @ 28 days.

.2.6 Tear tape shall be placed approximately one foot above the duct bank when being backfilled.

.2.7 Elbows shall be long-radius rigid steel conduit.

.2.8 End Bells shall be steel. Aluminum, plastic or pot metal end bells are prohibited. End bells on conduit entering a building or manhole shall have their broader opening mounted flush with the interior surface of the wall penetrated by the duct.

.2.9 Duct banks of 6 or more ducts should avoid crossing an area with an unfavorable thermal environment (i.e., crossing steam pipes, parking lots) as such cable installations may require de-rating.

.2.10 Ducts banks shall not pass within 10 feet of a buried steam line in any direction. If it becomes necessary to cross a steam line, acceptable insulation of the crossing must be provided and approved by UTHVS.

.2.11 Primary ducts banks shall cross gas lines below the gas piping without exception.

.2.12 Primary voltage cable within a building shall be installed in rigid steel conduit with UL approved steel pull boxes. Label conduit every 10 feet and pull boxes shall be labeled "DANGER 13,200 VOLTS".

.2.13 Cable or conductor bending radius shall not be less than eight times the overall diameter for non-shielded cable and twelve times the diameter of shielded cable during or after installation. On systems operating above 1 kV to ground, cables installed in nonmetallic conduit shall have an effectively grounded shield, and one 4/0 single conductor 600 V insulated ground wire run with the three phase circuit in the same conduit.

.2.14 Primary cable ducts between manholes or other terminal points shall be as straight as practical. All bends shall be "sweep" bends and any bend greater than ten (10) degrees per ten (10) foot length of duct, shall be made with rigid steel conduit. Where possible, duct banks shall be run straight from manhole
to manhole; where bends are necessary, the total shall not exceed 90 degrees in addition to any turn up at the pad or equipment.

.2.15 Layout: Primary duct banks shall be a maximum of two ducts wide by four ducts high. Exception may be taken on a case-by-case basis for accommodation of site specific issues and to address special circumstances of loading or for instances where duct installation is by boring or other means where a rectangular array is not practical. All requests for exception must be approved in advance of installation by OSU Utilities UTHVS.

.2.16 For final preparation, a properly sized steel mandrel shall be pulled through all new or repaired ducts. Mandrel shall be ¼” to ½” smaller in diameter than the duct; this shall be a test witnessed by UTHVS. Each duct shall be proved clear and usable, cleaned, have a No. 12 type TW pull wire left in place, and spare ducts shall have duct plugs installed.

.2.17 Color Additive: Concrete for Primary duct banks shall have a red color additive mixed in the concrete for identification. Specify Solomon 417 Apple Red; suggested mix approximately three and a half pounds (3-1/2 lbs.) per 80 pounds of cement to provide identifiable red color as warning to any one digging into the high voltage cable run. The concrete supplier shall premix concrete. Color additive shall not be hand-troweled in, and shall not be sprinkled.

.2.18 A member of UTHVS shall inspect and approve primary ducts before concrete is poured. A member of UTHVS shall witness the concrete pour.

.2.19 Excess concrete shall not be placed in the hole or used to raise the top of the duct bank greater than 3 " above the top of the ducts. Duct banks shall be a continuous pour from bottom to top. Concrete shall be poured and compacted so as to avoid inclusion of air pockets or areas where concrete doesn’t completely cover ducts and reinforcements. Remove all excess concrete from University property.

.2.20 Soil may be used to backfill duct bank excavations provided they are not in streets or where recurrent heavy surface loadings are anticipated. High traffic and heavy load areas must be backfilled with ¾” crushed stone or CDF with a covering layer of compacted soil or gravel and resurfaced to original wear surface.

.2.21 MV electrical duct banks are not to be routed under buildings or through locations where subsurface conditions are unsuitable or where major construction is anticipated that could destabilize adjacent soils and place the duct bank and the Primary circuits contained in jeopardy.

.3 MANHOLES

.3.1 Manholes shall not be installed inside buildings or in areas of public assembly.

.3.2 All medium voltage manholes or vaults shall have High Voltage Line and Utility truck access. It is common practice to place vaults under Primary switches to facilitate cabling and to allow for a lower switch profile. Such vaults follow the design for manholes and are constructed with not only manhole cover access but also an opening for cable entrance directly from the vault area into the bottom of the Primary switch enclosure.
.3.3 Manhole covers shall be round, 32-inch diameter, heavy duty, traffic rated (H20) with the word "ELECTRIC" cast in cover as applicable. Covers shall not have gaskets or be bolted down. Two slots, on opposite edges, shall be provided to permit using manhole hooks to remove cover.

.3.4 Flame Proofing: Cables in manholes, vaults, cable spreading areas, and at conductor terminations where more than one Primary Circuit is present shall be flame proofed with tape (3M #77l). Control cables and fiber optic cables shall also be flame proofed in manholes, vaults and cable spreading areas where power cables are present and can pose a threat if faulted.

.3.5 Cables in manholes shall be tagged with phase and feeder numbers marked using 1" x 3" plastic tags with 1/2" high by 1/16" thick engraved lettering (black on white).

.3.6 Primary Cables to the Transformers and Switches: Cables going into buildings from manholes shall be marked with the building's name for identification using plastic with engraved 1/2" high by 1/16" thick lettering (black on white).

.3.7 Manholes shall be located and sized to allow workable pulling tension on cables and other considerations in planning. Minimum inside measurement of the medium voltage compartment shall be 6' wide by 10' long by 7' high. Maximum spacing between successive manholes shall be 400' measured along the length of the duct bank. Throat and manhole overall depth shall be limited to facilitate cable pulling activity and limit the risk of injury from falling. (48" throat and overall depth to floor from finished grade of 16')

.3.8 Access shall not be less than a 32-inch round chimney equipped with removable steel ladder placed in each manhole.

.3.9 Hardware shall include pulling eyes in each wall opposite of a duct bank at 3' above finished floor and the center of the floor, inserts, and cable racks. Racks shall be Underground Devices CR 36 brackets with RA 14 or RA 20 support arms Hardware to be secured by stainless steel fasteners.

.3.10 At least one 5/8" diameter by 10' long driven copper-clad steel ground rod shall be installed in each manhole 6 inches from a wall.

.3.11 A 1" x 1/4" copper ground bus shall be placed around the perimeter of the manhole walls 6" from the ceiling for bonding all cable shields. Connect to ground rod with 4/0 copper cable. Connect manhole reinforcing steel, duct bank reinforcing steel and manhole metal hardware with #2 copper cable. Use Cadweld® for ground connections.

.3.12 All electrical ducts entering manhole shall be perpendicular to the manhole wall and shall be at least a minimum of ten feet (10 ft.) straight from the manhole wall. All ducts banks shall enter manhole within one foot of a corner. Do not center manhole on duct bank.

.3.13 End bells shall have their wide end positioned flush with the interior of the manhole wall.

.3.14 Provide a sump hole in manhole floor in area below cover. Slope floor to sump.

.3.15 Manhole covers shall be at finished grade. The ring and cover shall be centered over chimney.

.3.16 In applications where the duct bank employs a four or more high by two wide 6" duct design, Utilities UTHVS, as stated in previously in paragraph 33 71
49.1.6, may permit the duct bank to enter manholes without the requisite ten foot steel conduits and the use of cast steel end bells. This may be permitted in instances where the duct bank approach to the manhole is straight for ten feet or more and the intersection of the duct bank and manhole is at right angles.

.4 WIRE AND CABLE
.4.1 Copper conductors of 98 percent conductivity shall be used unless use is restricted by Government Agencies. Aluminum conductors are prohibited.

.4.2 COLOR CODING
Color coding for 13.2 kV cables and 5 kV cables shall be as follows:

<table>
<thead>
<tr>
<th>Phase</th>
<th>Voltage 13.2 kV and 5 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutral</td>
<td>White or Gray</td>
</tr>
<tr>
<td>A</td>
<td>Brown</td>
</tr>
<tr>
<td>B</td>
<td>Orange</td>
</tr>
<tr>
<td>C</td>
<td>Yellow</td>
</tr>
<tr>
<td>Equipment Ground</td>
<td>Green, Black</td>
</tr>
</tbody>
</table>

.5 PRIMARY VOLTAGE CABLES (13,200 Volt)
.5.1 The insulation must be compounded and mixed by the cable manufacturer in its own facilities using a closed, clean process to ensure maximum control and continuity of quality. The strand shield and insulation shield shall be extruded, semi-conducting thermosetting material that is compatible with the insulation.

.5.2 Cable shall be suitable for normal installation in conduit and shall be suitable for continuous submersion in water. The cable shall be capable of continuous operation in both a wet or dry environments at a conductor temperature of 105°C in normal operation, 130°C in emergency overload operation, and of 250°C in short-circuit operation.

.5.3 Main feeders in the Columbus campus power system shall be a minimum of 500 kcmil 4/0 cables shall be used for the laterals and load ways from the primary circuit taps into a building for each primary selective switch pair. Some circuit pairs have associated “Third Feeders” which are designed to back up multiple feeder pairs. Where applied, these circuits shall be conductor with 750 kcmil cable from the source CB in the Main substation to its end. Laterals to individual Primary switches are 750, 500, or 4/0 depending on the individual service requirements. In instances where building services are 1500 kVA or less, individual load ways may be sized #2 AWG or the standard 4/0. Any load way less than 4/0 must be designed to accommodate a replacement 4/0 cable including the duct bank housing the conductors.

.5.4 Only cables from companies with an established reputation and an excellent track record in the medium voltage power cable manufacturing industry shall be installed in primary system applications.

.5.5 13,200-volt primary feeder and service cables shall be UL Listed and from a list of manufacturers approved by UTHVS.
.5.5.1 One compact conductor per ASTM B496 or compressed soft-annealed copper per ASTM B-3, stranding per ASTM B-8.

.5.5.2 220 mil Ethylene Propylene Rubber (EPR) insulated, 15 kV, 133% rated, MV 105°C cables.

.5.5.3 The shields shall be uncoated 5 mil bare copper tape applied helically over the insulation with a minimum overlap of 25 percent of the tape width.

.5.5.4 The jacket shall be continuously extruded, 80 mil, ‘low-smoke (Critical Temperature Index > 240°C) zero halogen’.

.5.5.5 Cable construction shall comply with the latest requirements of ICEA S-93-639/NEMA WC-74.

.5.5.6 Under limited circumstances and on a case by case basis, where risk to personnel and equipment is considered to be minimal, the requirement for a zero halogen jacket may be waived with Utilities (UTHVS) approval. Utilities maintains a listing of approved MV cable suppliers and approved cable jacket materials and constructions.

.5.6 Each primary circuit shall have the power conductors arranged in a three phase array sharing a common duct. Each 3 conductor array shall include within its duct a 4/0, 600 volt insulation class ground wire bonded to all splices and terminations and grounded in substation(s) and manholes.

.5.7 Primary circuits comprised of multiple conductors per phase shall have the power conductors arranged in three phase arrays in multiple ducts. Each 3 conductor array shall include within its duct a 4/0, 600 volt insulation class ground wire bonded to all splices and terminations and grounded in substation(s) and manholes.

.5.8 Phase rotation of primary service termination shall be established prior to termination. Phase positions at terminating equipment shall be Phase "A", "B", and "C" left to right facing the front, or "A", "B", and "C" front to rear. Circuit phasing shall be from the Substation to the point of splicing/termination and be performed with the assistance and under the observation of an UTHVS representative.

.6 SPLICING AND CABLE TERMINATIONS

.6.1 All work performed on non-lead, medium voltage (1 kV to 35 kV) cables shall be performed by personnel with adequate training and experience and certified as qualified by the UTHVS. To be considered qualified for cable splicing, the individual’s employer must submit a resume with past training and experience supported by documentation of their having had the appropriate formal training in the preparation of relevant medium voltage splices and terminations prior to the individual performing any work. Splicing and termination experience shall be recent (one to five years depending on extent of prior experience) and relevant to the type of splice and cables being spliced.

.6.2 Add label, which is applied to each phase wire where all terminations and splices occur. Every splice shall be labeled with an engraved plastic tag (black on white) containing the following information:
• Date of splicing
• Name of company that performed splicing; this shall include both lead and non-lead splices.
• Label shall include phase identification and circuit number.

.6.3 All work performed on lead sheathed, medium voltage (1 kV to 35 kV) cables shall be performed only by personnel who have been tested and certified by UTHVS to be qualified. Contractor personnel approved by UTHVS as certified lead-cable splicers shall perform Paper Insulated Lead Covered (PILC) to PILC Splices and shall use UTHVS approved materials utilizing historical lead-wiping methods.

.6.4 PILC to Polymeric Splices (and PILC to PILC) wye, X and straight shall meet the requirements of ANSI/IEEE 404 (Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2,500 V to 500,000 V, most current version) for 15 kV 133% voltage rating. It must be rated for continuous operation at 105°C, with an emergency overload rating of 130°C. The joint manufacturer shall provide a test report, upon request, demonstrating the joint performance is equivalent to the cables per relevant sections of IEEE-48 (Standard Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV through 765 kV, most current version), IEEE 404 (Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 to 500000 V, most current version), AEIC-1, most current version. The joints shall be subjected to a UTHVS approved voltage withstand test sequence. The splice shall include a solder-less mechanical ground jumper. The splice shall be designed for splicing the types and sizes of power cable used. The splice shall be rated for indoor, outdoor, and immersion in water.

.6.5 A split-tinned solder connector may be used to join the cables conductors. As an approved alternative to soldering, a 360 degree crimped lug may also be employed. Crimps are to be made by a crimp tool approved by the lug manufacturer following their approved procedures. All crimps shall employ a 360 degree crimp.

.6.6 UTHVS approved, Raychem factory-manufactured heat shrink splice kits shall be used exclusively.

.6.7 Kits shall be factory-engineered to contain all necessary materials, except connector, to provide an oil block and oil seal electrical stress control, insulation, shielding and environmental sealing. The kit shall allow for external grounding.

.6.7.1 Straight splices shall use Raychem Number:
• HVS-1532-LC for 4/0 Cable Poly to Poly
• HVS-1533-LC for 500 KCMIL Cable Poly to Poly
• HVS-1582D for 4/0 Cable PILC to Poly
• HVS-1583D for 500 KCMIL Cable PILC to Poly
• HVS-1523S for 750 KCMIL Cable Poly to Poly

.6.7.2 Wye splices shall use Raychem Number:
• HVSY-1522-S for 4/0 Cable Poly to Poly
• HVSY-1523-S for 500 KCMIL Cable Poly to Poly
• HVSY-1582-D for 4/0 Cable PILC to Poly
• HVSY-1583-D for 500 KCMIL Cable PILC to Poly
• HVSY-1523-S for 750 KCMIL Poly to Poly
• HVSY-1523-MOD for 750-750-4/0 KCM Cable Poly to Poly X splice

.6.7.3 For 4/0 taps of 500 KCMIL Cable, use 500 KCMIL kit with HVS-shim-3 for 4/0 Cable.
.6.7.4 In advance of installation with written approval obtained from Utilities UTHVS Management wye, X and straight splices, exclusively for temporary purposes, may be constructed using the following separable cable joints or multi-point junctions:
• 600 Series Deadbreak Separable Cable Joints
• J Series 15kV EPDM Molded Multi-Point Junctions

.6.8 Polymeric to Polymeric splices wye, X and straight shall be the same as paragraph .6.7 above except without oil barrier tubing. Joints shall be Raychem HVS-1530-LC series (straight), HVSY-1520S-SC series (wy) with adapters as required for cable type.

.6.9 Termination shall meet Class I requirements and be design-proof tested to IEEE Standard 48, most current edition, and be capable of passing a test sequence per IEEE 404, most current edition. Termination kits shall be approved for the type and size of cables used and rated for 15 kV 133%.

.6.10 Polymeric Terminations shall consist of shrinkable stress control and outer non-tracking silicone rubber insulation tubing with two or greater silicone rubber skirts. In addition, PILC terminations require an oil stop tube. All terminations and splices shall be grounded. Heat-shrinkable tubing shall have high relative permittivity stress relief mastic for insulation shield cutback treatment with a heat-activated sealant for environmental sealing. Termination kits shall be from Raychem Corporation:
.6.10.1 For 4/0 cables - use type HVT-152-SG for outdoor -unheated areas.
.6.10.2 For 500 KCMIL cable - use HVT-153G for indoor or HVT-152-SG for outdoor/unheated areas.

.6.11 Cold-Shrink splice kits and terminations are prohibited for use on 15 kV and 5 kV class cables.

.6.12 Potheads may only be used to replace existing potheads in outdoor installations of existing PILC cable.

.7 PRIMARY VOLTAGE CABLES (5 kV)
.7.1 5,000-volt service cables shall be UL Listed, 1/c, copper, 115 mil EPR insulated, 15 kV, 133% rated, shielded, MV 105°C cables with low-smoke (260°C spread temperature) zero Halogen. Tape Shield Cables shall have a 5 mil bare copper tape applied helically over the extruded insulation with an average minimum overlap of 25 percent of the tape width. The overall jacket shall be a continuous extruded, 80 mil polyolefin jacket, which meets or exceeds the requirements of ICEA S-93-736, latest edition.
.7.2 Extension or modification of existing 4,160 volt cables can only be done with prior written approval of UTHVS.

.7.3 All work performed on 5 kV cable shall be done by qualified individuals subject to the requirements of paragraph .6 above.

.8 Requirements for Application of Fire Tape to Medium Voltage Cables

.8.1 Fire tape is applied to an exposed cable for the purpose of protecting that cable from the failure of adjacent cables. For the purposes of this discussion, “exposed cable” refers to cable hung in air or run in ventilated tray. Cable in conduit requires taping only where the cable enters and exits the conduit. Cable vaults and manholes are areas commonly associated with the need to fire tape, however the criteria governing fire taping is broader and may call for taping in other areas of a substation or industrial facility where there are extensive runs of MV cable such as are found in chiller plants and power plants.

.8.2 The application of fire tape serves two purposes. It limits the proximal damage caused by a cable failure and reduces the probability that a cable failure will result in the loss of redundant circuits. This is true for instances where there is a little risk of a general area fire caused by a large combustible inventory. Where an area fire is a serious concern, the recommended solution is to re-route critical cables and/or their redundant cables. The application of fire tape to cables in or out of trays offers some protection from an area fire of limited duration and intensity. Where there is little or no risk of an area or tray fire, adding barriers to trays containing redundant cables or placing redundant cables in separate trays is an acceptable alternative design approach.
signage. The formal inspection and determination of readiness for energization of the low voltage portions of the Service rests with the Project and the inspection authority(s) for the building. Utilities inspection of the low voltage portions of the building service does not in any way constitute a formal building inspection as would be routinely conducted by designated State and Local authorities.

.1.2 PRIMARY SELECT SWITCHES and SERVICE CONNECTIONS: Primary switches and service connections shall be fused load break designs with an interrupt rating greater than the maximum primary feeder fault duty (9600 amps). All new and upgraded Primary Select switches are to be SF₆ (Gas) switches. The use of air break switches is restricted to switch applications such as transfers and equipment disconnection that do not serve a Primary Select function and will not be operated routinely by UTHVS personnel. Primary switches shall employ fully insulated bus. Exposed energized bus terminations and connection points are to be taped or booted. All bus connections are to be bolted or brazed. All internal bus jumpers and connecting cables are to be made with 15 kV cable. Internal jumpers and connections to mating equipment such as primary transformers are to be made with unshielded 15 kV rated cable. All jumpers or connectors routed outside the switch to components remote from the switch cabinets are to be made with 15 kV shielded cable of a construction compliant with the requirements of this Standard. Jumper cables shall be terminated in crimped lugs in conformance with the requirements set forth in this Standard for medium voltage cable termination. Power cables are to be terminated in UTHVS approved solid, long barrel, plated lugs secured with two or more bolts. Crimps are to be made by a crimp tool approved by the lug manufacturer following their approved procedures. All crimps shall be six point or more. A 360 degree crimp is preferred. In instances where the equipment accepting the termination does not support two or more bolts, UTHVS shall be consulted and will determine the acceptability of the single bolt termination. Mechanical type connectors are not generally considered acceptable for power applications.

.2 PRIMARY SELECT SWITCHES - MEDIUM VOLTAGE

.2.1 A medium voltage service shall consist of a set of primary lightning/surge arrestors (line side of primary select), primary selective switches, fused primary disconnect switches, lightning/surge arrestors (load side of primary disconnect), medium voltage transformer, and low voltage unit substation application section. See Figure 2.

.2.2 The transformer primary fuses shall be located in an accessible area but shall not be located within the transformer enclosure.

.2.3 If the anticipated load requires a transformer larger than 1,500 KVA, or if the interruption of building power for maintenance of the low voltage unit substation is unacceptable, then the low voltage unit substation shall be double-ended with the appropriate number of primary selective switches, two separately fused primary disconnect switches, two transformers, and two low voltage sections with a tie breaker provided. On double-ended substations, the main secondary breakers shall be sized per requirements of Division 26.
2.4 For critical installations, such as Hospitals, research laboratories, vivaria, or computer centers, a complete double ended switchgear lineup shall be provided consisting of:

2.4.1 A pair of Primary Select Switches with cross-tie
2.4.2 Two sets of fused primary disconnect switches, two sets of lightning/surge arrestors, two medium voltage transformers, and two low voltage sections with the main breakers and tie breaker
2.4.3 Secondary bus tie and busses shall be sized for the emergency ratings of the transformers.
2.4.4 Secondary Mains and Tie breakers shall be rackable, metal enclosed electrically operated, with provisions for remote operation from a location outside the arc flash area.
2.4.5 Utilities may require specific Medium Voltage switch and cable arrangements for buildings with large distribution load requirements in order to facilitate power distribution system load balancing.

2.5 Primary Select Switches shall be rated electrically and mechanically for a minimum of 1,000 load break operations.

2.6 The Primary Select switches for the incoming power to each building shall be located outside or in a dedicated switch room directly accessible from the outside at ground level. When located inside a building, the Primary Select switch must be in plain sight from the point of entry to the building or within twenty (20) feet of entering into a building. The room containing the Primary Select switch shall be of a two-hour fire rated construction. The switch must be directly accessible from the outside. Primary cable pull boxes and conduit, ahead of the current limiting fuses shall not be located in or above public occupied areas.

2.7 Indoor applications shall be rodent proof and have drip shields to protect exposed High Voltage surfaces; outdoor applications shall be rodent and weatherproof. Switches shall not have floors. Switches shall be constructed to provide safe access to terminals without de-energizing the switch. Switches and bussing shall use porcelain insulators throughout. Switches shall be built on a specially designed pre-cast vaults, raised channel or I-beams, or minimum six (6) inch height concrete slabs above finished grade. The choice of mounting system shall be coordinated with OSU Utilities UTHVS and be approved by UTHVS.

2.8 There shall be provisions to protect outdoor mounted switches and associated enclosures from physical damage from Building and Grounds maintenance equipment and private, commercial or delivery vehicles (mowers, tractors, motor vehicles).

2.9 Switches shall not be placed in open underground or below grade vaults subject to flooding.

2.10 Gas switch handles and elbows shall face the front of the switch enclosure.

2.11 In primary select applications, low profile SF₆ switches are to be applied exclusively where electrical cable access permits. Adequate termination space must be provided to accommodate elbow fuses if approved in writing.
by UTHVS (TSG consulting), stress cones and minimum cable bend radius. The termination space provided shall not require bending the cable in the area of the stress cone.

.2.12 SF6 switch gear design shall be three-phase, 15 kV, and shall be rated 60 Hz, 600 amps minimum continuous, load break, and pad mount for outdoor at grade type applications. The switch shall be three phase with 3-way, 4-way, 5-way, or 6-way circuit configurations as required and may be provided with a tie switch. Load ways shall be rated at a minimum 600 A; but are generally fitted with 200 AMP deep well load break bushings unless inappropriate for the application. The choice of Primary Select configuration must be coordinated with Utilities UTHVS and be approved by UTHVS as it is first and foremost a part of the Campus Medium Voltage Distribution System.

.2.13 The switch shall be equipped with an automatic transfer capability. This includes automatic transfer to an alternate power supply upon loss of voltage on the preferred feeder. The switch shall also be equipped with user friendly, Human-Machine Interface (HMI) that allows personnel to set and adjust parameters for operation, maintenance and configuration. The UTHVS shall be the sole judge as to whether or not this transfer shall be set up as automatic transfer, or shall be set up as manual transfer.

.2.14 Switch housings shall be installed to provide sufficient safe access for switching and maintenance personnel.

.2.15 Cable connection points to the Primary Select switch shall all be 600-amp dead break bushing for incoming cables and 600-amp apparatus or 200 A deep well load break bushings as required for the switch design. Bushings shall be welded, not gasketed. The switch tank shall be stainless steel with all welded construction. Self-contained switch tripping protection, when required, shall be a three-phase resettable fault interrupter (RFI) field adjustable simulating E fuses. Load ways shall be either RFI or gas switch equipped in accordance with the technical requirements of the installation. An RFI is required when the load way powers a transformer through a fused air break disconnect switch. A gas switch is required when the transformer is supplied through a fuse directly and there is no air break switch installed. Power and sensing for the fault interrupter control shall be supplied by integral current transformers and not require auxiliary power or batteries. Power for the Transfer control is normally supplied from a CPT connected through a fuse to a bus tap in the switch. A dedicated building power fed at 120 VAC may also be provided in place of this feed if the Primary Select Switch in located inside a building and building power source is secure. A battery back-up is required and provided with the switch.

.2.16 The minimum Primary connection shall consist of one Primary Selective switch (three way) with two primary feeds off two associated primary pairs. Building specific usage and design considerations shall determine the appropriate number of primary switch ways, and fused sub-switches. Single-phase Primary transformer connections are prohibited. UTHVS shall establish the required Primary Selective switch configuration for each Primary Service based upon a careful evaluation of building service requirements and what is appropriate for the campus power system.
.2.17 A primary selective switch may be used to provide primary power to as many as four sub-switches or transformers through separate load ways and fuses. The maximum number of transformers that can be powered on a single way is dependent on the acceptability of simultaneous transformer outages for the buildings or services involved. The general practice is to have no more than one building in outage for a single transformer outage.

.2.18 Multiple buildings may be fed from one primary select switch equipped with multiple load ways.

.2.19 The primary selective switch shall not be used as a junction box or a tie point to provide power to another building when two transformers are not in the same building or room.

.2.20 Provide intermediate class, 10 kV, 8.4 kV MCOV (Maximum Continuous line-to-neutral Operating Voltage) polymer enclosed surge arresters on the line side of all primary select switches, and on the load side of all fused primary disconnect switches. Arresters shall be mounted inside of the switchgear compartment with the line side cables they are protecting. Arresters shall be mounted and connected in a manner to be easily disconnected for Hi-potting or Hi potential testing of cables.

.2.21 When the primary select switch is equipped with electronic fuse emulation, the chosen characteristic must provide coordination with the fused primary disconnect switch fuse.

.2.22 Doors to primary select switches shall be key-locked with locks and cylinders complying with the BDS standard of Best Access System key cylinders with removable 7-pin cores. Refer to DIVISION 8 for further details. In addition to the locking provision, a seven flat tamper resistant security bolting shall be provided to reduce the likelihood of unauthorized access to live parts and connections.

.3 PRIMARY DISCONNECT SWITCHES

.3.1 Air switch handles, fuses, and elbows (if used) shall face the front of the switch enclosure.

.3.2 Primary disconnect air switches shall be an minimum rated 600 amp, 15 kV, stored energy, load break fault interrupting switches. The switches shall be capable of being operated with the operator standing safely away from the front of the switch.

.3.3 Primary air break switches shall be Kirk key interlocked. Spare keys shall be provided to UTHVS. Both switches shall be capable of being closed at the same time, paralleled, and provided the spare key is used. Both fuse compartment doors shall be key-interlocked with the switches. The spare key shall permit opening the fuse compartment doors with the switch closed.

.3.4 All medium voltage switches shall be top fed with fuses (if used) below the switch. The switchblades shall pivot at the bottom (load side). Provide bussing to the top of the switch, if the switch enclosure is to be bottom feed.

.3.5 Doors to fused primary disconnect switches shall be key-locked with locks and cylinders complying with the BDS standard of Best Access System key cylinders with removable 7-pin cores. Refer to DIVISION 8 for further details.
.4 GENERAL
.4.1 Where applied, fuses shall be E fuses sized to provide thermal short circuit protection to the transformer and effective fault current limiting.
.4.2 The selected E fuse shall be applied to the Primary of the Transformer based on the size (KVA) of the transformer. The fuse chosen shall accommodate transformer in rush and the ANSI damage curve.

### TABLE # 1 RECOMMENDED FUSE SIZES

<table>
<thead>
<tr>
<th>TRANSFORMER RATING <a href="mailto:KVA@13.2kV">KVA@13.2kV</a></th>
<th>FLA</th>
<th>MINIMUM</th>
<th>133% DRY TYPE DOUBLE-ENDED</th>
</tr>
</thead>
<tbody>
<tr>
<td>112.5</td>
<td>4.9</td>
<td>10E</td>
<td>10E</td>
</tr>
<tr>
<td>150</td>
<td>6.6</td>
<td>10E</td>
<td>10E</td>
</tr>
<tr>
<td>225</td>
<td>9.8</td>
<td>15E</td>
<td>15E</td>
</tr>
<tr>
<td>300</td>
<td>13</td>
<td>15E</td>
<td>20E</td>
</tr>
<tr>
<td>500</td>
<td>22</td>
<td>25E</td>
<td>30E</td>
</tr>
<tr>
<td>750</td>
<td>33</td>
<td>40E</td>
<td>50E</td>
</tr>
<tr>
<td>1000</td>
<td>44</td>
<td>50E</td>
<td>65E</td>
</tr>
<tr>
<td>1500</td>
<td>66</td>
<td>80E</td>
<td>100E</td>
</tr>
<tr>
<td>2000</td>
<td>88</td>
<td>100E</td>
<td>125E</td>
</tr>
<tr>
<td>2500</td>
<td>109</td>
<td>125E</td>
<td>150E</td>
</tr>
<tr>
<td>3000</td>
<td>131</td>
<td>150E</td>
<td>200E</td>
</tr>
</tbody>
</table>

.4.3 All locks shall have manufacturer furnished covers and be provided with two sets of keys. Contractor is to provide all spare keys to UTHVS.

.4.4 Switch access door handles shall have provisions for padlocks or other locking means acceptable to UTHVS in both the open and closed positions. Front and rear compartment doors shall be hinged and have provisions for padlocks. If a door is required to be opened to operate a switch, the door shall be hinged on the opposite side from the switch handle.

.4.5 Padlocks for all fused primary disconnect switch handles (open and closed position); doors, and panels shall be supplied by the contractor. At final UTHVS inspection and acceptance, contractor shall supply all locks with a Utility approved core. Keys for these padlocks shall not to be provided to the contractor(s). All padlocks shall be able to accept BEST 7 pin interchangeable cores.

.4.6 Electric Heaters: All fused primary disconnect air switches located outdoor or located in unheated rooms shall be equipped with electric heaters, the size of the heaters shall be 500 watts/cubicle front and rear. The power supply to the heaters shall be from the secondary side of the transformer or from a reliable, labeled, and supervised building power source.

.4.7 Tempered viewing windows shall be provided through which it shall be possible to verify that all phases are opened or closed. All air break primary disconnect switches shall have visible contact with a 6” minimum break. Switch contact status for gas switches or vacuum switches shall be derived from positive position sensing of the primary contacts and be visually inspectable with the switch energized.
.4.8 Insulation: All medium voltage connections, bus bars, and devices in switchgear shall be insulated. Insulated barriers shall not be allowed to come in contact with insulated conductors and shall maintain a 3” clearance. A minimum of 6” clearance shall be observed as minimum required spacing for insulated and uninsulated barriers from uninsulated conductors.

.4.9 All primary switches shall be marked on the front by the switch handle with the feeder numbers and phases identified by 1" x 3" engraved, plastic tags screwed to front door or panel near the handle.

.4.10 The electrical contractor shall be responsible for ensuring that a level concrete pad is provided. Electrical gear must be installed plumb and level on a concrete pad or mounted on rails embedded in a level concrete pad.

.5 SWITCHGEAR - LOW VOLTAGE

5.1 The trip settings on the Secondary Main shall support proper coordination with the Primary Transformer fuses and any intervening devices. The A/E and Contractor shall provide design and As-Built settings and coordination information prior to Primary Service initial energization. See DIVISION 26, for specific requirements concerning sizing of facility distribution system, arc flash, coordination study, load flow, and short circuit analysis.

5.2 The Secondary Mains and Secondary Bus tie breakers, where they exist, shall be fully rated, metal clad, draw-out circuit breakers. The breakers shall be electrically operated both for close and for trip. A control station shall be provided and mounted external from the switchgear, located outside the arc flash hazard boundary, for remote closing and tripping of the secondary main and secondary bus tie breakers. The maximum operating force required to manually open or close a switch or breaker shall not be greater than 75 pounds force applied to the operating handle.

5.3 Building Emergency generation shall be designed so that no single failure of switching equipment or controls can result in back-feeding the primary transformer and inadvertently energizing the Primary system.

.6 DISTRIBUTED GENERATION

.6.1 Generation sources intended to be run in parallel with the OSU MV Distribution System are required to meet the appropriate provisions of the Ohio Revised Code and IEEE standards in addition to the following OSU Electrical Utility requirements for interface of Distributed Generation (DG):

.6.1.1 A primary safety consideration of DG systems interconnected to the OSU Electric Utility is that the DG system shall disconnect from a de-energized distribution service irrespective of connected loads or other generators. This is to prevent the back-feeding of the service, which could create a hazardous situation for OSU utility personnel and facility maintenance personnel. A distribution service can be de-energized for several reasons. De-energization can be caused by a substation feeder breaker opening due to fault conditions or the distribution feeder may be de-energized for maintenance or construction reasons.
.6.1.2 When the interface voltage deviates outside the range of chart below, the DG shall disconnect from the point of electrical interface to the Utility or facility distribution system. This applies to any phase of the three phase system.

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Maximum Trip Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>V&lt;45%</td>
<td>10 cycles</td>
</tr>
<tr>
<td>45%≤V&lt;60%</td>
<td>60 cycles</td>
</tr>
<tr>
<td>60%≤V&lt;88%</td>
<td>120 cycles</td>
</tr>
<tr>
<td>110%&lt;V&lt;120%</td>
<td>60 cycles</td>
</tr>
<tr>
<td>V≥120%</td>
<td>10 cycles</td>
</tr>
</tbody>
</table>

.6.1.3 When the interface frequency exceeds the bounds of 59.5 Hz to 60.5 Hz for longer than 2 seconds, the DG system shall disconnect from the OSU Electric Utility.

.6.1.4 Following DG system disconnects as a result of an out of bounds voltage or frequency event, the DG system shall remain disconnected until OSU utility service voltage has recovered to within acceptable voltage and frequency limits for at least 1 minute or until manually reset.

.6.1.5 The DG system shall not inject dc into the ac interface under normal or abnormal conditions. An isolation transformer connected between the power conditioning subsystems and the ac interface is one approved method that can be used to satisfy this requirement.

.6.1.6 The DG system and interfacing equipment shall be grounded in accord with other appropriate sections of the BDS DIV 33 and or DIV 26.

.6.1.7 The DG shall have surge protection in accord with this standard as well as comply with local and national codes.

.6.1.8 A lockable, visible, and accessible manual load break disconnect switch shall be provided for control by OSU Utility personnel.

.6.2 Permitting of Distributed Resources

.6.2.1 Distributed generation sources on Campus for connection to the OSU Campus MV Distribution System either directly or through a building service require a thorough review by OSU Utilities UTHVS at the planning, design and startup phases. OSU Utilities will review the initial application for connection and continue to coordinate with the local utility throughout the planning, design and installation.

.6.2.2 Requirements imposed by the University on Distributed Generation go beyond design and initial installation and include routine testing and power quality monitoring. Depending on the type of Distributed Generation involved, there may be other constraints imposed relating to such considerations as time of day switching and loading, circuit loading limits and operational constraints based on Distribution System operating constraints and accommodating
emergency system conditions. Permitting Distributed Generation is not a guarantee of access to the OSU Distribution System. Granting access to the OSU Medium Voltage Distribution System remains at the discretion of OSU Utilities.

**33 72 00. UTILITY SUBSTATIONS**

**33 72 33. SUBSTATION CONTROL HOUSES AND ASSOCIATED FACILITIES**

1. **WIRE AND CABLE**
   
   1.1 Copper conductors of 98 percent conductivity shall be used unless use is restricted by Government Agencies. Aluminum conductors are prohibited.
   
   1.2 **COLOR CODING**
   
   Color coding for 480/277V and 208/120V shall be as follows:
   
<table>
<thead>
<tr>
<th>Phase</th>
<th>Voltage</th>
<th>Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>480/277</td>
<td>208/120</td>
<td></td>
</tr>
<tr>
<td>Neutral</td>
<td>White or Gray</td>
<td>White</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

   (Each with identifiable colored stripe)

   - A: Brown, Black
   - B: Orange, Red
   - C: Yellow, Blue
   - Equipment Ground: Green w/Yellow stripe, Green or Bare

2. **LOW VOLTAGE CABLE (600 volt): For Power, Control and Protection**
   
   2.1 Solid and Stranded Wire: No 12 AWG and smaller may be solid. No 10 and larger shall be stranded.
   
   2.2 Minimum size for all 125 V DC and 124/240 V AC branch circuits is No 12 AWG.
   
   2.3 Use of minimum No 14 AWG stranded for AC control wiring and auxiliary system circuits is permitted.
   
   2.4 Use of No 12 AWG, or greater, for 125 V DC control wiring is required.
   
   2.5 Use of No 10 AWG for all current transformer circuit wiring is required.
   
   2.6 Use No 16 AWG TSP or TSQ for instrumentation analog current loop or voltage signal.
   
   2.7 General Use insulation for 600 volt rated wire and cable shall be NEC, 600 volt class type XHHW2 with SIS allowed for power component internal control wiring. Jacketing shall be Low Smoke Zero Halogen. Nylon conductor jackets and the use of PVC for conductor insulation or jacketing are prohibited for Utility applications. All wiring between equipment, cabinets or control panels for low voltage power equipment power and control circuits shall be in conduit or tray. All control wiring between power components, cabinets and control panels shall be in jacketed color coded cables bearing suitable durable cable identifiers. Cable conductor color coding shall conform to ICEA Method 1 table E2. Panel and component wiring shall have individual wire labels. Wiring shall not be color coded. Acceptable labeling conventions include: destination labeling, unique wire numbering.
   
   2.8 Power cables are to be terminated in UTHVS approved solid, long barrel, plated lugs. Power cables carrying high current (greater than 50 Amps) shall
have two or more bolts. Crimps are to be made by a crimp tool approved by the lug manufacturer following their approved procedures. All crimps shall be six point or more. A 360 degree crimp is preferred. In instances where the equipment taking the termination does not support two or more bolts, UTHVS shall be consulted and will determine the acceptability of the single bolt termination. Mechanical type connectors are not considered acceptable for power applications.

.3 INSTRUMENTATION (300 volt class and below)
.3.1 Use of minimum No 16 AWG for all analog instrument circuit wiring is required.
.3.2 Use of manufacturers approved plenum rated cable for all communications and digitally based signal cables is required within Substation Control Houses, Power Plants, Regional Chilled Water Plants, and Associated Facilities.

.4 GENERAL REQUIREMENTS FOR CONTROL AND INSTRUMENTATION
.4.1 AC and DC control circuits shall not be run in the same control cable. Low level (< 50 volts) instrument cables shall not be run in conduit or in tray shared by power or 110 volt AC, 125 volt DC control cables. Note: 120 VAC PLC inputs may be treated as instrument cable for the purposes of determining tray system placement. 120 volt AC and 125 volt DC branch circuits providing control power to equipment and systems shall be run via color coded jacketed cable of approved construction from the point or origin at the source distribution panel to the point of connection at the equipment, control panel, switchgear or enclosure. These cables shall be classified as control cable not power cable. These requirements pertain to all branch circuits providing control power to electrical and I&C equipment with wire sizes AWG 10 or smaller. AWG 8 and larger are exempted from the color coded, jacketed cable requirement.

.4.2 All control panel, control cabinet and switchgear wiring No 10 AWG and smaller shall be landed on UTHVS approved terminal blocks. Stranded wire termination shall be with approved ring type solid uninsulated barrel design. No more than two wires shall be terminated on any screw type terminal point. Thread on wire nuts or split bolt connectors are prohibited. In-line control wire splices are not acceptable for new installations. Control cable butt splicing for modifications or upgrades is permitted with prior written approval of UTHVS. Butt splices in control and instrument cable conductors shall be made with the appropriate sized Butt Connectors and insulated with electrical tape or approved heat shrink tubing with appropriate shimming.

.4.3 All control components are to be secured firmly to their supporting structures. Self-adhesive fasteners and thermo plastic fasteners are not acceptable.

.4.4 All cable and wiring that is field run to control panels or equipment enclosures shall be terminated on UTHVS approved terminal blocks. Landing field wires directly on serviceable components is prohibited. Small local control stations, local starters and local instruments may be excluded from this requirement. Purchased equipment and systems may come supplied with high density terminations. Termination of stranded wire to high density terminal blocks, or
to terminal blocks that employ pressure type terminal clamping, shall be via ferrule. In instances where the use of ferrules is not practical, the wires are to be stripped to allow enough exposed conductor to permit full penetration into the terminal and tinned to form a solid conductor. Terminations made to terminal blocks that employ a pressure type terminal shall have conductor insulation extend up to the block and not show exposed conductor. High density screw or post type terminations, where permitted, shall employ insulated barrel lugs where necessary to maintain adequate electrical clearance between adjacent terminations.

4.5 All current transformer secondary circuits shall be wired through shorting type terminal blocks.

4.6 All control cabinet and enclosure control wiring shall be dressed neatly, bundled and laced. Heavy duty UV resistant tie-wraps are an acceptable method of lacing. In general, Panduit or wire raceways shall not be used to organize wiring. Panduit may be used subject to OSU Utilities UTHVS approval to organize and support control wiring in high density applications. Cable bundles shall be supported at regular intervals. Generally lacing to cabinet mounted tie points is an acceptable approach. Self-adhesive tie-downs are not acceptable.

4.7 Every reasonable effort shall be made to separate 480 V equipment and circuits from control wiring. 480 V components and wiring shall be mounted separate from control components and provided separate access. Control components accessed for operations or maintenance shall not share the same enclosure with the power switching components or exposed power wiring without adequate protection from accidental contact by personnel or tools.

4.8 In instances where low voltage (125 volts or less) control components and wiring must be housed in a common enclosure with power circuits (208 volts or above), exposed power circuit conductor surfaces shall be provided with a barrier to reduce the likelihood of accidental shock or burn.

4.9 The preferred configuration for the separation of power and control is to have the power cabinet separate and to the side of the control cabinet. If this is not possible, the power cabinet and components should be mounted above rather than below the control cabinet or panel. Points of interface between control and power circuits, such as control transformers, shall be located with the power equipment. Secondary (control) fuses shall be located in the control area, not on the control transformer or in the power area.

4.10 Adequate consideration shall be given to the operating temperature environment for temperature sensitive components. Electronics shall be mounted below the mid-plane of their housing enclosure. Sources of heat generation such as transformers and power supplies shall be mounted above, not under temperature sensitive equipment and enclosures shall be sized to operate closed without forced ventilation or the need for fans or filters. A maximum of 10°C temperature rise is allowed on enclosures for equipment rated 60°C or less. This shall be verified by heat run test or analysis and the rise shall be measured at the top of the enclosure.
.4.11 All control cables entering control cabinets and enclosures shall be secured by their jackets to a cabinet or enclosure support to provide a strain relief for the cable wire terminations.

.4.12 Control wiring traversing hinges or other forms of flexible constructions shall be high stranded and shall traverse the area of bending normal to the plane of rotation so as to impart a twisting rather than a bending motion to the cable or wire bundle.

.5 CONDUIT and FITTINGS

.5.1 Conduits shall be galvanized rigid steel. The use of EMT or aluminum for conduit or fittings is strictly prohibited for power and control circuits within Substation Control Houses, Power Plants, Regional Chilled Water Plants, and Associated Facilities. Fiberglass conduit may be used in tunnels or basements where wet conditions persist, only by written approval from UTHVS (TSG consulting). The fiberglass conduit installation shall be filament wound reinforced epoxy manufactured in accordance with the latest revision of NEMA TC 2002 and UL 1684. The manufacturer selected shall offer a full line of fittings, adaptors and elbows manufactured from the same materials and process as the conduit. Joining shall be by compatible adhesive or in areas where expansion or contraction may be a concern, the use of an EPDM gasket O-ring in a tapered bell to provide a non-adhesive, moisture resistant mechanical joint is acceptable. Acceptable systems are Champion Fiberglass and United Fiberglass. Fiberglass conduit is prohibited for general use or in explosion hazard areas (Class I Div II or more stringent). Where appropriate for the application, the materials used to manufacture conduits, raceways, ducts, boxes, equipment enclosures, and the finished products shall conform to the latest edition of NFPA 130, NPA 502, NFPA 70(NAC) and shall have the capability to withstand high temperatures up to 500°F, low temperatures down to -60°F and have a maximum 2 hour rating of up to 1850°F.

.5.2 Conduit carrying power conductors shall be sized for the number and gauge of the wire contained. The minimum conduit size allowed is 1-inch conduit. NEC requirements for conductor count and fill shall be followed, except for control cables, and where specifically waived by UTHVS.

.5.3 Pull boxes shall be spaced at appropriate intervals to allow for pulling cable and not exceeding the manufacturer’s maximum pulling tension or sidewall pressures.

.5.4 Cable minimum bend radius limits shall be observed for all cables during installation and in the final installed condition. “L” boxes shall not be used for shielded power cables, multi-conductor control or instrument cables with more than four conductors of AWG #14 wire or greater.

.5.5 Conduits and boxes shall be routed and installed clear of traffic areas, equipment access lay-down or removal areas, mechanical equipment subject to high temperatures or movement or thermal displacement.

.5.6 Conduit shall be supported at regular intervals in both the vertical and horizontal directions.

.5.7 Multiple circuit power cables shall have all three phases and ground present in each conduit.
.5.8 All rigid steel conduits shall be provided with grounding bushings.
.5.9 Fittings for rigid steel conduit shall be galvanized steel, threaded, 2” diameter and below with insulated throats, 2.5” and above with grounding bushings. Compression fittings are permitted where use of threaded fittings are not practical, based on prior approval by UTHVS. Setscrew type fittings are prohibited.

.6 TRAY
.6.1 Tray may be used for power, control or instrument cable in areas known to be free from significant dirt or debris accumulation, physical, and explosion hazards.
.6.2 Power tray shall be ventilated, expanded metal or ladder construction. In mildly corrosive or damp environments galvanized steel tray is required or conduit shall be used. Multi-circuit power cables shall have their phase circuits transposed to avoid heating from circulating currents in the tray. Power cables are defined as cables supplying power to motor driven equipment, heaters, transformers etc. or power distribution panels where the loading of the cable may be substantial. Branch circuits serving only control loads with low to negligible circuit loading should treated as control.
.6.3 Control and Instrument tray may be ventilated or enclosed construction, solid metal, expanded metal or ladder construction. In mildly corrosive or damp environments, galvanized steel tray is required or conduit shall be used. The tray shall be closed and covered in areas where excessive dirt accumulation is anticipated.
.6.4 Tray shall be grounded. A continuous 4/0 stranded bare copper conductor shall be run the length of the tray clamped or bonded to each tray section and run to building ground directly or to building steel at regular intervals along the tray run, not to exceed 100 lineal feet of tray. This ground cable shall be run external to the tray and not placed in the tray with the electrical cables.
.6.5 All trays shall be sized for the intended loading and supported at regular intervals to building structural elements. Supporting tray from equipment, ductwork, pipes or pipe hangers is prohibited.

.7 DC BATTERY SYSTEM
.7.1 Battery
.7.1.1 A central substation battery system operating isolated from ground at a nominal 125 VDC is provided. The battery must be rated to handle worst-case switchgear and anticipated DC system loads for a minimum of 8 hours from an 80% charge condition. Battery cells shall be connected in series to achieve the desired battery terminal voltage. Battery cells shall be rated for the entire ampere-hour rating of the battery. Paralleling of cell strings is not acceptable.
.7.1.2 Batteries shall be located in clean dry and temperature controlled areas. They shall not be located within one foot of uninsulated outside walls to insure uniform cell temperatures are maintained. If batteries are contained in self standing enclosed cabinets this one foot limitation may be reduced to 3”. In cases where batteries are
located near insulated walls, batteries and or their cabinets shall be placed so as to insure an air space to allow free movement of room air. Batteries and battery cabinets are not to be mounted on or against exterior walls.

.7.1.3 Central DC system batteries shall be of the Substation type rechargeable wet cell design. They shall have a 20-year service life or better and be contained in transparent jars designed to facilitate the inspection of the battery internals. The jar size (number of individual cells contained) shall be limited to what can be managed for replacement by two persons. The entire battery shall be housed in a ventilated, lockable enclosure. The selection of battery technology shall appropriately reflect the service requirements and the ratings and limitations of the powered equipment.

.7.2 Battery Charger

.7.2.1 A dedicated Battery charger is provided that is rated to handle full dead battery charging current simultaneously with normal DC system continuous loads. The battery charger shall be rated to carry the DC system normal continuous load and recharge the battery from a 100% discharged state in a maximum of 16 hours.

.7.2.2 Battery chargers shall be located in clean dry and temperature controlled areas.

.7.2.3 The battery charger must be designed to maintain a float voltage on the battery while carrying the DC system load and be rated to support full DC system load currents for a worst case switching scenario.

.7.2.4 The battery charger must be designed to apply a programmed equalizing charge to the battery manufacturers’ requirements.

.7.2.5 The battery charger shall have an output breaker sized to automatically isolate the charger from the DC system battery for an internal charger fault without loss of DC system load or opening of the battery output breaker/fuse.

.7.2.6 The battery distribution system shall be designed to facilitate the use of a load bank for periodic battery discharge testing. Such testing shall be conducted without the need to shut down any DC system loads either for connection of the bank or during the test itself. For redundant battery systems, the system shall be designed to accommodate the test battery’s load from the redundant battery without the need for DC power interruption, or temporary connections. For single battery systems, the system shall be designed to allow all loads to be powered directly off the battery charge(s) without the need for DC power interruption, or temporary connections prior to or during discharge testing.

.7.3 DC System

.7.3.1 The DC system must be supplied with:

• Battery voltage and current indication
• Ground detection and alarming
• Off-nominal voltage and alarming
• Charger failure alarming
• Alarming for loss of charger AC power

Note: See Figures 6 and 7 for typical DC metering panel

.7.3.2 DC system protection shall be provided either by selectively applied Fuses or Circuit breakers. Protection is designed to isolate and eliminate faults. Battery and main distribution circuit fuses and breakers shall be sized to accommodate the short circuit duty of the system. If provided with a main breaker or fuse, the battery powered DC system circuit breaker or fuse shall be rated to ride through all DC system load faults.

.7.3.3 DC system loads shall be restricted to loads required for the safe and reliable operation of the power system.

.7.3.4 The normal source of power to DC loads shall be the battery charger. In critical applications the University may require redundant battery chargers aligned in a primary and backup configuration. Switching shall be accomplished with a transfer switch or through the use of output isolation devices in each charger. An acceptable alternative to two (2) permanently installed chargers is a cross-tie to another battery system or a provision to attach a temporary charger.

.7.3.5 The battery is the principal source of power. The system control, monitoring, provisions for maintenance and protection shall reflect this.

.7.3.6 DC System loads shall not require a battery tap, but shall be designed to operate at full battery voltage under normal and equalize voltage conditions. The use of low voltage control devices with series resistors is discouraged with the exception of indicating lamps that require series fusing for circuit reliability reasons.

.7.3.7 Surge or transient suppression schemes that can provide a short circuit path between battery positive and negative or from battery positive and negative to ground shall be fused.

.7.3.8 All circuit alarming and monitoring devices connected to the DC Battery System shall be protected by breaker or fuse.

.8 Annunciators

.8.1 Local annunciators and remote annunciators shall be equipped with identical displays. All annunciators and remote annunciators shall be fully supervised, and the annunciator system shall be self-monitoring. The alarm state on the annunciators shall remain locked in until manually reset.

.8.2 Annunciation shall be provided to support the maintenance and operational needs of the system or equipment being monitored. Individual annunciation points shall be grouped into one of three categories:

.8.2.1 Operations (critical) - Operations alarms are alarms requiring prompt remedial corrective action.
8.2.2 Maintenance (non-critical) - Maintenance alarms are alarms for conditions that need to be addressed in a planned or routine manner.

8.2.3 Status (informational) - Status alarms are alarms that provide information on the condition or change of state of equipment that might be of interest but of limited immediate concern to operations or maintenance staff.

8.2.4 Operations and maintenance alarms must be communicated to a manned location. Local annunciation shall be provided only in instances where the operators or maintenance personnel can be expected to require this information to be presented locally.

8.3 Annunciator power shall be supplied from the plant or substation 125 VDC system. Communications relaying the annunciator activity to a remote manned location shall also be powered from the plant or substation 125 VDC system.

9 LIGHTING

9.1 The lighting design shall provide for both task and access/egress lighting.

9.2 Task lighting shall be at illumination levels appropriate for reading labels, metering, test instruments, and written instructions.

9.3 Access/Egress lighting levels shall be adequate to insure that personnel gaining access to and traversing high voltage areas or leaving those areas can move safely and efficiently without concern for obstacles, tripping and bumping hazards.

33 73 00. UTILITY TRANSFORMERS

1 GENERAL

1.1 Position transformers for proper cooling, service, replacement and expansion room for future capacity addition.

1.2 Indoor dry type and liquid type transformers shall be power cast or resibloc-cast Dry Type, or silicon filled. In Dry type designs, both HV and LV windings shall each be separately cast as one rigid tubular coil. Indoor liquid filled transformers are not approved for general use as Primary transformers (see Section 1.4.2).

1.3 Outdoor transformers shall be either pad mounted liquid filled or substation liquid filled type.

1.4 Liquid filled pad mount and dry type transformers shall have a low loss, amorphous metal core. If other domain refined grain oriented silicon steels are used rather than amorphous metal core to achieve high performance unit then, the Manufacturer(s) must supply to the UTHVS and TSG the Certified Test Reports (CTR) referencing actual data taken from the units ordered for related project and the electrical, thermal and audible noise requirements. Measurements taken must meet the requirements of NIST Standards. Insulating fluid shall be type 2 mineral oil, silicone, FR 3 or an alternative fluid approved for use in the intended application by the University. Liquid-filled
transformers shall be labeled as to the type of dialectic fluid contained in the transformer.

.1.4.1 No-load losses for new primary service transformers shall not exceed the following:

<table>
<thead>
<tr>
<th>Transformer Size</th>
<th>No-Load Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 KVA</td>
<td>532 Watts</td>
</tr>
<tr>
<td>500 KVA</td>
<td>650 Watts</td>
</tr>
<tr>
<td>750 KVA</td>
<td>830 Watts</td>
</tr>
<tr>
<td>1,000 KVA</td>
<td>1,000 Watts</td>
</tr>
<tr>
<td>1,500 KVA</td>
<td>1,300 Watts</td>
</tr>
<tr>
<td>2,000 KVA</td>
<td>1,660 Watts</td>
</tr>
<tr>
<td>2,500 KVA</td>
<td>2,050 Watts</td>
</tr>
<tr>
<td>3,000 KVA*</td>
<td>2,500 Watts</td>
</tr>
</tbody>
</table>

*Any proposed design for a transformer 3,000 KVA or larger must be submitted by the A/E for prior review and approval by UTHVS and TSG. Submittal must include proposed load-losses, no-load-losses, and auxiliary losses and will be subjected to an economic comparison based on the estimated present worth of the combined losses over the service life of the transformer.

.1.4.2 Note: The requirements of this section apply in whole to all new installations. When the transformer application is for a repair or replacement or an upgrade to an existing building; one or more of the above requirements may be relaxed with the written consent from UTHVS and TSG, through the Project Manager.

.1.5 Primary winding shall be 13.2 kV 3 phase connected Delta. The secondary winding shall be connected grounded Wye. Primary winding shall be equipped with no load tap changing switch with a nominal tap and two 2½% taps above rated voltage, plus two 2½% taps below rated voltage. Special applications may require different secondary connections. Any variance from the specified configuration to meet the service requirements of an application must be reviewed and approved by Technical Service Group (TSG) and UTHVS.

.1.6 The transformer coils shall be wound of electrical grade copper and continuous wound construction; aluminum windings are prohibited.

.1.6.1 Transformers applied in primary service shall be supplied with a minimum 95 kV BIL on the primary and an appropriate BIL on the secondary (10 kV for 480 V dry type, 30 kV liquid filled).

.1.7 Buildings with critical loads such as research or main computer facilities or medical buildings shall have double ended substations with transformers sized to handle 120% of anticipated maximum normal secondary load without fan cooling or 110% of emergency loading with fan cooling whichever requires the larger self-cooled rating.

.1.8 For liquid-filled transformers, provide pressure-vacuum and liquid level gauges. Provide a temperature gauge with max pointer and alarm contacts.
Provide fan control on all cooling fan assisted transformers. Liquid-filled transformers shall have an over pressure relief with indicator.

1.9 Silicone oil transformer shall be equipped with service Viton gaskets.

1.10 The name of original manufacturer of the transformer shall be identified on the transformer nameplate. If the transformer has been supplied through another manufacturer or vendor, the name of that manufacturer or vendor shall also appear on the nameplate.

1.11 Dry type Primary transformers shall have bolted terminations on their high voltage windings. Liquid-filled Primary transformers shall be provided with Dead Front high side terminations with Dead Break elbows and load break arrestors as well as provisions for grounding and parking stands. All Primary transformers with cabled secondaries shall be provided with adequate secondary termination capacity and termination space to accommodate termination of secondary cable equivalent to twice the thermal capacity of the transformer rating.

1.12 All transformer fans are to be fully guarded. Guarding must be effective for personnel protection and for protecting transformer bus and windings from loose blades and blade assemblies.

1.13 The transformer shall be equipped with Intermediate class polymer enclosed surge arresters to protect the primary of the transformer. Porcelain enclosed arresters are not acceptable. Arresters shall be 10 kV rated, 8.4 kV MCOV (Maximum Continuous line to neutral Operating Voltage). Locate arresters as close to the transformer primary bushing with phase and ground leads as short as practical.

1.14 The fuses in the primary selective switches and the primary disconnect switches shall be "E" fuses sized to supply and isolate their associated transformer. (See Table 1) If more than one transformer is fed from the same primary select switch or primary disconnect switch, then each shall be separately switched and fused.

1.15 Power transformers shall be housed in their own enclosure and not be located within switchgear or switchboards. Transformer enclosures shall not house primary fuses. Enclosures for Dry Type transformers shall have removable panels on all sides as needed to facilitate access to core, coils, bus work and terminations for inspection and maintenance. Liquid-filled transformer termination enclosures shall provide adequate termination room for both primary and secondary terminations, and a reasonable level of physical separation consistent with the voltages involved. Liquid-filled transformers shall not have any fuses or fusible links inside the tank. All fusing shall be external to the transformer tank and enclosure.

1.16 Outdoor, oil filled transformers shall not be located within ten feet of building openings or fire escapes. If directly opposite a window or door, a blast wall shall be erected.

1.17 Work Space about transformers shall have minimum clear working space of five feet (5'0) to permit ready and safe access for preventative maintenance, emergency repair and inspection.

1.18 The transformer load and secondary bus voltage regulation requirements of the design, and practical fault limits of the applied switchgear, shall determine
the Primary Transformer impedance. Low transformer impedance provides
good voltage regulation and low flicker but increases the cost of the
downstream switchgear and may also interfere with the proper coordination
of Primary Transformer fuse and secondary main circuit breaker. It will also
increase Arc Flash values and make in-service maintenance more difficult.
High impedance can lead to excessive voltage dips on starting large motors
and unacceptable levels of flicker in the lighting system. In general, for the
size transformers applied as Primary Transformers and the types of loads
supplied, the impedance will not need to exceed 7% or be less than 3% on the
transformer Base KVA.

.1.18.1 Acceptable Primary transformer impedances are impedance values
that allow for proper coordination between Secondary Main Circuit
breaker protection and standard Primary transformer protection
without the need to resort to external reactors or current limiting
devices, and still provide acceptable voltage regulation for power
quality considerations, and acceptable arc flash values. UTHVS
reserves the right to deny primary electrical service to any facility
that cannot demonstrate proper coordination or fault rating of
secondary switchgear. See DIVISION 26 for specific requirements
concerning sizing of facility distribution, arc flash, coordination
study, load flow, and short circuit analysis.

.1.18.2 Main and Primary Distribution system Fault, Load Flow, Arc Flash,
and Coordination studies are maintained centrally by UTHVS.
System fault levels (phase and ground fault currents, X/R ratios and
coordination requirements) for l building service connections are
available to the A/E for their use in performing facility electrical
systems studies, by written request to UTHVS. System fault
collection is established by considering system conditions and
possible future system conditions and reconfigurations. On the
Columbus campus, the system contribution is 10,000 Amps Three
phase, 8500 Amps phase to Ground with an X/R of 30 for both.
System Nominal operating voltage is 13.2 kV with a maximum
continuous operating voltage of 13.6 kV.

.1.19 The transformer manufacturer shall provide the ANSI damage curve for the
transformer.

.1.20 Dry type transformers shall be designed for continuous operation at the rated
KVA with a nominal 40-year life expectancy and overload capabilities in
accordance with the latest ANSI-C57. The temperature rise of these
transformers shall be 80°C and the transformer shall be insulated with a UL-
recognized 220°C insulation system. Cast or resibloc-cast coil transformers
shall employ Nomex 410 (preferred) or Nomex E56 insulation turn to turn
with the remainder of the insulation system and encapsulation meeting an
overall 185°C insulation class rating.

.1.21 Liquid-filled transformers shall be designed for continuous operation at the
rated KVA with a nominal 40-year life expectancy in accordance to the latest
ANSI Standards. The temperature rise of these transformers shall be 55°C over a 40°C ambient.

1.22 The sound levels of the transformer shall be designed in accordance with ANSI/NEMA recommended levels.

1.23 Transformer enclosures shall match or exceed the NEMA class associated with the location and service chosen for the transformer. The transformer enclosure shall not rely on the addition of external enclosures, hoods or other forms of drip proofing to avoid the risk of spillage or contamination from sources known to be in the area.

1.24 Transformers shall be Factory tested prior to shipment in conformance with the applicable IEEE/ANSI Standards.

1.25 The Primary Transformer enclosure shall not be used as a place to mount metering CT’s or a point of connection for cables providing a power to the secondary bus for fire pumps or other loads. Metering CT’s and PT’s are prohibited from being installed within the primary transformer enclosure. Power taps to serve the Fire Pump are prohibited from being installed within the primary transformer enclosure.

1.26 When hinged-enclosure doors are provided for access to primary transformers, the doors shall be key-locked with locks and cylinders complying with the BDS standard of Best Access System key cylinders with removable 7-pin cores. Refer to DIVISION 8 for further details.

33 79 00. SITE GROUNDING

33 79 19. UTILITIES GROUNDING - ELECTRICAL

1. GENERAL

1.1 Station grounding is provided for personnel protection, reduce equipment over-voltage exposure due to lightning, and to control stray voltage caused by static charges and electrical faults. Perimeter grounds are run to reduce the likelihood of personnel experiencing injury from stray contact potential. Equipment case or enclosure grounding serves the same purpose.

1.2 The 13.2 kV power system is a multiple grounded design. There are no single phase loads connected phase-to-ground. All major primary power circuits are provided with grounds that run continuously back to the power source. Loads on the system are connected phase to phase. Feeders that traverse the campus to supply building loads are shielded cables with their shields grounded at all splice and termination points.

1.3 Grounding of major power components serves the purpose of conducting equipment fault currents safely away with very little increase in local contact potential.

2. PRACTICES:

.2.2 Submitted designs and Contract Documents shall show ground systems, protective conduit sizes, and relative locations. Specifications and Drawings shall include detailed requirements of the grounding system.

.2.3 Grounding systems applied shall at a minimum conform to applicable requirements of the National Electric Safety Code (NESC) for medium voltage installations (13.2 and 5 kV) and the NEC for low voltage installations. Where NEC requirements conflict with this Standard, this Standard shall govern.

.2.4 All connections in the primary grounding system shall be clamped, exothermic welded, Cadweld® or equivalent. Individual grounding rods connected to the grounding system shall have a measured ground resistance of ten ohms (10 Ω) or less. This measurement may be made by any of the commonly accepted methods for measuring ground rod resistance to earth. Grounding for power equipment power circuit neutral grounding shall be no greater than one tenth ohm (0.1 Ω) measured from the neutral bus to the local ground bus or building structural steel. Primary circuit (13.2 kV system) grounding shall conform to the NESC for potential rise during ground fault. Ground resistance shall be no greater than three ohms (3 Ω) for cabinet and control circuit grounds. Only copper-to-copper ground connections may be clamped or bolted. With limited exceptions, all other terminations shall be Cadweld®ed.

.3 SERVICE GROUND

.3.1 Grounding rods shall be a minimum size of 5/8" x 10' copper clad steel and shall not be placed in back-fill, but driven into undisturbed soil.

.3.2 Interconnection of the service ground, system neutral, and equipment ground conductors shall be made within the service equipment.

.3.3 All feeder circuit conduits shall include a 4/0 insulated ground conductor. The equipment enclosure (transformer case, etc.) shall not be used as a power grounding path. Two independent paths to a common ground point or ground reference shall ground all high voltage apparatus enclosures.

.3.4 Ground conductors shall be 600-volt insulated installed in rigid PVC or rigid galvanized conduit along with the circuit phase conductors. Main and Primary service transformers shall have a bonded secondary neutral that connects to an established ground grid, or grounding system. Cabinet grounds shall be 4/0 solid bare copper and run to an existing grounding system, an adjacent grounded cabinet or, in the absence of an established grounding system, to grounded building steel.

.3.5 Except where specifically allowed by UTHV3, all electrical equipment grounding shall be via 4/0 copper conductors. Conductor and insulation when specified shall conform to the following requirements:

.3.5.1 4/0 bare solid conductor shall be used in applications where the conductor is placed below grade or in a corrosive environment.

.3.5.2 4/0 bare medium stranded (7 strands) may be used in lieu of solid conductor in below grade applications and in mildly corrosive environments, and where conductor flexibility is a consideration.

.3.5.3 4/0 bare high stranding (up to 19 strands) is permitted in all above grade applications where exposure to corrosives is not a concern.
.3.6 All 4/0 bare copper ground cables shall be properly supported:
  .3.6.1 Solid: supported at 4-foot maximum spacing
  .3.6.2 Medium stranding: supported at 3-foot maximum spacing
  .3.6.3 High stranding: supported at 2-foot maximum spacing

.3.7 Ground cables may be required to be insulated based on their use.
  .3.7.1 Transformer and generator neutrals connected to neutral resistors or reactors to limit ground fault currents must be insulated. Cable insulation shall be line-to-line voltage rated. Ground cables running from the Grounding resistor/reactor and station ground shall be bare 4/0 copper unless specified differently in the design.
  .3.7.2 Ground cables run in conduit or tray with feeder cables shall be insulated to avoid the possibility of arcing from stray ground currents during a power system ground fault. The insulation system required in this application is 600 volt class.

.4 EQUIPMENT GROUNDING
  .4.1 All electrical equipment, enclosures and skids are to be provided with safety grounding.
    .4.1.1 Equipment case grounding shall be via 4/0 bare copper solid conductor. It shall be attached to the grounded equipment via Cadweld® or bolted connection where required to facilitate removal for equipment maintenance. It shall be bonded to an established ground grid, ground system, or grounded building steel.
    .4.2.2 Each design should have a detailed grounding plan that adequately describes the grounding requirements for the enclosure/skid and also the grounding requirements for major powered electrical components contained therein.

.4.2 Equipment skids and multiple equipment enclosure line-up shall have two independent 4/0 ground points. For one of these ground points, individual cabinets and small enclosures (e.g. lighting transformers) can utilize the ground carried back to the supply panel with the power cable as long as this conductor carries no load current and is properly identified as a grounding conductor. Multiple groupings of enclosures can have their equipment grounds daisy chained and do not require that both ground paths be direct to building or station ground so long as the maximum ground resistance limitation is observed.

.4.3 Portions of equipment skid may require separate grounding accommodations where vibration eliminators, non-conductive expansion joints or galvanic protection (isolation points) have been installed. These applications must be referred to the Design authority, UTHVS or the equipment manufacturer to establish the proper grounding design.

.4.4 Substation buildings and electrical equipment enclosures shall be provided with a continuous ground bus that runs the perimeter of the basement (or lowest) elevation. This ground bus shall be tied to adjacent structures and to the station grounding system at multiple points. As a preferred practice, all
grounds should be run to this bus. An acceptable alternative, equipment and enclosure grounds can be run and bonded to adequately grounded pre-existing equipment skids or building structural steel so long as the maximum ground resistance limitation is observed.

.4.5 Control and Relay panels:
In addition to the required provisions for equipment grounding, control panels shall be provided with an internal ground bus made up of a minimum 2” by ¼” inch copper bar. This bus shall be placed at the bottom or top of the panel front on the interior side and brought to substation ground. Where panels are arranged in multiple panel configurations, the ground bus shall have provisions to connect or jumper between panel sections via a bolted or Cad welded connector. All equipment case grounds, CT grounds, instrument transformer grounds and shielded control and instrument cable grounds shall be brought to this ground bus and connected via ¼” bolted fasteners.

.4.6 Buried control cable and ducts:
Control cables run to locations in the substation below grade in conduit, or where permitted direct buried, shall have all spare conductors grounded at the control panel end of the cable run. In addition a bare copper ground wire shall be placed below the duct bank running the length of the cable run and snaked at roughly 45 degree angle to the control cable. This ground cable shall be attached to substation ground at both ends of the run.

.4.7 Buried Power cable and ducts:
Feeders with each phase contained in a separate conduit in a three phase duct bank array shall be provided with un-insulated ground cables run external to the conduit. The conductors shall be run below the duct bank and bonded to substation ground at both ends of the conduit run. There shall be a minimum of one 4/0 bare copper cable per vertical duct bank column. Three phase arrays with only three ducts arranged in a single vertical column shall be provided with a minimum of two 4/0 bare copper ground cables. Feeders with all three phases and an insulated 4/0 ground cable contained within a conduit require no external ground conductor.

.4.8 Fences (perimeter grounding):
Substation fences shall be provided with continuous buried 4/0 bare copper ground cable run a nominal three to six feet on both sides of the fence and bonded to the fence at fifty foot intervals or less. These cables shall be attached to the substation ground mat at regular intervals. Gates shall be bonded via extra flexible ground leads and the gate opening area shall be ringed with buried 4/0 bare copper ground cables.

.4.9 Yard Operator stations, pads:
Operating positions and step-off pads shall be grounded to the adjacent strictures with 4/0 bare copper cable via two independent paths.

.4.10 Primary Switch Enclosure Grounding:
Primary switches mounted inside buildings or in vaults shall be grounded at two points in conformance with the general requirements for grounding stated in sub-section .2.4 of this section. Enclosures, where provided, are to be grounded to the switch grounding system providing two paths to ground for the enclosure in accordance with Section .4.3. Ground connections to
enclosure are to be bolted onto the inside of the enclosure. The bolting is to facilitate removal of the enclosure for switch maintenance or replacement.

.4.10.1 Primary switches mounted external to buildings on manholes, vaults or housekeeping pads or slabs shall be provided with enclosure touch potential grounding in addition to switch grounding. Grounding rods shall be driven at all four corners of the pad at a distance of 4’ 3” from the pad. A single 4/0 bare copper conductor shall be bonded to and run between the four rods at a distance of 3’ from the edge of the concrete, forming a loop. Two 4/0 copper conductors shall be bonded to the 4/0 loop at opposite corners and bolted to the switch enclosure. These conductors may be bare copper if run exposed or may be insulated. Ground connections to enclosures are to be bolted onto the inside of the enclosure.

.4.10.2 Primary switches with enclosures mounted external to buildings on pavement or a slab extending three feet or more beyond the extremities of the switch enclosure shall be grounded at two points in conformance with the general requirements for grounding stated in sub-section .2.4 of this section. Enclosures are to be grounded to the switch grounding system providing two paths to ground for the enclosure in accordance with Section .4.3. Ground connections to enclosure are to be bolted onto the inside of the enclosure. The bolting is to facilitate removal of the enclosure for switch maintenance or replacement.

.4.10.3 All remote electrical equipment, portable equipment or temporary service switches and outlets are to be grounded. Power panel branch circuits powering duplex outlets shall not be powered through a GFI or ACFI at the source but, if a GFI outlet is required, have the GFI local to, or integral with, the local service connection or outlet.

33 79 93. SITE LIGHTNING PROTECTION

.1 LIGHTNING PROTECTION

.1.1 Buildings and structures shall have lightning protection. This protection shall be designed to effectively protect not only the building but associated electrical structures and major electrical power equipment including transformers and cables.

.1.2 Protection may be afforded through the selective placement of air terminals on the buildings or structures or by shielding through the use of aerial ground wires placed to afford a 30 degree cone of protection.

.1.3 Protection from lightning induced voltage transients and large changes in local ground potential shall be afforded by properly applied lightning arrestors, spark gaps, and surge suppressors.


.1.5 See DIVISION 26 for requirements for building/structure lightning protection.
Figure 1

Fig. 1 Electrical One Line
Figure 2

- Motor Operated Disconnect Switch
- Resettable Fault Interrupter or Switch and Fuse

See Fig. 3 for other Switch Configurations

Fig. 2 Standard 13.2KV Switch Configurations
Two Feeders
Figure 3
Figure 4

**Main**

**Expanded Main**

**Lateral**

- SCHEDULE 40 PVC
- #6 REBAR
- FOR HEAVY TRAFFIC AREAS AND PARKING LOTS ONLY

Fig 4 Primary Duct Bank Configurations
Figure 5
END OF DIVISION 33 - UTILITIES

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