Oklahoma State University

Engineering Design Guidelines

OSU Facilities Management

OSU Long Range Facilities Planning

Developed by Cyntergy

with contributions from CEC and Guernsey

Version 07 | 6/10/2024

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Section 1: Administrative Guidelines

1-1. Introduction

These guidelines shall be used for the construction, renovation, and addition of all buildings at Oklahoma State University – Stillwater. These guidelines are not intended to address all possible project-specific design requirements or cover all applicable codes, standards, or other applicable requirements or end-user-specific requirements. Instead, the guidelines are meant to provide the engineer with guidance regarding OSU's requirements and expectations for projects.

The engineer shall design systems that are appropriate for the specific project, and such designs shall meet all applicable code requirements, industry standards, and engineering best practices.

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B. Abbreviations
   a. ADA – Americans with Disabilities Act
   b. AHJ – Authority Having Jurisdiction
   c. EHS – Environmental Health and Safety
   d. FM – Facilities Management
   e. IAQ – Indoor Air Quality
   f. LRFP – Long Range Facilities Planning
   g. OPR – Owner's Project Requirements
   h. UA – University Architect

C. Referenced Standards and Guidelines
   a. ASHRAE Standard 0-2019 – The Commissioning Process
   b. ASHRAE Standard 0.2-2015 – Commissioning Process for Existing Systems and Assemblies
   c. ASHRAE Standard 202-2018 – Commissioning Process for Buildings and Systems
   d. OSU Excavation, Alteration, Renovation, and Additions Policy
   e. OSU's Tree Protection Standards, Tree Care Plan, Landscape Master Plan, Landscape Design Standards and Irrigation Specification Standards

1-2. Administrative Items

The following includes general information regarding these guidelines. These guidelines were developed by OSU LRFP and FM.

A. Authority structure

a. The Executive Committee as referenced herein shall include:
    a. Director of LRFP
    b. Associate Director of LRFP
    c. University Planner
    d. Chief Facilities Officer
    e. FM – Director of Construction and Contract Services (Chairman)
    f. FM – Director of Energy Services
    g. FM – Director of Operations and Maintenance
b. The Working Committee referenced herein shall include:
    a. University Architect
    b. FM Distribution
    c. FM Utilities
    d. FM Energy Management
    e. FM Zones
    f. FM MEP
    g. FM Central Trades

1-3. General Design Requirements

The following general design requirements shall be incorporated into the engineering design. These guidelines are not all inclusive. The engineer is required to understand both the content of these guidelines and the specific requirements of each project.

A. Code
    a. All applicable codes and standards shall be followed. Applicable codes shall be determined by EHS and the AHJ.
    b. The AHJ for OSU is the OSU Fire Marshal.
    c. Neither the requirements of these guidelines nor any OSU review comment shall relieve the engineer of the requirement to meet codes.
    d. Where these guidelines conflict with code, the more stringent requirements shall form the basis of design. Any such conflict shall also be presented to OSU at the earliest possible phase of the project.
B. Compliance
    a. Work shall be performed in accordance with these guidelines and the requirements of the OSU Excavation, Alteration, Renovation, and Additions Policy.
    b. The Executive Committee is the sole authority for providing specific exceptions to guidelines compliance.
    c. These guidelines are not intended to limit the engineer's innovation and best practices. Where the engineer proposes to meet a higher standard than the guidelines put forth, the engineer shall present such concepts to OSU for approval prior to proceeding with the design.
    d. Any visible or aesthetic components of the engineering design must be approved by the UA. The requirements in this engineering guideline are intended to address building systems requirements and are not intended to form the basis of any aesthetic requirements.
    e. The engineer shall be responsible for following the latest published version of these guidelines at the start of each project.
    f. Should these guidelines be updated after the beginning of the project design, the engineer

shall not be required to follow the updated version of the guidelines. Where OSU requires the engineer to follow the updated guidelines on projects already in design, OSU will provide specific notice of updated guidelines to the engineer and the engineer will clearly indicate to OSU the design impact of the updated guidelines for the in-design project.

C. Communication
   a. It is expected and required that the engineer will communicate with OSU early and often. This includes areas of impact to OSU operations, issues that arise during the design process, information that OSU requires from the engineer as part of the OPR or the requirements of these guidelines, and information required to be provided to the engineer by OSU.
   b. Impacts to existing facilities
      a. Impacts to existing functions of facilities shall be minimized in design.
      b. Required downtime to existing facility functions shall be minimized.
      c. Construction activities requiring facility, infrastructure, or utility shut downs shall be identified during design and made clear to OSU as soon as they are identified.

D. General design requirements
   a. Work performed for OSU shall be of a quality commensurate with OSU's expectations and high-quality standards and shall prioritize the following goals:
      a. Ensure safety.
      b. Follow applicable code.
      c. Meet the OPR.
      d. Follow these guidelines.
      e. Maximize energy efficiency based on life cycle cost.
      f. Maximize IAQ.
   b. The engineer is responsible for reviewing the content of this guideline and shall not consider previous projects, experience, or prior OSU decisions to form the basis of new project requirements. Where this guideline indicates requirements are on a case-by-case or site-specific basis, the engineer shall coordinate with OSU and receive direction.
   c. The engineer shall notify OSU where deviations from these guidelines are under consideration and shall receive approval prior to finalizing the design should the intended design differ from the requirements of these guidelines.
   d. Title 61
      a. The engineering design documents shall comply fully with Title 61 of the Oklahoma Statutes.
      b. Within these guidelines, where the "basis of design" is included, the engineer shall base the design around one of the noted products or manufacturers. Approved equal products shall be coordinated with OSU.
   e. Equipment equipped with electronic controls shall not require proprietary information or equipment for access to system controls for repair, programming, and maintenance purposes. The use of proprietary dongles, fobs, cards, or other proprietary means of access shall not be required except where such access tools are provided to OSU for use in maintenance. Furthermore, any proprietary tools required for maintenance of equipment shall be provided to OSU prior to project closeout.

1-4. Guidelines Update Process

These guidelines should be reviewed and updated periodically. The following presents the method of review and update.

A. Update frequency
   a. The guidelines should be reviewed and updated yearly. Mid-cycle or periodic reviews and guidelines edits may be necessary.
   b. When agreed upon by the Executive Committee, the Working Committee will review the entirety of the guidelines in addition to other change suggestions and present all necessary change requests to the Executive Committee.
   c. The Executive Committee may then choose to mark the entirety of the guidelines updated and revised after this process, effectively moving the next required review period to one year from the revision date.

B. Receiving feedback and change proposals
   a. The Working Committee should solicit feedback, as required, from LRFP and FM contributors on at least an annual basis.
   b. The Executive Committee or Working Committee may, at their discretion, solicit feedback from engineers, contractors, vendors, and other personnel involved in the work covered by these guidelines.
   c. Change proposals may be issued by OSU personnel only, shall be issued in writing, and shall be directed to the Working Committee.

C. Working Committee review
   a. The Working Committee shall review the entirety of the guidelines annually, regardless of whether change proposals or feedback has been received.
   b. Change proposals and feedback shall be compiled by the Working Committee. The Working Committee shall deliver a complete written list of the proposed changes to the Executive Committee with recommendations. The recommendations list shall be dated. These recommendations could include:
      a. Recommendation for inclusion.
      b. Recommendation for inclusion with changes.
      c. Recommendation for rejection.

D. Executive Committee review
   a. The Executive Committee shall have the sole authority to determine the acceptability of changes to these guidelines.
   b. The Executive Committee shall review the Working Committee's recommendations and either approve, approve with comments, or reject each recommendation.
   c. Upon completion of their review, the Executive Committee shall deliver written directions to the Working Committee for implementation.

E. Editing the guidelines
   a. The Working Committee shall edit these guidelines as instructed by the Executive Committee.
   b. The Working Committee shall provide the final version of the guidelines, with added, deleted, or revised sections indicated in bold, to the Executive Committee for final approval.
   c. OSU should review all document hyperlinks to confirm functionality.

d. OSU should review all standard references to confirm the correct version is listed throughout the document.

F. Final approval and posting
   a. Should the updated guidelines find the approval of the Executive Committee; the Executive Committee shall document the approval and disseminate the updated guidelines electronically to FM and LRFP.
   b. The date of approval shall be listed on each sheet of the updated guidelines.
   c. The FM IT department shall publish the updated guidelines to their location on the web.
   d. FM shall notify all on-call design firms that updated guidelines are available.

G. Inter-cycle updates
   a. Should an update be required prior to the update cycle as defined above, the proposed change shall be in writing to the Working Committee requesting review prior to the standard annual process. The Working Committee shall convene and follow the regular update process for the individual change. The Working Committee shall be responsible for organizing this process.
   b. The approval process shall remain unchanged from the process defined above.

1-5. Commissioning

The following guidelines shall apply to the commissioning of projects. It shall be the engineer's responsibility to provide direction in accordance with these guidelines to the parties associated with commissioning.

A. Where required
   a. OSU prefers commissioning to be included on each project and will internally determine the extent of commissioning requirements at the beginning of the project. Commissioning shall follow the requirements of ASHRAE Standard 0, ASHRAE Standard 202, and ASHRAE Standard 0.2.
   b. The engineer shall coordinate with OSU regarding the scope of commissioning and include these requirements in the design documents.

B. Commissioning agent
   a. Commissioning shall be performed by a third-party licensed to perform commissioning of the systems required to be commissioned.
   b. Commissioning shall not be performed by the contractor, test and balance contractor, or any party involved in construction, unless that involvement is restricted to commissioning duties only.
   c. Where commissioning is required, test and balance, startup, training, or any other pre-commissioning activities shall not be acceptable in the place of commissioning as outlined in the contract documents.

1-6. General Requirements

The following section details general requirements that pertain to all disciplines.

A. ADA
   a. Compliance with ADA shall be included for all new projects and all major rehabilitation projects as determined by OSU. The engineer shall coordinate with the project architect

regarding the application of ADA to products, systems, and installations.

B. Landscape design and tree protection
   a. Landscape campus beautification and our urban forest play an important role in recruiting students and faculty while enhancing the quality of life for everyone that works at or calls OSU home. Landscape design and tree protection standards must be followed to ensure aesthetic continuity, maintenance affordability, and tree protection.
   b. Landscaping and Trees are a major investment and asset to the campus and should be protected and preserved to the greatest extent possible when designing and constructing new buildings, remodeling an old building, upgrading or installing new utilities. As a Tree Campus USA member, our requirements and objectives are to promote, educate and sustain a healthy urban forest and landscape that will benefit the campus and surrounding community.
   c. Refer to OSU's Tree Protection Standards, Tree Care Plan, Landscape Master Plan, Landscape Design Standards, and Irrigation Specification Standards. For landscape design and tree protection questions call (405)744-4753.

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Section 2: Site Utilities Guidelines

2-1. Introduction

The following section includes OSU Engineering Guidelines related to site utilities and other associated topics. The engineer should review this section and the rest of these Engineering Guidelines prior to beginning design.

A. Table of contents

B. Abbreviations
   a. AWWA – American Water Works Association
   b. ASTM – American Society of Testing and Materials
   c. CD – Construction Documents
   d. EPA – Environmental Protection Agency
   e. GFCI – Ground-fault circuit interrupter
   f. HDPE – High-Density Polyethylene
   g. ID – Internal diameter
   h. IT – Information technology
   i. NFPA – National Fire Protection Association
   j. OCP – Overcurrent protection
   k. ODEQ – Oklahoma Department of Environmental Quality
   l. ODOT – Oklahoma Department of Transportation
   m. OKIE – Oklahoma One-Call System
   n. PE – Polyethylene
   o. PHMSA – Pipeline and Hazardous Materials Safety Administration
   p. PVC – Polyvinyl chloride
   q. PSIG – Pounds per square inch, gauge
   r. RCP – Reinforced concrete pipe
   s. SCADA – Supervisory Control and Data Acquisition
   t. SDR – Standard dimension ratio
   u. UA – University Architect
   v. V – Volts

C. Referenced Standards and Guidelines
   a. AWWA Manual M14 – Backflow Prevention and Cross-Connection Control: Recommended Practices.
   b. AWWA MOP M31 – Distribution System Requirements for Fire Protection
   c. ODEQ Standard 252:626 – Public Water Supply Construction Standards
   d. ODEQ Standard 252:656 – Water Pollution Control Facility Construction Standards
   e. OSU EHS – Construction Codes and Policy
   f. OSU Geospatial Systems Requirements for University Project Archive Submittals

D. Appendices
   a. Appendix A: Utility Burial Details
   b. Appendix B: Campus Loop Connection Details
   c. Appendix C: Duct Bank Details
   d. Appendix D: Electric Meter Installation Details
   e. Appendix E: Outdoor Lighting Standards
   f. Appendix F: Medium Voltage Transformers and Switchgear
   g. Appendix G: Flow Meter Details
   h. Appendix H: Lighting Basis of Design Details
   i. Appendix I: Underground Electrical Vault
   j. Appendix J: Manhole Connections
   k. Appendix K: Domestic Water Layout
   l. Appendix L: Typical Monument Construction
   m. Appendix M: Equipment Grounding

2-2. General Site Utilities

The following general design requirements shall be incorporated into the engineering design. These guidelines are not all inclusive. The engineer is required to understand both the content of these guidelines and the specific requirements of the project.

A. General requirements
   a. Unless otherwise specifically directed by OSU, the engineering design shall include site utilities design, drawings, and specifications for all utilities required by the project. This shall include connection of new site utilities serving the project to existing mains. The estimated design load for all utilities shall be provided to OSU Utilities Engineering for review at the conceptual design phase. Design and drawings of all utilities systems shall be provided. If there is any change in the estimated design loads, it shall be communicated to OSU Utilities Engineering immediately for system capacity verification. Issued drawings shall include complete horizontal and vertical profiles with utility crossings noted preferably at 100% DD.
   b. Site utilities as referenced within these guidelines shall apply to the following systems:
      a. Domestic water and fire suppression water
      b. Natural gas
      c. Sanitary sewer
      d. Storm drain
      e. Chilled water
      f. Heating water

g. Steam and steam condensate
h. Electrical
i. Other utilities as defined by OSU or by project documents

c. Where these guidelines indicate for the engineer to coordinate with OSU, coordination should be directed to the OSU project management contact.

d. Load requirements shall be included on the contract documents by 95% CDs for OSU coordination purposes for all utilities.

e. The site utilities should be identified in the drawings with the following acronyms:
   a. DW - Domestic water
   b. FL - Fire line
   c. Natural gas
   d. SS - Sanitary sewer
   e. SD - Storm drain
   f. CW - Chilled water
   g. HW - Hot water
   h. STEAM - Steam
   i. COND - Steam condensate
   j. EL - Electrical

B. Utility coordination
   a. Coordinate with OSU for all tie-ins to non-university-owned utilities.
   b. If easements are required, the engineer shall coordinate with OSU. The location of existing easements discovered shall be provided to OSU.

C. Surveying
   a. A survey conducted by a Professional Licensed Surveyor is required. Utility maps provided by OSU are not all-encompassing and should not be used for design purposes. The engineer shall determine potholing or other discovery requirements prior to the survey. Utility crossing locations and elevations should be field verified during design via record drawings or potholing. Additional potholing may be required to investigate specific conflicts discovered during design.
   b. All surveys shall be performed under the OSU published control monument system. No arbitrary coordinate system will be allowed. NADA3-88 Oklahoma zone north US survey feet is the basis of OSU's control system.
   c. OSU IT is responsible for fiber optics, copper, and telecommunications locating. Energy Services locators are responsible for all other OSU-owned utilities. After the latest geospatial information is obtained, the engineer shall determine requirements for additional site visits and pothole locations. Potholes shall be performed per the requirements of the Oklahoma Underground Utilities Damage Prevention Act.
   d. Refers to the 3 1/2" bronze disc set flush with the ground surface in an 8" diameter reinforced concrete column poured in place and running 18" deep. The rebar shall extend down 24" deep. The discs are stamped: Oklahoma State University (Station Name), (Refer to Appendix L).

D. Excavation, burial, and backfill
   a. Burial shall conform to the details of Appendix A. Details show minimum burial depths; greater depths may be required in some places due to site conditions, crossing utilities, etc. Coordinate with site conditions and existing utilities to determine specific burial depths. Where burial depth requirements are in conflict with ODEQ or other applicable

codes, the more stringent shall apply.

b. The contractor is required to obtain OSU Excavation Permits and conform to the requirements thereof. Each contractor shall obtain their own Excavation Permit. No contractor shall use another contractor's Excavation Permit as per OKIE and OSU. Contact OKIE prior to excavation.
c. Utility color standards shall be as per OKIE.
d. Backfill
    a. The contractor shall hire a testing firm to perform density tests of fill-in utility trenches to verify appropriate compaction to minimize settling.
e. Tracer wire
    a. Tracer wire shall be taped to the top of pipe every eight (8) feet on all utilities, with the exception of gas. Tracer wire shall be Copperhead as the basis of design, 12 AWG copper clad with HDPE jacketing (minimum 30 mil).
        i. Open trench: high strength tracer wire with minimum 450 lb break load
        ii. Directional drilling/boring: extra high strength with minimum 1150 lb break load.
    b. Color of tracer wire shall be according to the APWA standards for the specific utility being marked.
    c. Provide water-tight, gel-filled wire connectors. The basis of design shall be 3M or Copperhead. Wire nuts, electrical tape, and heat shrink are not acceptable.
    d. At tees with valve(s), tracer wires shall be brought to the surface in proper termination ports (if possible).
    e. The basis of design for termination ports shall be a Copperhead Snake pit. Termination ports must be at an approved grade level at the hydrant/building face.
    f. Provide warning tape twelve (12) inches above utility. Tape shall be color-coded to specific utility per the OKIE Locate standard.
    g. Refer to Appendix A for tracer wire details.
f. Horizontal and vertical spacing between water distribution pipes and other utilities (sanitary sewer, storm, etc.) shall be as per the requirements of ODEQ and other applicable code requirements.

E. Valve boxes
    a. Provide a valve box at finished grade for all below-grade valves. Valve boxes shall be installed at finished grade. The valve box riser shall be six (6) inches in diameter and shall be constructed of PVC pressure pipe with a #70 cast iron valve can and cover. Where valve boxes are located in an area subject to vehicular traffic, the valve box riser shall be constructed of cast iron. The valve cover shall be marked with proper identification for the utility.
    b. For fire lines, the valve box cover shall be painted red.

F. Metering
    a. Refer to Appendix G for all flow meter, pressure transmitter, and data logger requirements.
    b. The following utilities shall be metered:
        a. Domestic water
        b. Natural gas
        c. Electrical
        d. Chilled water
        e. Heating water

f. Steam and steam condensate
g. Irrigation (provide submeter)

c. The following utilities shall not require metering:
   a. Sanitary sewer
   b. Storm
d. The meter type will be specified, sized, and purchased by OSU Energy Services. Note specific requirements in utility-specific sections below. The data logger (if necessary for smart meter installation) shall be provided with power (120V/20A dedicated circuit) and access to a data connection. The contractor shall label/identify the location of the breaker.
e. Meters other than electric and natural gas shall be installed by the contractor. Installation shall include installation of all sensor ports, isolation valves to pipe for pressure and temperature sensors/transmitters, data drops, and power according to the meter installation diagram for each utility. The conduit shall be attached to the data logger box with at least one foot of wire inside the box. The data plug shall be inside the data logger box. Refer to Appendix G and Appendix K.
f. The maximum distance from the meter head to the data logger (RSG45) is 600 ft if 18AWG shielded wire is used. The maximum distance from the meter head to the data logger (RSG45) is 1,000 ft if 13AWG shielded wire is used.
g. The maximum distance from the data logger (RSG45) to the IT cabinet is 300ft. In addition, CAT6 patch cable shall be used.
h. Due to meter maintenance requirements, a floor drain is recommended near meter locations.

G. Testing
   a. Coordinate utility testing 24 hours (minimum) in advance of the tie-in with incoming utility.
   b. The contractor shall possess all necessary tools and testing equipment required for testing in compliance with the project requirements, code, and these Guidelines. Test equipment shall be appropriate for the utility application, type, and volume being measured. Test device shall be appropriately calibrated within the manufacturer's required time frame. The contractor shall submit calibration records.

H. Regardless of whether as-builts are completed for every discipline, civil as-builts shall be delivered as soon as they are completed. OSU should verify all as-builts prior to acceptance. Refer to OSU Geospatial Systems requirements for details and place of submittal. The contractor shall provide as-built redlines from field adjustments/changes to the civil engineer to prepare record/as-built drawings.

I. Building hydronic systems shall be provided with initial fill and makeup water via the domestic water system. Filling, flushing, and making up building hydronic systems with campus chilled water or heating water is not allowed. All steel chilled water and heating hot water piping systems are to be passivated following a cleaning of the systems.

J. Inspection and Survey
   a. All new utilities shall be inspected by an OSU inspector and surveyed by OSU ES.
   b. The survey and inspection request form can be requested from OSU ES and must be sent by the project at least 24 business hours ahead of time.

2-3. Domestic Water – Distribution

The water distribution system shall be designed per the requirements of the following section. Note that where specific manufacturers or products are indicated as "basis of design," the engineer's design shall include those products where applicable. Except for meters, transmitters, and data loggers, equals are allowed and shall be coordinated with OSU.

A. General requirements
   a. The requirements of the latest edition of ODEQ Standard 252:626 shall apply to the design, installation, and testing of all water distribution lines. An ODEQ construction permit is required prior to construction activities.
   b. The design engineer shall verify the peak flow with OSU Energy Services by 60% CD

B. Design
   a. The engineer shall provide a flow test to determine the available pressure for all water systems. The engineer shall coordinate with OSU regarding the timing of the flow test and shall provide a minimum of one (1) week's notice prior to performing the test. The flow test report shall be provided to OSU upon completion.
   b. Connection to the main service
      a. Provide a mechanical joint for the service connection fitting.
      b. Tees should be designed with three valves (one per branch); tee fittings are preferred over taps. The engineer shall coordinate with OSU and receive approval prior to using a tap in lieu of a tee fitting. If a tap is approved, the branch line shall not be more than half the size of the main line. The tap shall be vertical, and the tapping valve actuator shall be accessible from ground level.
      c. Hot taps are not preferred. Where hot taps of existing water distribution lines are deemed necessary by the engineer, the engineer shall coordinate with and receive approval from OSU prior to proceeding.
      d. Polyethylene wrap: All fittings, restraints, and taps should be wrapped in polyethylene.
      e. Service lines shall not be located under any site features such as stairs, ADA ramps, planters, large vegetation, etc. If this is not possible due to the building conditions, the piping shall be installed in sleeves. A minimum of 25 feet of clearance downstream from the face of the building is needed to ensure maintenance and repairs tasks can be performed. The use of sleeves must be approved by OSU ES Utilities Engineering.
   c. Water distribution piping velocity shall be between 3.3 and 8.2 ft/s or as required by code. Velocities shall not exceed the manufacturer's maximum velocity recommendations.
   d. Dead legs are considered to be 15 feet or more in length. Avoid dead legs. Where dead legs are unavoidable, coordinate with and obtain approval prior to proceeding.
   e. Irrigation lines shall come out from the building where a meter and a backflow preventer shall be installed on the irrigation line. If the irrigation line must be tied into domestic water distribution, coordinate with Landscape Services and Energy Services to determine the exact location of the tie-in. A meter (in a box) and an above-ground backflow preventer (with protection case) shall be installed on the irrigation line.
   f. A backflow preventer shall be installed at the main line entrance into the building, in any irrigation branch lines, and in all other locations required by ODEQ, code, and the recommendations of AWWA Manual M14.

g. Provide air/vacuum release per ODEQ requirements.
h. Vertical separation of 2 feet between the water main and all other utilities – DEQ 252:626-19-2(h)(2).
i. Minimum horizontal separation from the sanitary sewer is 10 feet – DEQ 252:626-19-2(h)(1)(B).
j. Minimum horizontal separation from all other utilities Is 5 feet – DEQ 252:626-19-2(h)(1)(C).

C. Products
a. Water distribution pipe shall be at least 4" in diameter, PVC C900/905 (DR18 non-insulated), bell, and spigot. For pipe size below 4", use HDPE IPS DR-11 (blue stripe) with fused joints (contractor shall have poly fusion certification).
b. Ductile iron fittings with mechanical joint restraints shall be used. EBAA IRON shall be the basis of design. As a part of the design documents, the engineer shall provide calculations for the required joint restraint length. Engineered concrete thrust blocks are allowed in certain instances where reviewed and approved by OSU.
c. Water distribution valves shall be resilient-seat wedge-style gate valves. Mueller, American, or Clow model C515 shall form the basis of design. Where dead leg water distribution lines are present, provide valves to facilitate a flushing routine of the dead leg water line. The water distribution valve shall meet applicable AWWA standards.
d. Coordinate with OSU regarding the requirement for a flushing hydrant.
e. Meter
    a. Refer to Appendix G for meter sizing details.
    b. Meters shall be provided by OSU, installed by the contractor.
    c. For meter selection, the nominal flow shall be 80% of the maximum design flow unless the expected nominal flow is determined otherwise by the engineer.
    d. Upstream of the meter, a pressure transmitter shall be supplied and installed with an isolation valve (3/4" lead-free ball valve). The pressure transmitter shall be Endress Hauser Cerabar PMC11 to measure gauge pressure. The pressure transmitter shall be tied into an RSG45 data logger. Note that the pressure transmitter shall be compatible with the specified data logger.
    e. Water meters shall be located inside the building in the building water entry room. Any deviation must be approved by OSU. Isolation valves shall be installed on either side of the meter for maintenance purposes (Refer to Appendix K). Refer to Section 3: Plumbing Guidelines for service bypass and submetering requirements.
    f. All fittings for the meter assembly shall be ductile iron, copper type K, or HDPE DR-11.
    g. Restraints shall be used for the meter assembly. EBAA IRON shall be the basis of the design.
    h. If the water meter is installed outside the building, a traffic rated meter box and a meter setter shall be used.

D. Execution
a. Joint deflection shall be limited to two (2) degrees per joint or per the manufacturer's standard deflection limits.
b. Burial
    a. Provide sand bedding 6" below and above pipe for pressurized (non-gravity) flow.
    b. Minimum cover: 30 inches on top of pipe – DEQ 252:626-19-2(c).
    c. When a new domestic waterline (C900) is being tied to an existing transite domestic

waterline, provide gravel bedding at the tie-in (tee) plus 5 ft in all directions.

c. Testing
    a. Water distribution pipe shall be tested per the latest edition of ODEQ Standard 252:626. Test the installed pipe for leakage in accordance with AWWA standard specifications. Leakage shall not exceed 10 gallons per inch-diameter per mile of pipe when tested for 24 hours and 150 psi testing pressure. The minimum duration shall be two (2) hours.
    b. Water distribution pipe shall be provided with bacteriological testing per the latest edition of ODEQ Standard 252:626 and per the requirements of IPC. Disinfect all waterlines according to AWWA standard specifications. Obtain safe bacteriological samples on two consecutive days before placing the waterline into service.

2-4. Fire Protection – Distribution

The fire protection water line system shall be designed per the requirements of the following section. Note that where specific manufacturers or products are indicated as "basis of design," the engineer's design shall include those products where applicable. Equals are allowed and shall be coordinated with OSU.

Note that these Guidelines pertain to only the site utility portion of the fire protection system. Refer to the OSU EHS Construction Codes and Policy for other fire protection requirements.

A. Design
    a. It is preferred that only one domestic water service line is tied into the OSU domestic water main system. The line that will supply portable water should be teed off from the service line as close to the building as possible. Provide isolation valves for both the domestic water and the fire protection water lines at the tee.
    b. The maximum dead leg for underground fire lines outside of the building shall be 15 feet. Refer to section 2-3-B-d.
    c. Fire hydrants
        a. Fire hydrant locations shall meet NFPA, Fire Code, AWWA MOP M31, and the requirements of the OSU Fire Marshal.
        b. The maximum distance from any point on a street or road frontage of a building to a hydrant shall be 250 ft. Depending upon the required fire flow, this distance may need to be closer than 250 ft and may require multiple fire hydrants. Please refer to Table C102.1 Required Number and Spacing of Fire Hydrants in IFC-2018. In addition, fire hydrants must be within ten (10) ft of a drivable surface.
        c. There shall be a fire hydrant located within 150 feet of the FDC and shall be on the same side of the road as the FDC.
        d. Each fire hydrant must have a gate valve for isolation.
        e. The fire hydrant connection size shall be 6" at minimum.
        f. Fire hydrant branch lines shall be not more than five (5) feet from the main. If a hydrant cannot be installed less than five (5) feet from the main, the line is considered a dead leg and shall have a backflow preventer installed. The backflow preventer shall meet the requirements of NFPA.
        g. Fire hydrant shall be installed where the center of the lowest outlet is a minimum of 18 inches above grade and no more than 24 inches above grade.

h. Hydrant shall be installed where the large discharge port is facing the roadway.

B. Products
   a. Fire hydrants
      a. Fire hydrants shall be Mueller Super Centurion or Clow Medallion as the basis of design.
      b. Fire hydrant valves shall be Mueller Resilient Wedge Gate or Clow Resilient Wedge Gate as the basis of design.

C. Execution
   a. Hydrants shall be installed plumb and level to ensure proper function.
   b. Burial
      a. Backfill with class A rock for draining around the fire plug.

2-5. Natural Gas – Distribution

The natural gas system shall be designed per the requirements of the following section. Note that where specific manufacturers or products are indicated as "basis of design," the engineer's design shall include those products where applicable. Equals are allowed and shall be coordinated with OSU.

A. General requirements
   a. OSU self-performs all underground gas piping to the building wall including meter set. The engineer shall provide loads to OSU for installation of site gas. Loads shall be clearly indicated in MBH or CFH on design documents.
   b. No contractor shall perform any exterior work on OSU natural gas distribution system.
   c. The engineer shall design the gas line size and routing on site based on gas loads as calculated. Natural gas line shall not be designed or installed in the same trench with other utilities.
   d. If a back-up gas generator is to be installed, the design engineer shall provide a gas system design. The gas demand and pressure at the gas riser assembly shall be provided to OSU ES, to size the gas meter assembly.

B. Design
   a. No gas may enter the building below grade per code.
   b. Horizontal and vertical spacing between natural gas and other utilities shall be per code. Separation of five (5) feet horizontal and two (2) feet vertical is preferred.
   c. Gas meter
      a. The gas meter shall be located per U.S. DOT PHMSA regulations. The preferred location is three (3) feet from the exterior building wall, ten (10) feet from any building openings or fresh air intakes, and not less than the required separations per code. Coordinate with OSU regarding any deviations.
      b. Closely coordinate the location of the gas meter and any screening requirements with the UA.
      c. Provide a 1/4" weldo let downstream of the meter for steel piping.
      d. Regulators shall be specified as Fisher or American as basis of design.
   d. Electro fuse style hot taps are not allowed. Electrofusion branch saddles with full port valves may be used with the permission of OSU ES.
   e. For any required boring, the engineer shall coordinate sleeving and sleeve vent requirements with OSU.

f. Where abandonment of gas lines is approved by OSU, cap abandoned lines at both ends.

C. Products
   a. Site natural gas piping shall be SDR 11 or 11.5 HDPE
   b. Fittings shall be:
      a. HDPE for underground piping.
      b. Schedule 40 steel with screw connections for above ground piping (no steel shall be allowed below ground).
   c. Valves
      a. Underground ball valves shall be quarter turn PE valves.
      b. Aboveground BALON gas valves shall be specified as the basis of design.
   d. Gas meters shall be either diaphragm type (basis of design: American) or rotary type (basis of design: Roots).
   e. Risers shall be anode less.

D. Execution
   a. Burial
      a. The minimum burial depth for direct bury natural gas piping shall be 24 inches.
      b. Provide sand embedment for natural gas piping below ground.
      c. Provide yellow warning tape bearing the label "CAUTION" in addition to all other locating requirements in Section 2: General Site Utilities Requirements.
      d. Tracer wire: Yellow. Separation from top of pipe 3 inches (sand on top of pipe). Refer to section 2-2-D-e.
   b. Testing
      a. Pressure testing shall be performed on underground poly pipe per the requirement of code and the gas company. A pressure test shall be conducted at 100 PSIG for 24 hours minimum.

2-6. Sanitary Sewer – Site

The sanitary sewer system shall be designed per the requirements of the following section. Note that where specific manufacturers or products are indicated as "basis of design," the engineer's design shall include those products where applicable. Equals are allowed and shall be coordinated with OSU.

A. General requirements
   a. Specialized waste systems (e.g. animal digestion, chemical waste, hazardous waste, etc.) shall follow ODEQ requirements.
   b. Permits
      a. Applicable permits shall be filed including a downstream sewer study for gravity systems. The connection fee to the City of Stillwater is only valid on construction tying into city main directly. The engineer shall prepare permit paperwork and pay all associated fees.
      b. An ODEQ permit is required for public sanitary sewer mains per the latest edition of ODEQ Standard 252:656. An ODEQ permit is not required for service lines to buildings. The engineer shall prepare all permit paperwork and pay all associated fees.

B. Design
   a. Design engineer shall verify existing system capacity with Energy Services before design.
   b. Tie-ins to existing services

a. For all tie-ins to existing sewer lines equal to or smaller than 6", a service wye and cleanout are preferred. For all tie-ins to existing sewer lines greater than 6", a manhole should be installed.
b. External drops are preferred (Refer to Appendix J). OSU approval is required for internal drops (Refer to Appendix J). Drops shall be no higher than twelve (12) inches above the bottom of the manhole.

c. Sanitary sewer pipes shall be four (4) inches minimum in diameter.
d. Slopes shall be as per section 5-2(b) of ODEQ Standard 252:656 for minimum slopes for different sizes of pipe to meet the required flow velocity.
e. Provide cleanouts or manholes as required by code. At a minimum, provide cleanouts or manholes every 100 feet and for all changes in direction greater than 45°. Provide manholes for all piping greater than 6 inches in diameter. Provide cleanouts at the connection between the building sanitary system and the site sanitary sewer.
f. Force mains are allowed only with prior approval from OSU.
g. Backwater valves
    a. Provide backwater valves for all force mains and in all other locations required by applicable code. Coordinate location of backwater valve with plumbing engineer. PVC backflow valves may be provided if approved by OSU.
h. Where existing piping is present and requires replacement in the same location, the engineer shall evaluate the applicability of pipe bursting for replacement of this piping. Where pipe bursting is recommended, the engineer shall coordinate with OSU and receive OSU approval.
i. Manhole shall be 48" ID concrete with concentric riser. Manhole must be marked appropriately as "Sanitary Sewer" or "Sanitary". Manholes cover shall be 24" ID cover frame of cast iron and traffic rated based on location (basis of design Neenah and East Jordan).

C. Products
a. Sanitary piping shall be one of:
    a. PVC: C900/C905, SDR 26, SDR 21 with bell and spigot joints
    b. Poly-pipe: DR-17
    c. Ductile iron (for below-foundation building entries only)
b. Flow troughs in manholes shall be installed and shall be precast unless otherwise approved by OSU.
c. Cleanouts shall consist of schedule 40 PVC with a 45 degree sweep double wye. Cleanout surface shall be at ground level with a water-tight seal. Cleanouts at the surface level shall be encased in a concrete ring and shall not be an obstruction to landscaping equipment.

D. Execution
a. Burial
    a. For gravity systems, use rock embedment. For pressurized systems, use sand embedment. Where rock embedment is required, use a six (6) inch bedding of #8 or one and one half (1 ½) inches washed crushed rock below, around, and above pipe.
    b. Compaction of aggregate backfill shall be in eight (8) inch lifts to a minimum of 95% Proctor criteria density or greater to finish grade under concrete and paved areas. Compaction of in situ materials shall be in eight (8) inch lifts to 85% Proctor criteria density or greater to finish grade under grass areas.
    c. Minimum cover from top of pipe: 30 inches – DEQ 252:626-5-4(b)(3).

b. Testing
    a. Provide a deflection test and a leakage test per ASTM standards.
c. Sewers (sanitary and storm) and sewer services shall cross at least 24 inches below (preferred) or above water lines. At the crossing, joints shall be as far as possible from the water line by centering the crossing section – DEQ 252:656-5-4(c)(2).

2-7. Storm Sewer – Site

The storm sewer system shall be designed per the requirements of the following section. Note that where specific manufacturers or products are indicated as "basis of design," the engineer's design shall include those products where applicable. Equals are allowed and shall be coordinated with OSU.

A. General requirements
    a. Permits
        a. Applicable permits shall be filed including required storm water drainage reports. The connection fee to the City of Stillwater is only valid on construction tying into city main directly. The engineer shall prepare permit paperwork and pay all associated fees.
B. Design
    a. Tie-ins to existing services
        a. The engineer shall verify existing system capacity before designing a tie-in to the existing utility. This shall include upstream and downstream connected loads.
    b. The storm system volume shall be designed for the 100-year storm event. The storm system shall include both building storm drainage and site drainage. Peak flow calculations of the 25, 50, and 100-year storm events shall be sent to OSU ES Utilities Engineering.
    c. The engineer shall evaluate the predeveloped conditions of the site and adjacent storm sewer system and compare these to the post developed conditions and make recommendations regarding detention to OSU.
    d. Slope piping a minimum of 0.5% per foot slope for pipes up to 24" in diameter. Storm system shall be designed to be non-pressurized flow.
    e. Discharge shall be per latest EPA and ODEQ requirements and in compliance with the City of Stillwater discharge permit.
    f. Roof leaders shall be tied into the storm system with appropriate cleanouts. Coordinate with OSU Landscaping for locations of cleanouts.
    g. The civil engineer shall determine the requirement for foundation or below-slab drainage systems and shall provide design flow rates to the plumbing engineer where such systems are required to be pumped to a point of discharge.
    h. The diameter of storm water pipe shall be minimum 12 inches, except single laterals less than 50 feet long which can be 8 inches in diameter.
    i. Storm water velocity: Minimum 3 FPS, Maximum 10 FPS.
    j. The storm water pipe shall have a minimum cover of 18 inches from the top of pipe.
C. Products
    a. Storm piping shall be one of:
        a. RCP pipe
        b. Schedule 40 PVC

c. HDPE (for sliplining)
d. Corrugated double-wall HDPE

b. Connections
a. RCP pipe: Bell and spigot
b. PVC: Bell and spigot
c. Corrugated double-wall HDPE: Bell and spigot
d. HDPE for sliplining: Butt welded

c. Manholes
a. The manhole shall be 48" minimum diameter.
b. Manholes covers shall be standard 24" ID cover frame of cast iron with a label corresponding to storm and traffic rated based on location.
c. Barrel sections shall be RCP. PVC is not allowed.

D. Execution
a. Burial
a. For gravity systems, use rock embedment. For pressurized systems, use sand embedment. Where rock embedment is required, use a six (6) inch bedding of #8 or one and one half (1 ½) inches washed crushed rock below, around, and above pipe.

Compaction of aggregate backfill shall be in eight (8) inch lifts to a minimum of 95% Proctor criteria density or greater to finish grade under concrete and paved areas. Compaction of *in situ* materials shall be in eight (8) inch lifts to 85% Proctor criteria density or greater to finish grade under grass areas.

2-8. Chilled Water – Distribution

The chilled water system shall be designed per the requirements of the following section. Note that where specific manufacturers or products are indicated as “basis of design,” the engineer’s design shall include those products where applicable. Except for meters, transmitters, and data loggers, equals are allowed and shall be coordinated with OSU.

A. Design
a. Connection to campus chilled water system
a. Refer to Appendix B for specific requirements of the chilled water building connection.
b. Isolation valves shall be installed at the building connection. Site utilities will pick up piping at five (5) feet outside the building. This connection shall not be located under any site features such as stairs, ADA ramps, planters, large vegetation, etc. If this is not possible due to the building conditions, piping shall be installed in sleeves. A minimum 25 feet of clearance downstream from the face of the building is needed to ensure maintenance and repairs tasks can be performed. The use of sleeves must be approved by OSU ES Utilities Engineering.
c. Coordinate with OSU for available pressure at the building.
d. Design temperatures
i. Chilled water supply is delivered from the plant at 40°F. The engineer shall coordinate with OSU regarding the expected chilled water supply temperature at the building connection.
ii. Design the building system to provide chilled water return at 52°F.

b. The engineer shall coordinate with OSU regarding additional design capacity required

beyond the base building load requirements. Where additional capacity is included, the capacity factor shall be clearly stated on drawings.

c. In east-west runs, the chilled water supply line shall be located to the south. In north-south runs, the chilled water supply line shall be located to the east.
d. Tee fittings are preferred to taps. Any taps shall be approved by OSU. At tees, isolation valves shall be provided on all three sides of the tee.
e. Provide an air release at all high points. Supply and return lines shall have their own independent air release. Air releases shall not be combined. The vent line shall be constructed of stainless steel with a ball valve located at the tap and a second ball valve 3" below grade, in a box rated for traffic use.
f. Metering
    a. Refer to Appendix G for meter sizing details.
    b. Meters shall be provided by OSU, installed by the contractor.
    c. Meters shall be located on the chilled water supply line inside building. No meters shall be installed outside. Meters shall have temperature sensors installed on supply and return lines to allow for energy usage calculation.
    d. Pressure and temperature wells required to be installed with the meter shall be located at a location downstream of the meter by the manufacturer-required distance of straight pipe for accurate readings.
    e. 3/4" taps shall be supplied on both supply and return lines for pressure and temperature. For temperature, a thermowell with ¾" NPT outer (process) and ½" NPSM inner connections shall be installed in the tap. The thermowell shall be of appropriate length to locate the temperature sensor in the center of the pipe.
g. All pipe joints shall be restrained using mechanical joint restraints.
h. No thrust restraints are allowed on HDPE pipe. Refer to the manufacturer's recommendations.

B. Products
a. Chilled water piping shall be one of:
    a. PVC C900/C905 with bell and spigot ends, DR18 minimum.
    b. Butt welded HDPE, DR11 minimum.
    c. Steel pipe (only to be used in tunnels and/or at building connections), schedule 40.
b. Fittings
    a. Steel pipe shall be welded with bolted and gasketed flanges at fittings.
    b. PVC pipe fittings shall be ductile iron, mechanical joint fittings.
    c. All fittings, restraints, and taps to be wrapped in polyethylene, and do not need to be insulated.
c. Insulation
    a. Chilled water supply lines shall be insulated as follows.
        i. All pipes 12" and below are to be insulated with a minimum two (2) inch thick polyurethane insulation.
        ii. Pipes 12" to 18": CWS is insulated, CWR uninsulated.
        iii. Pipes above 18": uninsulated.
    b. The engineer shall analyze the applicability of insulation on return chilled water return lines to determine if insulation should be applied. Coordinate with OSU for final approval.
    c. For direct burial chilled water steel piping, provide a pre-insulated piping system with two (2) inch thick foam insulation, with a PVC or HDPE outer jacket. Thermal Pipe

Systems Kool-Kore shall form the basis of design, minimum k factor of 0.16.

d. For chilled water in tunnels, provide two (2) inch thick mineral wool insulation with metal jacketing.

d. Direct bury valves shall be Pratt Groundhog butterfly valves as basis of design.

e. Air release

a. Provide a saddle tap on main line with 3/4" tap. Piping shall be 3/4" stainless steel, with ball valves installed at the saddle tap and at ground elevation inside the valve box.

b. The riser shall be six (6) inch PVC piping.

f. Mechanical joint restraints shall be EBAA Iron Megalug as basis of design.

C. Execution

a. Burial

a. In roadways or areas to be paved, fill the entire depth starting above sand layer with Type "A" aggregate base or flowable fill. Provide stone backfill above embedment material (sand or rock).

b. The engineer shall determine the required compaction criteria.

c. Install tracer wire on each CWS and CWR line, per tracer wire section in Appendix A.

d. When new chilled water lines (C900) are being tied to existing transite chilled water lines, provide gravel bedding at the tie-in (tee) plus 5 ft in all directions.

b. Testing

a. Chilled water pipe shall be pressure tested. Conduct pressure tests at 150% of the design pressure for two (2) hours. The test pressure shall not exceed the rated pressure of the piping system.

c. The engineer shall review pipe flushing requirements and provide specifications. Flushing shall be accomplished with domestic water. Chilled water shall not be used for system flushing.

d. Once the flushing is completed per specifications, all piping (building and outdoor piping up to isolation valves from mains) shall be filled with domestic water. OSU Facilities Management Energy Services Utilities Distribution is responsible for opening the isolation valves at the mains, to bring the building online.

2-9. Heating Water – Distribution

The heating water system shall be designed per the requirements of the following section. Note that where specific manufacturers or products are indicated as "basis of design," the engineer's design shall include those products where applicable. Except for meters, transmitters, and data loggers, equals are allowed and shall be coordinated with OSU.

A. Design

a. Connection to campus heating water system

a. Refer to Appendix B for specific requirements of the heating water building connection.

b. Heating water shall be provided via a water-to-water heat plate and frame exchanger unless otherwise directed by OSU. Tertiary pumps shall be provided and shall be sized to handle the pressure drop of the entire building-side heating water delivery system. The piping connections to the heat exchanger shall be flanged for 3" and above,

threaded below 3”.

c. Isolation valves shall be installed at the building connection. Site utilities will pick up piping at five (5) feet outside the building. This connection shall not be located under any site features such as stairs, ADA ramps, planters, large vegetation, etc. If this is not possible due to the building conditions, the piping shall be installed in sleeves. A minimum 25 feet of clearance downstream from the face of the building is needed to ensure maintenance and repairs tasks can be performed. The use of sleeves must be approved by OSU ES Utilities Engineering.

d. Coordinate with OSU for available pressure at the building.

e. Design temperatures

i. Heating water supply is delivered from the plant at 180°F.

ii. Design the building system to provide heating water return at 160°F.

b. The engineer shall coordinate with OSU regarding additional design capacity required beyond the base building load requirements. Where additional capacity is included, the capacity factor shall be clearly stated on drawings.

c. Mains and branch lines shall be designed at a max pressure drop of 3.3'/100' of pipe, not including a pipe fitting factor (4'/100’ of pipe with pipe fitting factor).

d. In east-west runs, the heating water return line shall be located to the north. In north- south runs, the heating water return line shall be located to the east.

e. Tee fittings are preferred to taps. Any taps shall be approved by OSU. At tees, isolation valves shall be provided on all three sides of the tee.

f. Provide an air release at all high points. Supply and return lines shall have their own independent air release. Air releases shall not be combined.

g. Metering

a. Refer to Appendix G for flow meter sizing details.

b. Meters shall be provided by OSU, and installed by the contractor.

c. Meters shall be located on the primary distribution side of the heat exchanger and shall be located inside the building. No meters shall be installed outside. Meters shall have temperature sensors installed on supply and return lines to allow for energy usage calculation.

d. Pressure and temperature wells required to be installed with the meter shall be located at a location downstream of the meter by the manufacturer-required distance of straight pipe for accurate readings.

e. 3/4" taps shall be supplied on both supply and return lines for pressure and temperature. For temperature, a 1/2" thermowell shall be installed in the tap. The thermowell shall be of appropriate length to locate the temperature sensor in the center of the pipe.

h. All pipe joints shall be restrained using mechanical joint restraints. Provide butt welded HDPE, mechanical joints at fittings.

i. Refer to manufacturer’s recommendations for thrust restraint on HDPE pipe.

B. Products

a. Heating water piping shall be one of:

a. Lines less than three (3) inches in diameter shall be Pre-insulated PEX-A with HDPE jacketing (Uponor EcoFlex as the basis of design).

b. Lines three (3) inches and larger shall be HDPE PERT piping (Performance pipe as the basis of design). Piping shall be pre-insulated with 2" foam insulation and have HDPE outer jacket.

b. Fittings
    a. Provide polyethylene mechanical joint adapters (with stiffener) when required. HDPE mechanical joint adapter shall be butt welded to HDPE piping, and joined to mechanical joint fitting using the mechanical joint adapter kit supplied by the HDPE manufacturer.
    b. For all-size piping, provide ductile iron mechanical joint fittings.
c. Direct bury valves shall be Pratt Groundhog butterfly valves as the basis of design.
d. Air release
    a. Provide a saddle tap on the main line with a ¾-inch tap. Piping shall be 3/4" stainless steel, with ball valves installed at the saddle tap and ground elevation inside the valve box.
e. Mechanical joint restraints shall be EBAA Iron Megalug as the basis of design.

C. Execution
a. Burial
    a. The minimum burial depth for heating water piping shall be 30 inches.
    b. Bedding shall be six (6) inches of sand below the pipe and six (6) inches of sand above the pipe. Backfill as required for minimal settlement. Bedding and backfill shall meet the manufacturer's installation recommendations.
    c. In roadways or areas to be paved, fill the entire depth starting above the sand layer with Type “A” aggregate base or flowable fill. Provide stone backfill above embedment material (sand or rock). Compact per the engineer's design recommendations.
b. Testing
    a. Pressure tests are required. Conduct pressure tests at 150% of the design pressure for two (2) hours. The test pressure shall not exceed the rated pressure of the piping system.
c. The engineer shall review pipe flushing requirements and provide specifications. Flushing shall be accomplished with domestic water. Heating water shall not be used for system flushing.

2-10. Steam and Steam Condensate – Distribution

The steam and steam condensate system shall be designed per the requirements of the following section. Note that where specific manufacturers or products are indicated as “basis of design,” the engineer’s design shall include those products where applicable. Except for meters, transmitters, and data loggers, equals are allowed and shall be coordinated with OSU.

A. Design
a. The campus steam distribution system operates at pressures up to 60 PSIG, saturated steam. Coordinate with OSU for steam pressure at each building.
b. Mains shall be designed at a velocity of 50-80 feet per second. Branch lines are allowed to operate at a velocity of up to 120 feet per second, unless they slope against the direction of steam flow. In such case, they should be designed for a maximum steam velocity of 50 feet per second at design load.
c. The service tap shall be a welded tee with isolation valves on all three legs of the tee. When possible, the service line shall come out of the top of the steam main. If this is not possible, the branch line is allowed to be tapped into the side of the main. Bottom

connections are not allowed unless otherwise approved by OSU. Service lines shall not be located under any site features such as stairs, ADA ramps, planters, large vegetation, etc. If this is not possible due to the building conditions, the piping shall be installed in sleeves. A minimum 25 feet of clearance downstream from the face of the building is needed to ensure maintenance and repairs tasks can be performed. The use of sleeves must be approved by OSU ES Utilities Engineering.

d. Drip legs
    a. A drip leg shall be located at the building entrance. The steam line serving the building shall come out of the top of the drip leg. On distribution mains, drip legs shall be installed every 150 feet.
    b. Drip legs shall be sized per industry standards. Drip leg diameter shall be the same as the mains diameter size for pipes up to 4" diameter, and half the diameter of the mains diameter for larger pipes (but not less than 4" diameter). The condensate trap shall be six (6) inches above the bottom. Condensate lines shall have a strainer, isolation valves, check valves, and an inverted bucket-type steam trap. The bottom of the drip leg shall have a ball valve to drain the dirt leg.
e. Pipes shall be sloped per standard steam best design practices and the requirements of code.
f. For branch lines tying into existing mains, branch line design shall consider expansion of main.
g. If lines are direct-buried, drip legs and expansion joints shall be installed in access vaults sized appropriately for maintenance purposes.
h. Anchors and anchor loads are to be designed by the engineer and included in design documents. The design of anchors shall not be delegated to the contractor.
i. Traps
    a. Provide steam traps at all drip legs along with steam mains.
    b. Distribution main steam traps shall be inverted bucket types with Armstrong as the basis of design.
j. Metering
    a. For meter selection, please contact OSU ES Utilities Engineering.
    b. Meters shall be provided by OSU, installed by the contractor.
    c. Locate condensate meters on the main return line. No meters shall be installed outside.
    d. The condensate meter shall be located downstream of the condensate pump. The condensate piping must be full for the meter to function properly. Therefore, if the meter is installed in a horizontal pipe, a drop shall be installed for meter installation.
    e. The steam meter shall be installed on the high-pressure side upstream of any building branch lines.
k. Steam bypass valves
    a. All steam shut-off valves shall have a 1" bypass for warm-up service.
    b. Bypass valves shall be globe type, bolted bonnet, full port, NPT.
    c. Piping shall be 1" schedule 80.
    d. Fittings to be threaded NPT. Use threadolets on mains. Provide a threaded (NPT) union downstream of the globe valve.

B. Products
a. Steam piping shall be the following:
    a. Schedule 40 steel pipes in tunnel
    b. Schedule 40 steel pipe, pre-insulated with aerogel insulation (or otherwise approved

by OSU Energy Services) and provided with HDPE outer jacket for direct-bury

b. Condensate piping shall be the following:
    a. Schedule 80 steel pipes in tunnel
    b. Schedule 80 steel pipe, pre-insulated with aerogel insulation (or otherwise approved by OSU Energy Services) and provided with HDPE outer jacket for direct-bury
c. Fittings
    a. Welded steel fittings
    b. For branch lines only: The use of steel piping with a slip joint (such as Thermal Pipe Systems' Super Temp-Tite® offering) may be considered. Contact Energy Services for details.
d. Insulation
    a. Steam and steam condensate piping located in tunnels shall be insulated with one of the following:
        i. Aerogel blanket insulation
        ii. Foam glass (space permitting)
    b. Direct bury steam and steam condensate will be pre-insulated as described above.
e. Jacketing
    a. If aerogel is used in tunnels, no jacketing is required.
    b. If foam glass is used in tunnels, metal jacketing shall be provided.
    c. For direct-bury piping, jacketing shall be pre-installed as described above.
f. Expansion joints on the distribution side shall be single or double slip type with ATS Thermal Pak as the basis of design.
g. Valves
    a. Steam and condensate valves in the tunnel shall be double offset, high-performance butterfly valves with basis of design as Bray/McCannalok. Steam valves shall be operable from the surface without requiring access to the tunnel.
    b. Direct-bury valves shall be double offset, high-performance butterfly valves rated for direct buried service. Provide means of operation from the surface.
    c. For condensate line 2" and below only, a full port ball valve with NPT connections can be used. It shall have a carbon steel body (no bronze) with stainless steel trim and a three piece design, such as Jamesbury Series 3. A union must be installed in line with the valve for future maintenance purposes.
h. Gaskets shall be spiral wound and shall be rated for the required pressure and temperature. Fiber gaskets are not allowed.
i. Flanges shall be rated for 150# minimum. Where higher pressures are present, the engineer shall specify flanges for a higher pressure rating as is necessary.

C. Execution
a. Pipe supports shall be anchored to the floor. Anchoring to the ceiling is not allowed. Anchors should sit on a concrete pedestal (six (6) inches in diameter and three (3) inches high) to keep the base of the anchor of the tunnel floor.
b. Burial
    a. The minimum burial depth for direct-bury steam and steam condensate piping shall be 30 inches.
    b. Bedding shall be six (6) inches sand below pipe, six (6) inches sand above the pipe and backfill as required for minimal settlement, and as per the manufacturer's recommendations.

2-11. Electrical – Distribution

The electrical distribution system shall be designed per the requirements of the following section. Note that where specific manufacturers or products are indicated as "basis of design," the engineer's design shall include those products where applicable. Except for switchgear, transformer, and meter, equals are allowed. Coordinate with OSU ES Utilities Engineering.

A. Design
   a. Distribution cable
      a. Standard cable sizes shall be 750kcmil, 500kcmil, #2 AWG, and 00AWG.
      b. New primary (distribution) cable should be sized to carry the intended load and shall not be designed to operate at more than 35% ampacity de-rated by NEC 310.60(C)(77).
      c. Branch circuit conductors should be sized to prevent a maximum voltage drop of 3 % and the maximum total for a combination of both branch circuit and feeder should not exceed 5% as per the NEC article 210.19(A).
   b. Conduit
      a. Refer to Appendix C for primary service conduit sizes. All 90-degree, 45-degree, and custom angles shall be five (5) feet in radius. Tight 90-degree turns are not allowed. Elbows shall be fiberglass with PVC couplings epoxied at the factory.
      b. Conduit fill shall not exceed 40% of the cross-sectional conduit internal area.
      c. Exterior primary (>1000V) conduits shall be concrete encased.
      d. All conduits exiting the vault shall be perpendicular to the vault face.
   c. Duct banks
      a. Refer to Appendix C for duct bank details.
      b. The duct bank slope shall be determined by the engineer. Local low points are discouraged.
   d. Refer to Appendix C for secondary duct bank and conduit requirements.
   e. Direct buried secondary duct.
      a. Coordinate with OSU ES for the approval of direct buried secondary ducts.
      b. bedding requirements- to be included
      c. Where OSU standard minimum cover requirement cannot be met, a concrete cover shall be installed over the ducts.
   f. Transformers and Switchgear
      a. Electrical transformers and switchgear shall be provided by OSU.
      b. Transformer and switchgear pads shall be provided by the contractor. Coordinate with OSU for details of pad construction requirements. Refer to the manufacturer's transformer size guide for additional coordination.
      c. Transformer shall be installed with five (5) feet (minimum) clearance on all sides, except the front which shall have ten (10) feet of clearance. Clearance shall be measured from the pad. When transformers are located near windows, doors, air intakes or exhaust louvers, ten (10) feet of clear space or a blast wall is required. If a blast wall is required, coordinate with the UA and OSU ES Utilities Engineering. Refer to code requirements. Coordinate with OSU ES for requirements of indoor transformer installation.
      d. PMH switchgear shall be installed with ten (10) feet (minimum) clearances on two operational sides and three (3) feet of clearances on other two sides. Clearance shall

be measured from the pad.

e. Vista switchgear shall be installed with five (5) feet (minimum) clearances on termination side, ten (10) feet of clearances on operational side (switching side), and three (3) feet of clearance on other two side. Clearance shall be measured from the pad.

g. Meter
   a. Electrical meters shall be provided by OSU and installed by OSU electrical distribution.
   b. The meter base and socket are to be provided by OSU and installed by the contractor.
   c. The electric meter shall be located outside the building adjacent to the transformer and equipped with a 4G LTE™ wireless cellular modem, unless there is newer technology available. Cellular technology lower than 4G LTE will not be accepted.
   d. Single point metering is required.
   e. Refer to Appendix D for meter installation details.

h. Minimum cover from surface grade to the top of the duct bank shall be 36".

i. Provide one (1) foot of gravel over sand under switchgear and transformer pads.

j. Vaults
   a. Provide and install one (1) GFCI 3" below disconnect.
   b. Provide and install one (1) 20A non-GFCI twist-lock outlet and one (1) industrial-grade GFCI in a separate weather-resistant box, adjacent to the twist lock outlet for the sump pump. The outlets shall be located as high on the wall above the sump pump as possible.
   c. The sump pump piping shall discharge to storm drain or to a location otherwise approved by OSU. Provide a check valve and isolation valve on the discharge of the sump pump per code.
   d. Neck ring extensions shall be no more than three (3) feet. Cover and neck ring installation shall be watertight. Cover shall be EJ H20 composite manhole cover.

k. The engineer shall include language in specifications requiring the installing contractor to perform a coordination/OCP/Arc Flash study. The study shall be generated in SKM (no equals) and a functioning copy of the one-line drawing with the equipment library shall be delivered to the OSU Energy Services Utility Engineering. A .pdf of the study results shall also be delivered to the OSU Energy Services Utility Engineering and included in the close out documents.

l. Electrical enclosure box

An electrical enclosure box shall be installed for non-roadway applications such as driveways, sidewalks, and green areas.

B. Products

a. Primary cable shall be Southwire 1/C CU 15KV 220 NL-EPR 133% TS SIMpull® PVC MV-105 as basis of design.

b. Conduits
   a. Schedule 40 PVC conduits shall be used in duct banks and below grade applications.
   b. SDR 11 PE conduits shall be used in bored-in applications.
   c. All conduits in vaults, manholes, and at equipment pads shall be terminated with end bells installed flush with the finished surface.

c. Switchgear
   a. Switchgear shall be S&C Vista and shall be furnished by OSU. Switchgear shall be installed by the contractor.

b. PMH switchgear will be allowed in like for like replacements or on a case by case basis.

c. Switchgear fuses shall be the standard OEM version for the type of switch being installed.

d. Refer to Appendix F for switchgear details.

d. Transformers

a. Primary service transformer shall be pad-mount Cooper Envirotran VFI, furnished by OSU and installed by the contractor.

b. Refer to Appendix F for transformers details.

e. Meter

a. The electric meter shall be Electro Industries Shark 270, Part number: Shark-270-9S-60-20-V5-S-X-4GLTE-X, furnished and installed by OSU. The meter base and socket are furnished by OSU and installed by the contractor. The socket is a pre-wired 9S, 13 Jaw.

b. OSU standard meter socket part number is 1006194A custom built by Durham.

c. Refer to Appendix D for meter installation details.

f. Duct banks

a. Solomon Apple Red (basis of design) dye shall be wet applied liberally to top of duct bank when wet.

b. Tracer wire in duct banks shall be red Copperhead 12AWG high strength with Snakepit Termination box system as basis of design.

c. Refer to Appendix C for duct bank details.

d. Joint sealant shall be asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade. ConSeal CS-102 shall be the basis of design.

g. Vaults

a. Vaults shall be twelve (12) feet Octagonal OSU custom 4-way vault with sump pit and ground rod coupling - Oldcastle Precast of Mansfield, TX as basis of design.

b. Vaults dewatering sump pumps shall be by Little Giant as basis of design (6EC-CIA-SFS series, 115 volt with integral snap action float #506804 and 20 foot cord). Vault sump pump discharge piping shall be 1 ½" in diameter.

c. Vaults shall contain a Louisville Ladder fiberglass 375# rated ladder # FE89XX (XX = length) as basis of design.

d. Vault manhole covers shall be EJ composite 36" H-20 rated with "ELECTRIC" embossed.

e. Vault pulling irons shall be provided as part of the manufactured vault.

f. Refer to Appendix I for Underground Electrical Vault

h. Primary cable splices shall be made with Tyco Raychem Heat Shrink as basis of design. The contractor shall be trained on performing medium voltage cable splicing and possessed the Raychem (TE) certification prior to work.

i. Insulated connector products for MV cables.

a. Cooper Power series shall be used as basis of design for elbows, tees, and other insulated connectors.

b. Cable termination shall be made using Cooper Power 600A Deadbreak (Deadbreak: B T 6 2 5 ? ? ? ? C 1 (???? = cable range code & compression conductor code)) and

200A Loadbreak (Loadbreak: LE215 ? ? ? ? (???? = cable range code & conductor code)).

c. All the connectors shall be installed correctly using recommended tools and according to the manufacturer's instruction sheet that provided with each kit.

d. All connections with stated torque values shall be tightened as specified by the manufacturer.

e. OSU ES shall check and approve the installed torque values for each termination prior to energizing.

j. Electrical enclosure box.

a. For lighting and small circuitry applications, a small unit Quazite® box PC1212BA12 shall be used with a heavy-duty cover PC1212HA17

b. For large circuitry applications, a Quazite box PG2436BA24 shall be used with a heavy-duty cover PG2436HA17.

C. Execution

a. The maximum pull distance and maximum change in direction shall be determined by the engineer and shall be in conformance with code and cable manufacturer's requirements and be approved by OSU ES Utilities Engineering.

b. Testing and acceptance criteria

a. The duct bank shall be inspected and surveyed by OSU ES Utilities Engineering prior to backfilling.

b. Conduits shall be cleaned with a mandrel until all foreign objects are removed prior to pulling cable. Install pull string in all conduits after cleaning.

c. Provide tracer wire continuity test. Tracer wire continuity test shall be conducted by OSU ES.

d. Conduct VLF testing to 20KV with a 30-minute hold on each cable.

e. All test results shall be provided to OSU ES Utilities Engineering for review and acceptance.

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Section 3: Plumbing Guidelines

3-1. Introduction

The following section includes OSU Engineering Guidelines related to plumbing and other associated topics. The engineer should review this section and the rest of these Engineering Guidelines prior to beginning design.

A. Table of contents

B. Abbreviations
   a. AFF – Above finished floor
   b. ANSI – American National Standards Institute
   c. ASME – American Society of Mechanical Engineers
   d. ASSE – American Society of Sanitary Engineers
   e. AWWA – American Water Works Association
   f. BAS – Building automation system
   g. BFP – Backflow preventer
   h. CWI – Certified Welding Inspector
   i. DDC – Direct digital control
   j. DEQ – Department of Environmental Quality
   k. EPA – Environmental Protection Agency
   l. GFCI – Ground-fault circuit interrupter
   m. GPF – Gallons per flush
   n. GPM – Gallons per minute
   o. IECC – International Energy Conservation Code
   p. IFGC – International Fuel Gas Code
   q. NFGC – National Fuel Gas Code
   r. NFPA – National Fire Protection Association
   s. PE – Polyethylene
   t. PEX-A – Cross-linked polyethylene
   u. PP-R – Polypropylene-random
   v. PSIG – Pounds per square inch, gauge
   w. PRV – Pressure relief valve
   x. TMV – Thermostatic Mixing Valve
   y. UA – University Architect
   z. WG – Water column, gauge

C. Referenced Standards and Guidelines
   a. ANSI Z358.1 – American National Standard for Emergency Eyewash and Shower Equipment
   b. ASHRAE Standard 188 – Legionellosis: Risk Management for Building Water Systems
   c. ASME 13.1 – Standard for the Identification of Pipes
   d. ASSE 1016 – Performance Requirements for Automatic Compensating Valves for Individual Showers and Tub/Shower Combinations
   e. ASSE 1017 – Performance Requirements for Temperature Actuated Mixing Valves for Hot Water Distribution Systems
   f. ASSE 1069 – Automatic Temperature Control Mixing Valves
   g. ASSE 1070 – Performance Requirements for Water Temperature Limiting Devices
   h. ASSE 1071 – Performance Requirements for Temperature Actuated Mixing Valves for Plumbed Emergency Equipment
   i. AWWA C651 – Disinfecting Water Mains
   j. AWWA C652 – Disinfection of Water-Storage Facilities
   k. EPA WaterSense
   l. IECC – International Energy Conservation Code
   m. IFGC – International Fuel Gas Code
   n. IPC – International Plumbing Code
   o. Kaiser Compressors Compressed Air System Guide
   p. NFGC – National Fuel Gas Code
   q. NFPA 37 – Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
   r. NFPA 99 – Health Care Facilities Code
   s. OSU EHS Fire Sprinkler System Standard
   t. Reduction of Lead in Drinking Water Act
   u. UL 2200 – Standard for Stationary Engine Generator Assemblies

3-2. General Plumbing Requirements

The following general design requirements shall be incorporated into the plumbing design. These guidelines are not all inclusive. The engineer is required to understand both the content of these guidelines and the specific requirements of the project. Furthermore, the engineer shall read the entirety of these guidelines.

A. General design requirements
   a. Scope
      a. These plumbing guidelines shall apply to all plumbing systems inside the building and to within five (5) feet of the building. All plumbing outside of five (5) feet from the building shall comply with Section 2: Site Utilities.
   b. Safety
      a. The engineer shall design the system to prevent exposing occupants to legionella.
      b. For all potable systems, all components of the potable water system shall meet the requirements of code including all lead-free requirements as defined in the Reduction of Lead in Drinking Water Act.
   c. Water conservation requirements
      a. Waterless urinals are not allowed.

b. Non-emergency plumbing fixture water flow rates shall be per EPA WaterSense and as follows for specific fixtures:
    i. Hand sinks and lavatories: 0.5 GPM
    ii. Urinals: 0.125 GPF
    iii. Water Closets: 1.28 GPF
    iv. Shower heads: 2 GPM

d. Calculations
    a. The engineer shall perform all necessary plumbing calculations.
    b. Plumbing calculations shall be performed per the requirements of applicable code.

e. Multi-discipline coordination
    a. Civil engineering
        i. Plumbing piping requiring interface with site utilities shall terminate five (5) feet outside the exterior walls of the building.
        ii. Coordinate with the civil engineer for the interface between building piping and site utilities.
        iii. The plumbing engineer shall clearly indicate the expected sanitary sewer invert at the building exit for all below-grade gravity piping systems.
    b. Electrical engineering
        i. Coordinate the power required for all equipment requiring electrical service with the electrical engineer.
        ii. Coordination shall include but not be limited to: disconnects (supplied with equipment or supplied by the electrical contractor), equipment voltage and phase, coordination of piping location and the location of electrical panels (do not route plumbing piping over electrical panels and equipment), and where water coolers are located (GFCI receptacles are required for each water cooler).
    c. Structural engineering
        i. Coordinate all equipment weights with the structural engineer.
        ii. Provide the location and sizing for required housekeeping pads to structural for detail and dimensioning. Note that a six (6) inch tall housekeeping pad is required for each piece of floor-mounted equipment.
        iii. Coordinate piping penetrations with the structural engineer in all structural elements including structural walls, sleeves through foundations, and structural slabs.
    d. Architectural
        i. Coordinate with the UA for all visible elements of the plumbing system.

f. Valves
    a. Valves shall be accessible.
    b. Valves in mechanical rooms over seven (7) feet AFF shall be supplied with chain operators.
    c. Provide all valves as required by code including but not limited to code-required PRVs, backwater valves, BFPs, and check valves on sump pump discharge lines.

g. Cleanouts
    a. Provide cleanouts where required by code in drainage piping. At minimum, cleanouts shall be provided as follows:
        i. At the base of each riser.
        ii. Two-way cleanouts at all building exits and entries.

iii. Each 50 feet (maximum).
iv. Floor cleanouts are required at the end of each run and at changes in direction greater than 45° unless otherwise approved by OSU.
v. At each bank of water closets and/or urinals.
vi. At sinks and drinking fountains.

b. Cleanouts shall be sized and located per code and shall be positioned above the flow line to prevent backflow upon opening. Locate floor cleanouts in inconspicuous locations and coordinate all floor cleanouts visible to the occupants with the UA.

h. Controls
a. Where equipment monitoring and controls are required, connect the equipment to the BAS via BACnet protocol.
b. Refer to Section 4: Mechanical Engineering Guidelines for detailed BAS requirements.

B. General products requirements
a. Piping
a. The engineer shall specify the temperature and pressure rating of piping, piping joints, valves, and fittings for the intended service for each piping system.
b. Where piping, including drain piping, is exposed to fluid exceeding the temperature rating of plastic piping (including where the drainage system receives intermittent or emergency discharges of high-temperature fluids from pressure relief devices, steam blow off valves, etc.), the piping material shall be rated for the highest possible fluid temperature.
c. Piping shall be provided in readily-available sizes. Five (5) inch diameter piping is not allowed unless otherwise approved by OSU.

b. Valves
a. Isolation valves shall be full-port ball valves up to two and one half (2 ½) inches in diameter.
b. Isolation valves shall be butterfly valves for valves three (3) inches in diameter and greater.
c. Provide valve stem extensions where valves are insulated to provide easy operation of the insulated valve.

C. General execution requirements
a. Piping installation
a. Piping shall be installed parallel and perpendicular to building elements and other piping, and ductwork where piping is exposed to view.
b. Provide dielectric unions at all dissimilar piping connections including at all galvanized piping dissimilar connections.
c. Provide marker wire for all underground piping including steel piping. Marker wire shall be located above the pipe. Provide warning tape. Refer to Section 2: Site Utilities and coordination with the civil engineer.

b. Identification and labeling
a. Symbols and abbreviations on the drawings shall be consistent with the drawing legend.
b. All equipment, piping, valves, ductwork, and all other components shall be labeled using permanent tags and labels with non-fading letters. Labeling shall be per ASME 13.1 and NFPA 99.

c. Identification of plumbing equipment and piping shall be as per standard engineering practice and shall be consistent with existing identification systems on campus.
d. Pipes shall be labeled every 5 feet (minimum) and a minimum of one (1) label shall be visible in each room where the pipe is located.
e. The following abbreviations shall be used for plumbing systems and fixtures:
    i. DCW – Domestic cold water
    ii. DHW 120F – Domestic hot water, 120°F
    iii. DHW 140F – Domestic hot water, 140°F
    iv. DHWR – Domestic hot water return
    v. DI – Deionized water
    vi. TW – Tempered water
    vii. X LB CW – High pressure water of X PSIG
    viii. CA – Compressed air
    ix. VAC – Vacuum
    x. NG – Natural gas
    xi. SS – Sanitary sewer
    xii. PD – Pumped drain
    xiii. V – Vent
    xiv. SD – Storm drain
    xv. LW – Lab waste
    xvi. PRD – Primary roof drain
    xvii. ORD – Overflow roof drain
    xviii. CD – Condensate drain
    xix. PCD – Pumped condensate drain
    xx. Where piping systems are not listed above, coordinate with OSU for the required labeling.
f. Valves
    i. The engineer shall provide a valve legend on the drawings.
    ii. Label system-level valves per the usage.
    iii. Provide valve tags with permanent, non-fading lettering.

c. For renovations, values for tags shall be incremented based on existing equipment tags. The engineer shall contact OSU for equipment tagging requirements. The following convention shall be used for new equipment tags:
    a. "Type Acronym"-"Incremental #" (e.g. Circulating pump, first unit: CP-1).

3-3. Plumbing Fixtures

Plumbing fixtures shall meet the following requirements. Note that where specific manufacturers or products are indicated as “basis of design,” the engineer’s design shall include those products where applicable. Equals are allowed and shall be coordinated with OSU.

A. Basis of design manufacturers
    a. The engineer shall include one of the following manufacturers as the basis of design for the following equipment. Where equipment is not listed below, the engineer shall coordinate with OSU regarding the basis of design equipment manufacturer.
    b. Typical plumbing fixtures such water closets, urinals, lavatories, etc.
        a. American Standard

b. Elkay
c. Kohler
d. Toto
e. Zurn

c. Electric water coolers
a. Elkay (preferred)
b. Halsey Taylor
c. Oasis

d. Trim including faucets and thermostatic mixing valves, etc.
a. American Standard
b. Chicago
c. Delta
d. Kohler
e. Sloan
f. Symmons
g. T&S
h. Toto
i. Watts
j. Wolverine

e. Emergency fixtures
a. Acorn
b. Bradley
c. Guardian
d. Legend

f. Plumbing fixture carriers
a. American Standard
b. Josam
c. Kohler
d. Toto
e. Wade
f. Zurn

g. Drains
a. Jay R Smith
b. Josam
c. Mifab
d. Sioux Chief
e. Zurn

h. Freeze proof wall hydrants and hose bibbs
a. Woodford
b. Zurn

B. General fixture requirements
a. Typical plumbing fixtures
a. In new construction, non-residential lavatories, urinals, and water closets shall be wall hung. Coordinate with the UA for the specific fixture and trim types.
b. Where sensor-operated battery-powered flush valves and faucets are used, provide self-generating type battery charging.
c. Flush valves

i. For water closets and urinals, flush valves shall be supplied rather than flush tanks unless otherwise approved by OSU.
ii. Flush valves shall be sensor-operated and battery-powered.

d. Faucets
i. Faucet types shall be coordinated with the UA.
ii. Faucets shall be manually operated unless otherwise approved by OSU.

b. Electric water coolers
a. Electric water coolers must accept a standard Elkay filter cartridge.
b. One water bottle refill station shall be provided per floor or wing and water bottle refill stations must include a filter and a filter status light.

c. Emergency fixtures
a. Provide local pull station notification.
b. The engineer shall coordinate the type of emergency fixtures with OSU.
c. No drains shall be provided below emergency showers and fixtures.

3-4. Plumbing Equipment and Accessories

Plumbing equipment shall meet the following requirements. Note that where specific manufacturers or products are indicated as "basis of design," the engineer's design shall include those products where applicable. Equals are allowed and shall be coordinated with OSU.

A. Basis of design manufacturers
a. The engineer shall include one of the following manufacturers as the basis of design for the following equipment. For specification purposes, other approved manufacturers shall be coordinated with OSU. Where equipment is not listed below, the engineer shall coordinate with OSU regarding the basis of design equipment manufacturer.
b. Domestic hot water equipment
a. Steam to hot water heat exchangers shall be Armstrong as basis of design and shall be provided with digital mixing valves. Steam to hot water heat exchangers shall be pre-piped for addition of a second tube bundle.
c. Circulating pumps
a. Aurora
b. Grundfos
c. Taco
d. Air compressors
a. Quincy
e. Backflow preventers
a. Watts
b. Zurn
f. TMVs
a. Acorn
b. Leonard
c. Symmons
d. Watts
g. Water hammer arrestors
a. Sioux Chief
b. Watts

B. Domestic hot water equipment requirements
   a. Natural gas-fired equipment
      a. Provide combustion air and makeup air as required by the manufacturer and per code.
      b. Equipment flues shall be of a material meeting the manufacturer's requirements and the requirements of code.
   b. Pressure vessels
      a. All pressure vessels shall have an ASME rating and stamp.
   c. Heat trace
      a. Where heat trace is used, self-regulating heat trace is required.
      b. Provide waterproof heat trace where required.
      c. Coordinate heat trace electrical requirements with the electrical engineer.
   d. Water heaters and tanks
      a. Water heaters and tanks shall be inspected by the Oklahoma Department of Labor per code.
      b. Bottom-feed heaters and tanks shall have a vacuum breaker.
      c. Where leaks would be damaging to surrounding equipment, provide a galvanized steel drain pan no less than 1 ½ inches deep, with drain piping and termination of the same material as the pressure relief piping. The engineer shall verify moisture sensing and DDC alarm requirements.
   e. Tankless water heaters
      a. The engineer shall calculate the highest hot water GPM demand and verify the specified tankless water heater can deliver the correct GPM at the desired temperature rise using wintertime ground water temperature as the entering water temperature.
      b. Tankless gas-fired water heater heat exchangers shall be of stainless steel construction.
      c. Electric tankless water heaters shall only be used where specifically approved by OSU.
      d. For electric point of use tankless water heaters serving single lavatories or sinks, confirm the faucet aerator GPM matches the water heater GPM at the desired temperature rise. Do not oversize these heaters. Scald protection via ASSE 1070 temperature limiting devices shall be provided whether integral or external to the water heater.
   f. Combustion air and venting
      a. For natural gas-fired water heating equipment, the preferred method of combustion air intake and vent is direct vent. Coordinate any visible combustion air and vent terminations on the exterior of the building with the UA. The engineer should consider concentric venting to limit building envelope penetrations.
      b. If openings to the exterior are used in lieu of direct venting to provide indirect combustion air, interlock a motorized damper or supply fan with the equipment burner. Make provision for domestic cold water piping, fire protection piping, and other elements subject to freezing from freezing while the combustion air intake is in operation.
   g. Expansion tanks
      a. Provide and size expansion tanks per code.
      b. Bladder type expansion tanks are required.

C. Pump requirements

a. Circulating pumps
    a. Provide on-board variable speed control.
    b. For domestic hot water return circulator pumps, provide thermostatic control for limiting pump power consumption.
b. Sewage ejectors and sump pumps
    a. Provide float systems for operation of pump(s) with relays for alarm connection to the BAS.

D. Accessories requirements
a. TMVs
    a. TMVs shall be listed and labeled to all applicable ASSE standards, as required by code, including the following:
        i. Showers and tub/shower combinations – ASSE 1016
        ii. Temperature actuated mixing valves for hot water systems – ASSE 1017
        iii. Fixtures served with a pre-set temperature through a single pipe supply – ASSE 1069
        iv. Lavatories and hand sinks – ASSE 1070
        v. Emergency fixtures – ASSE 1071
    b. Strainers
        i. Provide Y-pattern strainers for water systems or as required by the manufacturer's installation requirements

E. General installation requirements
a. Equipment shall be accessible.
b. Maintain the manufacturer's recommended clearances.
c. Maintain 36 inches clear in front of all electrical connections per code.
d. Where equipment, valves, or accessories are mounted in inaccessible areas, provide access panels and coordinate with the UA.

3-5. Domestic Water

Domestic water systems shall meet the following requirements.

A. Design
a. Domestic cold water
    a. Provide irrigation stub outs, isolation valves, and backflow preventers. Coordinate with OSU and the UA for the location of these irrigation stub outs.
    b. Provide hose bibbs or freeze-proof wall hydrants on the exterior of new buildings at a spacing of 100 feet maximum.
    c. On roofs, provide roof hydrants located not more than 50 feet from roof-mounted equipment.
    d. Booster pumps
        i. Coordinate with OSU utilities to determine the water pressure at the building. Provide booster pumps as necessary.
        ii. Where required, a flow test shall be provided by the engineer.
        iii. The booster pump system shall be sized for the minimum of minimum per code, minimum code-required pressure to safety fixtures; and manufacturer's required minimum pressure for flush valve fixtures.
        iv. Specific booster pump requirements shall be determined on a case-by-case basis

with OSU. The preferred booster pump configuration is duplex with each pump sized at 100% of the load, skid mounted, with a manual bypass.

e. Water softeners
    i. The engineer shall coordinate with OSU for water softening requirements.

b. Domestic hot water and hot water return
    a. Hot water generation
        i. Where steam from the central plant is available, the use of a steam to hot water heat exchanger is the preferred method of generating hot water; or where hot water is available from the central plant, a water-to-water heat exchanger may be used. Variations shall be coordinated and pre-approved by OSU.
        ii. Coordinate hot water storage requirements with OSU.
        iii. Where on-demand systems are applied, connect such systems to the BAS.
    b. Delivery temperature
        i. Coordinate with OSU regarding where 140°F hot water is required. Typically, provide 140°F water for kitchens only.
        ii. Kitchen hand sinks shall be provided with code-compliant temperature limiting devices to limit the discharge to 120°F.
        iii. Mop service sinks and all other domestic fixtures shall be provided with 120°F hot water.
    c. Domestic hot water return configuration
        i. Provide thermostatic hot water mixing valve control.
        ii. One (1) thermostatic hot water mixing valve shall be provided for each group of fixtures as determined by the engineer. The thermostatic hot water mixing valves shall be set at the desired loop circulation temperature.
        iii. The DWHR circulation pump shall be capable of modulating its speed automatically based on the system demand to save pump energy.
    d. Alarms
        i. High temperature alarms shall be provided at the BAS for all equipment capable of producing hot water at temperatures of 140°F or greater.

c. Tepid water
    a. Tepid water shall be provided to emergency plumbing fixtures.
    b. Tepid water flow and pressure shall be per applicable codes and manufacturer's requirements including but not limited to ANSI Z358.1.

d. Legionellosis
    a. The engineer shall design the domestic water system to meet the requirements of ASHRAE Standard 188 – Risk Management for Building Water Systems.
    b. Domestic hot water shall be stored at 140°F minimum.

e. Piping
    a. Provide air vents as necessary to remove air from system and prevent air locks. Provide automatic air vents in the mechanical room. Provide manual air vents elsewhere. Pipe the discharge of air vents to the nearest floor drain in the mechanical room or janitor’s closet where feasible. Provide a normally-open full-port ball valve in the air vent piping.
    b. Pressure relief piping shall be indirectly connected to the building drain in a visible location and shall discharge to a piping system rated for the temperature of the relief discharge. The pressure relief piping discharge piping shall route as directly to the drain as possible.

c. Drainability
    i. The entire domestic water system shall be drainable. Slope the system to a location with a hose-end drain valve and a floor sink or mop sink nearby.
    ii. Provide accessible hose-end drains at the base of each domestic water riser.
d. Expansion loops
    i. The engineer shall calculate the long run expansion and provide expansion loops as required by these calculations and at areas indicated by structural for building expansion joints.
    ii. Flexible expansion loops are not allowed.

f. Freeze protection
    a. Avoid locating water piping in unheated areas or other spaces subject to freezing. Where this is unavoidable, and where approved by OSU, provide heat trace to prevent system freezing.

g. Valves and accessories
    a. Isolation
        i. Provide isolation valves to isolate each main branch, each floor, each minor branch, each group of fixtures, and at each hot water return as a minimum, and provide isolation where required for specific requirements of the building domestic water system functions.
        ii. Isolation valves shall be accessible.
    b. Gate valves are not allowed.
    c. Provide valved wall boxes for service to the following fixtures
        i. Clothes washers
        ii. Dishwashers
        iii. Ice machines
        iv. Refrigerators
        v. Coffee makers
    d. Backflow preventers
        i. Provide backflow prevention as required by code including in all water lines serving faucets with hose-ended connections.
        ii. Backflow preventers shall be accessible for inspection and maintenance.
        iii. Where backflow preventers include a drain line, route the drain line to the nearest floor drain and connect the drain to the drainage system using an indirect connection.
    e. TMVs
        i. Manual master mixing valves are preferred for hot water distribution systems.
        ii. Provide point of use TMVs for each lavatory or gang of lavatories.
        iii. Provide TMVs meeting the requirements of ANSI Z358.1 and ASSE 1071 at each safety shower or eye wash unless a tempered water system for the use of serving emergency fixtures is available.
        iv. The engineer shall determine the minimum expected flow rates for each TMV and confirm that the TMV is rated at that minimum flow.
    f. Water hammer arrestors
        i. Provide water hammer arrestors where water hammer may occur, including in makeup lines to cooling towers and other evaporative mechanical equipment.
        ii. Provide threaded ends for maintenance removal of water hammer arrestors.

iii. Where possible, locate water hammer arrestors to serve multiple fixtures.

B. Products
   a. Piping
      a. Domestic water piping shall be one of:
         i. Copper piping
         ii. PEX-A (allowed on a case-by-case basis)
         iii. PP-R piping is not allowed
      b. Pressure relief piping shall be of code compliant material.
   b. Piping insulation
      a. Provide fiberglass pipe insulation
      b. Thickness shall be as follows:
         i. 1 inch for DCW piping
         ii. 1 ½ inches for DHW and DHWR piping
         iii. Or as per the requirements of the latest OSU adopted version of IECC and as required for condensate control.

C. Execution
   a. Flushing and disinfection
      a. Thoroughly flush and remove foreign material from the entire domestic water system.
      b. Disinfect the entire domestic water system including water mains per AWWA C651 or AWWA C652 standards and per code for public drinking water.
   b. Testing
      a. Domestic water systems shall be tested at the greater of 100 PSIG and 150% of the working pressure without exceeding the pressure rating of the piping system.

3-6. Compressed Air

Compressed air systems shall meet the following requirements.

A. General requirements
   a. Refer to the Kaiser Compressors Compressed Air System Guide for additional design considerations.

B. Design
   a. System layout
      a. Consider looped mains to allow more uniform air distribution and to equalize pressure in piping.
      b. For large compressed air systems, provide sectionalizing valves to allow maintenance on portions of the system without shutting down the entire system.
   b. Pressure drop calculations
      a. The maximum system pressure drop shall be two (2) PSIG.
   c. Noise and vibration
      a. Acoustical considerations shall be considered when locating air compressors. Provide intake silencers, when necessary, to meet the required noise criteria.
      b. Vibration isolation shall be provided for the compressor with connecting piping isolated from the building structure.
   d. Condensate
      a. Condensate drains shall be provided for all compressors, receivers and air dryers.
      b. Condensate piping shall be indirectly connected to the sanitary sewer system and

condensate treatment shall be provided to avoid sanitary piping system corrosion.

e. Air compressors
    a. Indicate the compressor start and stop points on the design drawings and provide an adequate differential between start and stop points to prevent short-cycling of the compressor.
    b. Coordinate where connection of the compressor to the BAS is required with OSU.
f. Air dryers, filers, lubricators, and other compressed air components shall be provided where required by OSU for the end user application.

C. Products
    a. Compressed air piping shall be one of:
        a. Copper
        b. Black steel
        c. Stainless steel

3-7. Specialty Piping

Specialty piping systems shall comply with the following requirements.

A. Design
    a. Vacuum pumps for laboratories shall be coordinated with the end user requirements.
    b. Coordinate with OSU and the end-user for process water system requirements.
B. Products
    a. Vacuum piping for laboratory equipment shall be as per the requirements of code.
    b. Medical gas piping for health and veterinary buildings shall be as per the requirements of code.

3-8. Natural Gas

Natural gas systems downstream of the building gas meter shall comply with the following requirements. Refer to Section 2: Site Utilities for requirements of natural gas piping upstream of and including the gas meter.

A. Design
    a. Pressure
        a. Coordinate with OSU to determine the available gas pressure at the meter.
        b. Low and high pressures as referenced herein shall be as per the definitions found in the International Fuel Gas Code.
        c. Gas pressure shall be regulated to operate at low pressure (less than one (1) PSIG) inside the building except in mechanical rooms or where approved by OSU. Refer to code requirements for indoor high pressure natural gas.
    b. Building entry
        a. Provide exterior, accessible isolation valves at the gas entry to the building per code.
    c. Equipment connection
        a. At each connection between the natural gas system and gas-fired equipment, provide a gas regulator if the pressure of the natural gas system exceeds the required pressure of the gas-fired equipment. Regulators located indoors shall be vented to the exterior per code.
        b. At the connection of natural gas to the serve equipment, provide an isolation valve,

union, and dirt leg. Isolation valves shall be accessible.
    c. Automatic shut-off valves shall be listed for the application and shall be accessible.
    d. Provide quick connects or similar for kitchen equipment per code.
  d. Generators
    a. Natural gas service to gas-fired generators and all associated installation and operation shall meet the requirements of NFPA 37 and UL 2200 and all other applicable codes.
  e. Below-grade piping. All below-grade piping work shall be performed by OSU ES.

B. Products
  a. Piping
    a. Above-grade piping shall be black steel, schedule 40 with screwed or welded joints.
      i. Exposed above-grade piping shall be painted. Coordinate paint color with OSU and the UA.
    b. Below-grade piping shall be gas-rated PE pipe with fusion joints.
    c. Where natural gas located is in a return air plenum, provide welded joints.

C. Execution
  a. Gas piping shall not be placed in an inaccessible area per the requirements of IFGC.
  b. Testing
    a. Test the natural gas system per the requirements of the IFGC.
    b. The system test pressure shall be the greater of three (3) PSIG and 150% of the working pressure. The test pressure shall not exceed piping system pressure rating.
  c. Inspection
    a. All underground pipe work shall be performed by OSU ES.
    b. Where piping is found to be damaged or defective, damaged, or defective piping shall be replaced prior to being put in service.
  d. Permits and certifications
    a. Welders shall have the required permits
    b. Welder's certification papers and welding procedures shall be submitted for review during the project submittal process.

3-9. Drain, Waste, and Vent

Drain, waste, and vent systems shall comply with the following requirements.

A. Design
  a. Below grade drainage piping shall be not less than four (4) inches in diameter.
  b. Sanitary sewer
    a. Sanitary sewer is not required to be insulated except where above-grade sanitary sewer piping receives the discharge of ice makers, water coolers, condensate drains, and other discharges colder than incoming domestic cold water temperature and cold enough to form condensate on the sanitary piping. Where sanitary sewer requires insulation, insulate the first ten (10) feet past the point of connection with the cold-water source.
    b. Floor drains shall be provided in all areas prone to spilling, overflow, and leaking, including in all restrooms unless otherwise directed by OSU and the UA. Provision shall be made to prevent water from entering other areas of building upon a leak. All mechanical rooms shall be provided with recessed floor drains, six (6) inch curbs for all floor-mounted equipment, and water-proof flooring. Additionally, provide floor

drains in all basement areas prone to overflow or water leakage and pipe these floor drains to the basement sump system.

c. Provide overflow alarms at the BAS in mechanical rooms and basements.

c. Storm drain
   a. Insulate the entire storm piping system to prevent condensate buildup.
   b. Secondary storm drains and leaders shall be provided and sized per all applicable codes, including local codes and the requirements of the Oklahoma Building Code Commission. Terminations of secondary storm leaders shall be above grade in visible locations approved by the UA.
   c. The requirements for storm water retention tanks shall be coordinated with OSU and the end-user.

d. Indirect waste
   a. Where waste is required to be connected to the drainage system in an indirect manner, locate the indirect connection in an accessible area or provide code-compliant access.
   b. Provide an indirect connection to the drainage system where code is required and for the following items:
      i. All food-service waste.
      ii. Pumped discharge from elevator sump pumps.
      iii. Condensate drainage.

e. Vent
   a. Vent sanitary sewer systems as required by IPC.
   b. Coordinate the location of vents terminating on the exterior of the building with the location of all mechanical air intakes, operable windows, and other openings into the building. Where vent terminations are visible, coordinate with the UA.
   c. Air admittance valves (Studor® vents) are acceptable where specifically approved by OSU.

f. Pumped drain
   a. For sewage ejectors and sump pumps, provide duplex pumps where possible with each sized for 100% of the load.
   b. The engineer shall confirm the requirement for providing pumps with emergency or backup power for each project. Backup or emergency power is preferred by OSU.
   c. Provide isolation valves and check valves in the pump discharge. Provide ball check valves where the discharge is routed vertically; provide swing check valves where the discharge is routed horizontally.
   d. Where pumped drainage is indirectly connected to the gravity drainage system, the receptor shall be sized such that the total flow does not overwhelm the receptor.
   e. Elevator sump pumps
      i. Size elevator sump pumps to remove 50 GPM minimum per elevator.
      ii. For sump pumps serving elevator shafts with hydraulic elevators, provide packaged oil detection systems with oil alarms at the BAS.

g. Condensate
   a. Condensate disposal shall be installed per code. This shall include the requirement to install cleanouts as required by code. Condensate shall be indirectly connected to the drainage system through an approved air gap.
   b. Condensate shall be disposed into floor sinks. Floor sinks receiving condensate shall have a minimum depth of six (6) inches (ten (10) inches is preferred). Floor sinks shall

be cast iron. PVC is not allowed. Provide 1/4, 1/2, or full grate, as needed.

c. Where it is not possible to dispose condensate into floor sinks, condensate may be disposed into condensate standpipes.
d. If condensate standpipes are concealed, provide access panels for inspection and cleanout. Coordinate the location of standpipe access panels with the UA.
e. Condensate shall be insulated to prevent condensation from forming on the exterior of the pipe.
f. New condensate tanks shall have hard pipe (copper or steel pipe) from the tank drain to the nearest working floor drain.

h. Interceptors
   a. General
      i. Where interceptors are located in a visible area, or where interceptors are located under counters, coordinate the location of the interceptor with the UA.
      ii. Where interceptors are located exterior to the building, coordinate with the requirements of Section 2: Site Utilities.
      iii. For interceptors requiring periodic pumping, interceptors shall be located exterior to the building. The preferred location for exterior interceptors is at the back of the building or nearby to loading docks.
   b. Grease interceptors
      i. The engineer shall coordinate with OSU for the type and location of grease interceptors.
      ii. For below grade installation, vent the interceptor to grade and provide pump connections at grade where applicable.
      iii. The engineer shall provide grease interceptor calculations on the drawings.
   c. Solids interceptors
      i. Solids interceptors shall be provided per code but not limited to: at the outlet of waste disposals prior to connection to the sanitary sewer system.
      ii. Solids interceptors shall be in ground or below counter type.
      iii. Vent solids interceptors as required by code and the manufacturer's installation requirements.
   d. Lint interceptors
      i. Provide lint interceptors in the laundry waste discharge prior to connection to the sanitary sewer system.
   e. Oil interceptors
      i. Provide oil interceptors as required by code and prior to connection to the sanitary sewer system at repair garages, at minimum.
   f. Sand interceptors
      i. Provide sand interceptors as required by code and prior to connection to sanitary sewer system at repair garages, at minimum.

i. Septic systems
   a. Septic systems are not preferred. Septic systems shall not be provided except where approved by OSU.
   b. Coordinate with the Oklahoma DEQ and OSU for septic system requirements.

j. Gray-water storage
   a. The requirements for gray-water storage tanks shall be coordinated with OSU and the end-user.

k. P-traps
    a. Provide trap primers or deep seal P-traps for floor drains, floor sinks, and condensate disposal standpipes and other drains that have the potential to lose their water seal due to evaporation. Mechanical trap seals shall be used only with OSU approval.
l. Backwater valves
    a. Provide backwater valves as required by code.
    b. Provide a means of access from grade.
m. Hangers
    a. Hangers shall be sized appropriately for the piping and fluid.
    b. Where hangers support insulated piping, provide clamp inserts to prevent compression of the pipe insulation. Provide a thermal and vapor barrier between the pipe and the hanger and clamp.
    c. Hangers used on bare copper pipe must be brass or have an approved dielectric spacer.
n. Condensate neutralization
    a. Provide condensate neutralization as required by code and at condensing boiler drains and the drains of 90% (or better) efficient furnace drains, at minimum.

B. Products
    a. Piping
        a. SS and SD piping shall be:
            i. Cast iron with no hub connections above ground.
            ii. Cast iron with hub and spigot connections below ground.
        b. Lab waste piping
            i. Coordinate the required type of lab waste piping with OSU. Lab waste piping shall not degrade when exposed to the chemicals in the lab.
            ii. Glue-type joints are preferred above grade. For below-grade installations, where consistent with the intended use of the lab, provide Spears® LabWaste® CPVC piping as basis of design.
        c. Condensate piping shall be one of:
            i. Copper
            ii. PVC
            iii. CPVC is not allowed.
    b. Backwater valves
        a. Where listed for the application, Rectorseal® shall be the basis of design.

C. Execution
    a. Testing
        a. Sanitary and storm systems shall be provided with a water test at ten (10) feet of head for rough-in installation and an air test at one (1) inch WG for final installations. Air tests shall not be performed on plastic piping.
        b. Piping tests shall meet the requirements of applicable codes.

3-10. Fire Protection Piping

Fire protection piping shall meet the following requirements.

A. General requirements
    a. All fire protection design shall meet the requirements of the OSU EHS Fire Sprinkler

System Standard.

B. Design
   a. Refer to Section 2: Site Utilities for other fire protection water service requirements.
C. Products
   a. All above-ground fire protection piping shall be Schedule 40 black pipe without reducing bushings.
   b. No CPVC piping or fittings will be allowed.
   c. Pre-Action systems shall be Schedule 40 Galvanized pipe.

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Section 4: Mechanical Guidelines

4-1. Introduction

The following section includes guidelines related to heating, ventilation, and air conditioning as well as controls and other associated topics. The engineer should review this section and the rest of these guidelines prior to beginning the design.

A. Table of contents

B. Abbreviations
   a. ADA – Americans with Disabilities Act
   b. AFF – Above finished floor
   c. AHU – Air handling unit
   d. ASHRAE – American Society of Heating, Refrigeration, and Air-Conditioning Engineers
   e. ASME – American Society of Mechanical Engineers
   f. BAS – Building automation system
   g. BTU – British thermal unit
   h. CO – Carbon monoxide
   i. CO2 – Carbon dioxide
   j. CRAC – Computer room air conditioner
   k. DOAS – Dedicated outside air system
   l. DCV – Demand control ventilation
   m. DX – Direct expansion
   n. EC – Electronically commutated
   o. EEV – Electronic expansion valve
   p. EPA – Environmental Protection Agency
   q. ES – Energy Services
   r. FACP – Fire alarm control panel
   s. FCU – Fan coil unit
   t. FCV – Flow control valves
   u. FSE – Fan-system effect
   v. GA – Gauge
   w. GUI – Graphical user interface
   x. HP – Horsepower
   y. HDPE – High-density polyethylene

z. HVLS – High-Velocity Low Speed
aa. IECC – International Energy Conservation Code
bb. IMC – International Mechanical Code
cc. HVAC – Heating, ventilation, and air-conditioning
dd. LCCA – Life cycle cost analysis
ee. MERV – Minimum Efficiency Reporting Value
ff. MVD – Manual volume damper
gg. NC – Noise Criteria
hh. NEC – National Electrical Code
ii. NFPA – National Fire Protection Association
jj. PEX-A - Cross-linked polyethylene
kk. PSIG – Pounds per square inch, gauge
ll. RH – Relative humidity
mm. RTU – Rooftop unit
nn. SCR – Silicon Controlled Rectifier
oo. SDR – Standard dimension ratio
pp. SMACNA – Sheet Metal and Air Conditioning Contractors' National Association
qq. TAB – Test and balance
rr. UA – University Architect
ss. VAV – Variable air volume
tt. VFD – Variable frequency drive
uu. VPF – Variable primary flow
vv. WG – Water column, gauge

C. Referenced Standards and Guidelines
a. ASHRAE Handbook – Fundamentals
b. ASHRAE Handbook – Applications
c. ASHRAE Standard 15 – Safety Standard for Refrigeration Systems
d. ASHRAE Standard 34 – Designation and Classification of Refrigerants
e. ASHRAE Standard 62.1 – Ventilation for Acceptable Indoor Air Quality
f. ASHRAE Standard 55 – Thermal Environment Conditions for Human Occupancy
g. ASHRAE Standard 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings
h. ASHRAE Standard 110 – Methods of Testing Performance of Laboratory Fume Hoods
i. ASHRAE Standard 183 – Peak Heating and Cooling Load Calculations in Buildings Except Low-rise Residential Buildings
j. ASME 13.1 – Standard for the Identification of Pipes
k. IGSHPA Closed-Loop/Geothermal Heat Pump Systems: Design and Installation Standards
l. NFPA 99 – Health Care Facilities Code
m. OSU Energy Guidelines

4-2. General Mechanical Engineering Requirements

The following general design requirements shall be incorporated into the engineering design. These guidelines are not all inclusive. The engineer is required to understand both the content of

these guidelines and the specific requirements of the project. Furthermore, the engineer shall read the entirety of these guidelines.

A. Thermal environmental requirements
   a. Design setpoints.
      a. Indoor design setpoints shall comply with the OSU Energy Guidelines. Use these guidelines for occupied and unoccupied (setback) temperature setpoints only.
      b. Indoor RH requirements differ from project to project and shall be determined and coordinated with OSU on a case-by-case basis.
      c. The engineer shall design occupied spaces to meet the requirements of ASHRAE Standard 55.
      d. For IT rooms, the temperature setpoint shall be 68°F unless otherwise required by OSU.
   b. Indoor air quality
      a. Indoor air quality and ventilation requirements shall be per the latest OSU accepted version of ASHRAE Standard 62.1.
      b. Ventilation for maintaining indoor air quality shall be calculated per code and the requirements of ASHRAE Standard 62.1. The engineer shall include the ventilation effectiveness in these calculations and shall clearly state the design effectiveness used to determine ventilation flow rates.
      c. Ensure that all outside air intake locations are separated from sources of contamination by the code required distances.
   c. Humidity control
      a. The engineer shall design each space to prevent elevated humidity levels unless the project requires elevated RH for a specific process or environment.
      b. The engineer shall coordinate with the project architect regarding the vapor barrier condition of the exterior envelope to confirm the intent of humidity control is achievable by the HVAC system.
      c. The engineer shall select and size equipment to provide an adequate run time for moisture removal.
      d. Where spaces see high latent loads that may not coincide with peak sensible loads, the engineer should consider a dehumidification sequence.
      e. The engineer shall coordinate with OSU for any minimum humidification requirements. Campus steam is the preferred method of humidification and shall be provided through a steam-to-steam heat exchanger. Campus steam shall not be directly used for humidification. Water quality should be analyzed for softening requirements.
B. HVAC load calculations
   a. The engineer shall perform heating and cooling load calculations per the latest OSU accepted version of ASHRAE Standard 183.
   b. Use the latest version of the ASHRAE Fundamentals handbook accepted by OSU to determine applicable design conditions. Use the 0.4% cooling, 0.4% dehumidification, 99.6% heating, and 99.6% humidification data.
   c. Coordinate with OSU regarding IT loads for data rooms and closets. In some cases, OSU will provide the cooling equipment sizing to the engineer.
C. Design safety factors

a. Use appropriate engineering safety factors. Avoid oversizing equipment in order to prevent excessive equipment cycling, space sub-cooling and overheating, and dehumidification difficulties.
b. Do not include multiple safety factor multipliers.
c. Clearly state the heating and cooling load safety factors in design documents.

D. Redundancy and expansion
   a. The engineer shall coordinate with OSU for any required expansion capacity in designed equipment or systems.
   b. OSU prefers both redundancy and extra capacity to maintain building conditions upon failure of individual equipment. Multiple units or units with multiple independent circuits are preferred in many cases to provide backup. The engineer shall coordinate with OSU regarding the required level of redundancy and equipment oversizing (if any). Application of oversized equipment or multiple units serving the space shall comply with the requirements of section 4-2:C.
   c. The engineer shall consider the necessary equipment run time to prevent humid conditions from developing in the space. Dehumidification sequences (including reheat) and humidity sensors may be necessary in some cases to prevent humid conditions from persisting.

E. Multi-discipline coordination
   a. Coordinate all visible elements with the UA.
   b. Coordinate all equipment requiring electrical service with the electrical engineer. Coordination shall include but not be limited to:
      a. Disconnects (note that OSU prefers disconnects to be provided installed by the factory where possible).
      b. Required voltage/phase/amperage.
      c. Location and routing of piping and ductwork to prevent routing over electrical rooms, IT rooms, server rooms, electrical panels or electrical equipment.
      d. Location of the BAS panel.
   c. Coordinate the interface of mechanical piping with the civil engineer.
      a. In general, the mechanical scope of piping shall terminate five (5) feet outside the building.
      b. Coordinate the location of ground-loop heat exchanger piping and all other underground mechanical piping with the civil engineer to prevent conflicts between mechanical piping and site utilities.
   d. Coordinate all equipment and products requiring structural support with the structural engineer. Coordination shall include but not be limited to:
      a. Equipment weights including all optional accessories such as roof curbs
      b. Coordinate large ductwork with structural members
      c. Coordinate the location and size of housekeeping pads with structural for detail and dimensioning
      d. Coordinate sizes and locations of penetrations in structural walls and floors
   e. Coordinate the location of all smoke dampers, fire/smoke dampers, and associated smoke detectors including those provided with mechanical equipment with the fire alarm contractor where smoke detectors are to be interfaced with the fire alarm system.

F. Miscellaneous requirements
   a. HVAC zoning shall be per the latest OSU accepted version of ASHRAE 90.1. Further, efforts must be made to zone HVAC in such a way that classrooms, offices, conference

rooms, and other spaces which do not need 24/7 HVAC are zoned separately from spaces needing 24/7 HVAC such as laboratories. Conference rooms and assembly spaces shall have individual zones unless the space is served by a constant volume RTU.

b. 24/7 cooling loads
    a. Spaces requiring 24/7 cooling shall be on individual zones.
    b. Spaces requiring 24/7 cooling shall not be served from central systems unless central systems are configured to allow for 24/7 cooling and there is a means of preventing heated air delivery to the space.
    c. The engineer should consider dedicated cooling systems for spaces requiring 24/7 cooling.
c. Building pressure
    a. The engineer shall provide an overall positive building pressure unless negative pressure is required by the specific space.
    b. Where feasible, provide powered exhaust for building relief with automatic controls based on the building pressure and an adjustable setpoint.
    c. Where the building pressure is monitored and controlled, the building pressure setpoint shall be determined during TAB to avoid the building being too negative or too positive. Separate pressure setpoints shall be provided for occupied and unoccupied mode to promote energy efficiency.
    d. All HVAC needs in elevator shafts need to be ducted to accessible and serviceable locations.

G. Dedicated outside air
    a. The application of dedicated outside air for ventilation shall be coordinated with OSU on a case-by-case basis.
    b. Where DOAS is used, consider energy recovery.
    c. OSU prefers to deliver air at a neutral, dry condition directly to space to provide for simplicity of controls and avoid overcooling or overheating a space due to the provision of non-neutral ventilation air from the DOAS. To achieve this, reheat may be required. Where the engineer deems cold (or warm) air delivery provides energy savings or other advantages, the engineer shall coordinate with OSU regarding controls requirements and training and receive approval to deliver non-neutral air by design.
    d. A means of reheat shall be provided for all DOAS systems. Reheat for DX units shall be modulating hot gas type.
    e. Energy recovery shall be provided as noted in Section 4-3: Energy Efficiency.

H. General installation requirements
    a. The engineer shall specifically instruct the contractor via the design documents to install all piping and ductwork parallel and perpendicular to other pipes and ductwork and to building elements.

I. Identification
    a. All equipment, piping, valves, ductwork, and all other components shall be labeled using permanent tags and labels with non-fading letters. Labeling shall be per ASME 13.1 and NFPA 99.
    b. The following abbreviations shall be used for mechanical systems:
        a. CHWS/CHWR – Chilled water supply/chilled water return
        b. HWS/HWR – Heating water supply/heating water return
        c. S/A – Supply air
        d. R/A – Return air

e. O/A – Outside air
f. T/A – Transfer air
g. E/A – Exhaust air
h. L/E – Laboratory exhaust air
i. G/E – Grease exhaust air

c. For renovations, values for tags shall be incremented based on existing equipment tags. The engineer shall contact OSU for equipment tagging requirements. The following convention shall be used for new equipment tags:
   a. "Type Acronym"-"Incremental #" (e.g. Air handling unit, first unit: AHU-1)

J. Test and balance
   a. Test and balance requirements including tolerances shall be determined by the engineer based on the space use and operational requirements. Tolerances should ensure positive or negative pressurization as required for each space.

4-3. Energy Efficiency

The engineer should pursue energy efficiency in the design of each project. The following includes the minimum energy efficiency requirements. The engineer shall coordinate with OSU to determine the specific energy efficiency requirements of each project.

A. Life Cycle Cost Analysis
   a. An LCCA shall be required for new buildings and major renovations as defined by OSU to aid in system selection and selection of energy conserving measures.
   b. The length of the life cycle analysis shall be coordinated with OSU.
   c. An LCCA shall include but not be limited to:
      a. Installed costs.
      b. Maintenance costs (coordinate with OSU FM).
      c. Replacement costs.
      d. Energy costs.
   d. An LCCA should be used for comparison purposes only. Costs similar between all compared alternatives may be ignored.
   e. The various system options included in an LCCA shall be coordinated between the engineer and OSU. The engineer should consider using the ASHRAE 90.1 Appendix G method for determining the baseline system option.

B. IECC compliance
   a. Where an LCCA is impractical as determined by OSU, use the prescriptive method of the latest OSU adopted version of IECC as described below. The following shall meet the requirements of IECC.
      a. Equipment efficiency ratings
      b. HVAC Zoning
      c. Requirements for use of economizer
      d. Requirements for use of energy recovery

C. Energy Use Model

   The design Architect/Engineer shall develop a building energy model (BEM) and run a complete building energy simulation to estimate energy consumption (heating, cooling, ventilation, and other electrical loads) and water consumption use in the new building. The design Architect/Engineer shall provide the following to OSU:

a. Copy of the developed model (EnergyPlus Version 9.1.0 or latest version)
b. Copy of the EnergyPlus report
c. Annual loads for:
    a. Domestic Water (kgal)
    b. Irrigation (kgal)
    c. Chilled Water (MMBTU)
    d. Steam (klb)
    e. Electrical (kWh)
d. Peak flow for:
    a. Domestic Water (kgal)
    b. Irrigation (kgal)
    c. Chilled Water (MMBTU)
    d. Steam (klb)
    e. Electrical (kWh)
e. Estimated load profiles for:
    a. Domestic Water
    b. Irrigation
    c. Chilled Water
    d. Steam
    e. Electrical

4-4. Mechanical Equipment

Mechanical equipment shall meet the following requirements. Note that where specific manufacturers or products are indicated as "basis of design," the engineer's design shall design selected systems around the noted products. Equals are allowed and shall be coordinated with OSU.

A. Basis of design manufacturers
    a. The engineer shall include one of the following manufacturers as the basis of design for the following equipment. For specification purposes, other approved manufacturers shall be coordinated with OSU. Where equipment is not listed below, the engineer shall coordinate with OSU regarding the basis of the design equipment manufacturer.
    b. Common equipment
        a. VFD
            i. ABB
    c. Air-moving and air-handling equipment
        a. Fans
            i. Loren Cook Company
        b. Split systems and mini-split systems
            i. Trane
            ii. Lennox International, Inc.
            iii. Carrier
        c. Air Handling Unit
            i. Temtrol®
        d. Packaged rooftop equipment
            i. Trane

ii. Lennox International, Inc.
iii. AAON®

e. Dedicated outdoor air unit
i. AAON®

f. CRAC unit
i. Liebert

g. Unit heater
i. Lennox
ii. Reznor
iii. Modine

d. Hydronic equipment

a. Pumps
i. Taco Comfort Solutions
ii. Grundfos Pumps Corporation

b. Low pressure steam and standard efficiency hot water boilers
i. Cleaver Brooks
ii. Laars®
iii. Lochinvar®
iv. Weil McLain®

c. Condensing boilers
i. KN Series
ii. Laars®
iii. Lochinvar®
iv. Weil McLain®

d. Heat exchangers
i. Armstrong
ii. Howard products shall not be specified.

e. Water-source heat pump
i. AAON®
ii. ClimateMaster®
iii. WaterFurnace®
iv. Florida Heat Pumps products shall not be specified.

f. Heat trace
i. Raychem

B. General installation requirements

a. Installation location

a. All reasonable attempts shall be made to ensure that equipment is accessible and removable without removing permanent construction or other equipment. Where this is not possible, the engineer shall coordinate with OSU as soon as these conditions are discovered.

b. OSU prefers all central system mechanical equipment to be located in mechanical rooms or on accessible roofs with permanent ladders installed for access.

c. Limit installations near the edge of the roof. Where equipment is located ten (10) feet or less from the edge of the roof, provide railing meeting the requirements of IMC and all other applicable codes and standards.

d. Ladders, walkways, railings, and platforms shall be provided per the requirements of IMC. Proper fall protection and tie off points shall be provided where required by

code and OSU.

e. Avoid installing equipment on the side of the building greater than 16'-0" high.
f. Exterior installations shall be coordinated with the UA for any required site line or screening requirements.

b. Installation requirements
   a. Provide a six (6) inch (minimum) tall pad for floor-mounted equipment. A taller pad may be required for connection of all required piping (drain, trap, etc.).

c. Accessibility
   a. Maintain required clearances per code and the manufacturer's requirements. A minimum of 36 inches of clearance is required to all electrical connections for all equipment.
   b. Clearances must be maintained for coil pull, heating and cooling air flows of DX equipment, and all other service considerations.
   c. Where equipment is mounted above the ceiling, provide a means of access and removal. The removal of lights is not an acceptable means of achieving this requirement.
   d. Provide factory-installed cabinet lights (where available) for large air handling equipment located indoors.

C. Miscellaneous equipment requirements

a. Noise and vibration
   a. The engineer shall design the system to minimize objectionable sound. This shall include (at a minimum) following best practice NC guidelines. Target NC levels shall be included in the drawings.
   b. Coordinate the location of large sound producing equipment (cooling towers, air cooled chillers, etc.) with OSU, especially in sound-sensitive areas.
   c. Provide vibration isolation for equipment per the ASHRAE Handbook – Applications unless rotating parts are internally isolated in packaged equipment or equipment is manufactured to be mounted without isolators.
   d. For rotating equipment, all connections to the equipment (piping, conduit, ductwork, etc.) shall be made with flexible connectors.
   e. The engineer shall consider providing internal acoustical lining for transfer air where sound transmission between spaces is a concern. Acoustical lining shall meet the requirements of ASHRAE Standard 62.1 for surfaces in contact with the air stream. Coordinate with OSU for locations where sound transmission shall be minimized.
   f. Minimize noise in occupied spaces by locating equipment serving these spaces outside of the occupied area where possible.
   g. Where sound attenuators are specified, the drawings shall clearly indicate the attenuation level for each octave band.
   h. Do not mount equipment, equipment supports, ductwork, or piping on the conduit that may allow transmission of additional vibration to permanent construction including floors, walls, windows, and other permanent elements.

b. Motors
   a. OSU prefers all motors to be configured for easy balancing. Belt drive fans and VFDs meet these requirements. Where direct drive fans are applied without a VFD, an on-board potentiometer shall be included.
   b. EC motors are allowed only for fractional horsepower motors and motors installed in

packaged equipment.

c. VFDs
   i. Motors shall be equipped with a soft start system or VFD if the motor horsepower is greater than 20 HP, or as determined by OSU ES.
   ii. Where VFDs are provided, premium efficiency motors shall be used.
   iii. For motors over 20 HP equipped with VFDs, provide shaft grounding rings.
   iv. OSU engineer's approval shall be gained before providing bypass or hand mode to the VFD application.

d. Provide motor space heaters as recommended by the manufacturer where the potential for condensation exists.

c. Roof-mounted equipment
   a. For roof-mounted equipment requiring roof curbs, provide 14-inch tall (minimum) roof curbs. Roof curbs shall be insulated and level regardless of the roof pitch. Coordinate roof curb requirements with the specific roof type and slope especially for standing seam roofs.
   b. Coordinate the final height of roof-mounted equipment and any required screening with the UA.
   c. For roof-mounted packaged equipment, provide service receptacles wired on a separate circuit. Wiring shall be by the electrical contractor.
   d. Where roof-mounted equipment is located on a sloped roof, provide code-compliant service platforms and railings and access to the platform.
   e. Coordinate the curb type with the roof type and confirm the curb is compatible with the intended roof installation.
   f. Roof equipment and roof curbs shall be installed in a manner that is consistent with the roof manufacturer's requirements for a warranty.

d. Natural gas-fired equipment
   a. Provide combustion air and makeup air as required by the manufacturer and per code. Combustion air shall not be room-direct where equipment containing refrigerant is present in the room.
   b. Equipment flues shall be of a material meeting the manufacturer's requirements and the requirements of code and shall be appropriate for the application (i.e. forced draft or natural draft).
   c. Flues shall be routed in chases where required by code and shall be terminated as per the requirements of NFPA 54. All visible flue terminations shall be coordinated with UA.
   d. Where combination flues or combination combustion air intakes are used, design and installation shall be as per the manufacturer's requirements. Do not combine flues for the forced draft and natural draft equipment.

e. Pressure vessels
   a. All pressure vessels shall have an ASME rating and stamp. Where equipment is not available with an ASME stamp, the engineer shall receive OSU approval.

f. Heat trace
   a. Where heat trace is required, self-regulating heat trace is required.
   b. Provide waterproof heat trace where required.
   c. Coordinate heat trace electrical requirements with the electrical engineer.

g. Electrical disconnects
    a. Provide factory-installed disconnects where they are available from the manufacturer.
    b. Where disconnects are field-installed, do not obscure equipment labels, data tags, or other identifying information.
    c. Where a VFD is used as a disconnect and where the VFD breaker is not within sight of the motor (as defined by NEC), coordinate with the electrical engineer to provide a disconnect upstream of the motor.
h. Refrigerant systems
    a. The engineer shall coordinate with OSU regarding refrigerants to be used.
    b. Refrigerants shall be currently available per EPA guidelines and shall be appropriate for the intended use.
    c. The system design shall comply with the requirements of ASHRAE Standards 15 and 34.

D. Air-moving and air-handling equipment
a. General requirements
    a. Central air handling filtration shall be required to meet MERV 8 as a minimum.
    b. Filtration requirements may vary on a case-by-case basis. The engineer shall review energy efficiency and project filtration requirements for each project.
b. Fans
    a. The engineer shall determine the type of supply, return, and exhaust fans used based on the specific requirements of each project. The engineer should consider fan walls where applicable. Where fan walls are employed, the individual fans shall have built-in coplanar silencers or similar technology to reduce AHU sound levels (if required).
    b. Laundry exhaust fans must meet the requirements of applicable codes. Where a common multi-story duct system is designed and installed to convey exhaust from multiple clothes dryers, standby power is required per code.
    c. Kitchen exhaust fans serving Type I hoods or other grease systems shall be listed for application in grease exhaust and all related curbs shall be vented per code and the manufacturer's requirements. Provide hinged kitchen exhaust fans for ease of cleaning.
c. Air handling equipment
    a. FCU type shall be determined by the engineer in accordance with these guidelines.
    b. VAV terminal type (single-duct, fan-powered series, fan-powered parallel, etc.) shall be determined by the engineer for the specific application.
    c. Central station air handling equipment shall be supplied with frames independent of cabinets.
    d. The air handling units can be both of custom or semi-custom design; the type used shall be determined in the initial stages of the project by OSU with the engineer's input. As a general guideline, custom air handlers would be used for high demand areas (laboratories, operating rooms, etc.) whereas semi-custom units would be used for general purposes (offices, classrooms, etc.)
d. Energy recovery equipment
    a. The application of energy recovery shall be determined on a case-by-case basis by OSU.
    b. Where energy recovery is required, provide total enthalpy type energy recovery unless the exhaust air stream is hazardous
    c. Where the exhaust air stream is hazardous, the energy recovery method shall present

no possibility of recirculation. Run-around loops are the preferred method of energy recovery in conditions such as these.

d. Provide controls, bypasses, and all other necessary features to avoid negatively impacting energy recovery during economizer conditions.

e. Kitchen systems
   a. Kitchen exhaust hoods and makeup air systems shall be suitable for application in a commercial environment unless otherwise approved by OSU.
   b. For hoods with integral wash-down, the hot water system must be sized for peak demand
   c. Makeup air equipment shall provide heated and mechanically cooled air to the kitchen.

f. Electric heating coils
   a. The engineer shall consider SCR control for electric heating coils requiring variable capacity.

g. Chilled beams
   a. Where chilled beams are applied, humidity levels shall be monitored and closely controlled to prevent condensation of the chilled beam.

h. Split DX systems
   a. For split DX systems, whether cooling only or heat pump, the engineer shall calculate the capacity of the basis of the design system based on ambient condensing design temperature and refrigerant line length derates. These derated values shall be included in the equipment schedule.
   b. Heat pump systems shall be required except in areas not requiring heat or unless otherwise approved by OSU.

i. Air terminal devices
   a. Coordinate diffuser types with the UA.
   b. Preferred filter locations are in mechanical rooms, on accessible roofs, or in other easily accessible areas. Filter grilles are allowed in specific applications as approved by OSU.
   c. Dampers at the face of the air terminal are not allowed unless otherwise approved by OSU. Where OSU approval is provided, dampers at the face of the grille shall not be used as the source of balancing in place of an MVD.

E. Hydronic equipment

a. General
   a. Where glycol solutions have been approved by OSU for use in hydronic systems, the contract documents and schedules shall clearly indicate the type of glycol in use, the percent of glycol in the system by volume, and the derated capacities of all equipment. All equipment schedules shall clearly indicate the correct glycol type and percentage were used in developing the equipment capacities.

b. Pumps
   a. Split case pumps are not allowed.

c. Air-cooled Chillers
   a. For capacities up to 50 tons, use scroll chillers with a minimum of two (2) circuits.
   b. For capacities greater than 50 tons, screw chillers may be used if sound-dampening or other sound treatment is applied. Sound data shall be provided to OSU for review and approval.
   c. Condenser fan motors shall be variable-speed EC motors or shall be equipped with

VFDs for condenser fan speed modulation.

d. Chillers shall be designed to handle part-load operation. To achieve this capacity reduction, digital scrolls may be provided with EEV, or hot gas bypass (not preferred) may be used.
e. Provide low ambient operation to 0F.

d. Cooling towers
   a. Locate cooling towers as required by code to avoid exposing inhabitants to legionella.
   b. Provide separately metered makeup water lines.
e. Boilers
   a. Where heating water is not provided by the central plant, condensing boilers are preferred.
   b. Where condensing boilers are used, the engineer shall confirm that return water temperature is designed to maximize condensing boiler efficiency.
f. Hydronic coils
   a. Stainless steel coil frames are preferred.
   b. Provide a vacuum breaker at the high point of each coil connection to prevent an airlock.
   c. Cooling coils shall be provided with stainless steel or other non-degrading material drain pans. The drain pans shall be double-sloped and galvanized drain pans are not allowed.
   d. For equipment located where damage to permanent construction or other equipment may occur upon overflow, provide a condensate overflow sensor and a shutoff switch wired to shut the unit down upon detection or provide overflow piping with an alarm for condensate pans.

4-5. Air Distribution Systems

Air distribution systems shall meet the following requirements.

A. Design
   a. General ductwork design
      a. The engineer shall determine the most appropriate method of ductwork sizing for each project.
      b. For VAV systems designed to operate at pressures greater than two (2) inches WG, the engineer shall consider using spiral ductwork and sizing the ductwork based on static pressure regain.
      c. The engineer shall design the ductwork to limit duct velocities to minimize noise. Follow ASHRAE guidelines for duct velocities.
      d. Ductwork layout
         i. Branch take-offs shall be located not less than four (4) duct diameters from changes in direction.
         ii. At the end of duct mains, the final tap shall be located not less than 24 inches from the end of the duct main.
         iii. Provide conical or heel-toe ductwork takeoffs to minimize pressure drop at takeoffs.
         iv. For connections to VAV boxes, provide four (4) duct diameters of straight ductwork into the VAV box inlet.

b. Exposed ductwork
    a. Exposed ductwork shall be spiral unless otherwise approved by OSU.
    b. Where ductwork is exposed, use internal sealing and gasketed joints. Mastic applied to the outside of ductwork joints is not allowed in these spaces.
    c. The engineer shall determine the requirement for double-wall spiral ductwork based on the potential for condensate formation.
    d. Where ductwork is exposed in the space, ductwork installation shall be straight, free of sags, free of burrs, and parallel and perpendicular to building elements.
    e. Coordinate exposed ductwork finish requirements with the UA. Where painted ductwork is required, the ductwork shall be provided with a paintable coating specifically designed to facilitate adherence between the metal ductwork surface and the finish paint.
c. Pressure drop calculations
    a. The engineer shall perform air pressure drop calculations and schedule equipment with appropriate pressure capacity for the service.
    b. The engineer shall determine the appropriate pressure drop safety factor and clearly state such on the drawings.
    c. The engineer shall consider FSE when sizing fans. Avoid duct design leading to elevated FSE.
d. Return air systems
    a. Plenum return air systems are not preferred. Ducted return systems shall be used unless otherwise approved by OSU.
    b. Coordinate with all building elements including full-height walls to ensure that the return air path is not impeded. Provide jumper ducts and other transfer air paths as necessary and in accordance with code. Corridors shall not be used as a means of returning air unless except where code exceptions conditions are met.
e. Air terminal design
    a. Where a well-mixed condition is the design intent, avoid stratification by carefully locating air terminal inlets and outlets or use HVLS fans where approved by OSU.
    b. Select air terminal devices to provide proper throw per ASHRAE Standard 55.
    c. Size and locate air terminal devices to avoid dumping air. Refer to the recommendations of the ASHRAE Handbook: Fundamentals.
    d. Consider locating the return inlet low in the space to improve ventilation efficiency. Refer to ASHARE Standard 62.1 for ventilation efficiency values.
    e. Locate return inlets opposite supply outlets and near the door, if possible, to prevent short-cycling of cooling or heating air.

B. Products
a. Ductwork
    a. Unpainted ductwork shall be provided with G90 coating.
    b. For painted ductwork, provide a primer surface specifically intended to be used to prepare the surface of the ductwork to adhere to the finish paint.
    c. Sheet metal ductwork shall be fabricated per the recommendations of SMACNA.
    d. Sheet metal ductwork stiffening shall be provided as per the recommendations of SMACNA.
b. Flexible ductwork
    a. Flexible ductwork is prohibited to be used for direction changes, connections between

VAV box inlets and the main, and in exposed areas.

i. Flex duct shall be limited to six (6) feet in length.

b. Flexible ductwork shall be foil-faced.
c. Vinyl flexible ductwork is not allowed.

c. MVDs
   a. MVDs shall be located as required for balancing of air distribution systems.
   b. MVDs shall be located as close to the takeoff as possible and shall be accessible.
   c. Where ductwork is insulated, the contractor shall provide a ribbon or other marker to show the location of the MVD.
   d. Do not locate MVDs above a hard ceiling or in inaccessible areas except as approved by OSU. Where MVDs are located above an inaccessible ceiling, provide access to the MVD or provide an electronic remotely operated damper with the connection jack located at the face of the air terminal.

d. Ductwork connections
   a. Ductwork connections to the equipment shall be made with flexible canvas connectors for acoustical and vibration mitigation.
   b. Where elbows are required for ductwork connections to diffusers, a hard elbow is required. Flexible ductwork shall not be used to form this connection.

e. Life safety dampers
   a. Provide fire, smoke, and fire/smoke dampers where required by code. Coordinate the location of required smoke detectors with the fire alarm consultant.
   b. Provide access to life safety dampers and label access doors as required by code.
   c. Life safety dampers shall be provided by the mechanical contractor. Power and branch circuits shall be provided by the electrical contractor. Control wiring and controls shall be by the fire alarm contractor.

f. Hangers and supports
   a. Hangers shall not damage or compress insulation. Provide a vapor barrier between the hanger and ductwork.
   b. Ductwork routing along the roof shall be properly supported along its length. Provision shall be made for ductwork expansion based on expansion calculations for long duct runs. Pre-manufactured supports are preferred.

g. Grease ductwork
   a. Grease ductwork shall be specified to meet all requirements of the code.
   b. Where grease reservoirs are required, provide reservoirs with automatic washdown. Grease reservoirs must be provided with a means of access for cleaning.
   c. Ductwork shall be designed and installed such that cleaning can be accomplished from the roof or other easily accessible location.

h. Insulation
   a. The engineer shall determine the insulation type and thickness to minimize energy loss and prevent condensate formation.
   b. Insulation shall be foil-wrapped and external to sheet metal ductwork.
   c. For ductwork located outdoors, provide a 24 GA aluminum jacket over the insulation.
   d. An acoustical liner shall not be used other than for transfer air ductwork or other sound-transfer sensitive areas, or for sections of return air ductwork prone to producing nuisance noise. Where acoustical liner is used, liner shall meet the requirements of ASHRAE 62.1.

C. Execution
   a. Metal ductwork
      a. Metal ductwork construction, seal class, and material thickness shall be as per IMC and the latest edition of SMACNA. The applicable seal classes shall be noted on the contract documents.
      b. Where elbows are required, use radius elbows with a radius equal to or greater than the ductwork diameter or mitered elbows with double turning vanes.
   b. Flexible ductwork
      a. Flexible ductwork shall be connected and sealed per SMACNA and applicable code. A vapor seal shall be provided.
   c. Fume hood and hazardous air ductwork
      a. Fume hood and hazardous air ductwork shall be constructed per the ACGIH Industrial Ventilation Guide and the requirements of code and SMACNA.
   d. All air distribution systems shall be tested and balanced. Test and balance shall include all operating modes.

4-6. Hydronic Systems

Hydronic systems shall meet the following requirements.

A. General requirements
   a. Valve types indicated on plans shall be consistent with the drawing legend and shall be coordinated with the project specifications for the intended duty and service.
B. Design
   a. Connection to the campus chilled and heating water systems.
      a. Refer to Section 2: Site Utilities for requirements of connection to the campus chilled and heating water systems.
      b. For tertiary pumps, provide a valved bypass with a strainer at each pump so that the system can run on campus pressure temporarily while the tertiary pump is serviced. The system shall be configured to allow removal of the bypass strainer when the system is returned to normal operation.
      c. The hydronic system should be a variable flow as the basis of design in order to preserve energy and ensure smooth plant operation. In the event of a system upgrade, a constant flow system should be upgraded into a variable flow system.
   b. Standalone systems.
      a. Where hydronic systems do not communicate with the campus systems, the engineer shall determine the appropriate design temperatures. Coordinate with OSU regarding whether OSU intends to connect the system to the campus loop. OSU may require design based around the OSU campus loop chilled and heating water temperatures and design temperatures.
      b. Where condensing boilers are used for stand-alone systems, the engineer shall confirm that the return water temperature is cool enough to allow for condensing. Use outside air reset for part-load conditions.
   c. Piping design
      a. The engineer shall design the piping system to minimize the potential for pipe noise. Refer to the latest OSU accepted version of ASHRAE Standard 90.1.
      b. The system shall be completely drainable to the mechanical room. Provide hose end

drains at the base of each riser and at the lowest point of system and confirm that a nearby location exists for the disposal of drained hydronic fluid.

c. Pipe expansion
    i. Calculate long run pipe expansion and provide expansion loops at calculated locations and locations indicated by the structural engineer for building expansion joints.
    ii. Hard pipe expansion joints shall be used. Flexible expansion loops are not allowed.
d. Piping connection to pumps
    i. Long radius elbows and straight inlets of the length required by the manufacturer shall be provided or suction diffusers may be used where space is limited.
e. Where dissimilar pipes are connected, provide dielectric unions.

d. Water treatment, filtering, and separation
    a. Provide chemical pot feeders for closed loops and coordinate with OSU regarding closed-loop water treatment systems.
    b. For closed-loop heating water systems, provide a five (5) micron yarn filter in a ¾-inch side-stream configuration.
    c. Provide coalescing air and dirt separators on hydronic systems. Separators shall be located at the highest temperature, lowest pressure location, and shall be located on the suction side of the pump.
e. Pressure drop calculations
    a. The engineer shall perform pressure drop calculations to determine the required pump head pressure at the design flow rate.
    b. The engineering safety factor shall be appropriate for the application. Coordinate the safety factor with OSU and clearly state the utilized safety factor on the project drawings.
f. Condensate
    a. Size and install condensate per code, except where these guidelines call for larger piping.
    b. Condensate shall be properly trapped and vented.
    c. Where multiple condensate drains are connected into a main, the condensate piping shall be 1¼-inch minimum in diameter.
g. Insulation thickness shall be as per the requirements of ASHRAE Standard 90.1 and as required for condensation control.
h. Penetrations and sleeves
    a. Provide sleeves per code and install sleeves per the manufacturer's requirements.
    b. Penetration sleeves shall be sized for the outside diameter of the piping and insulation.
    c. A mechanical link seal system shall be provided for below-grade penetrations. The interstitial space between the pipe and sleeve on the outside portion of the wall shall be filled with non-shrink polymer grout.
i. Pumps
    a. Tertiary pumps
        i. Tertiary pumps shall be provided at all buildings served by campus chilled water.
        ii. Tertiary pumps shall be capable of handling the entire building pressure regardless of the incoming pressure from the campus system.
    b. Pumps shall be controlled by differential pressure and shall be equipped with VFDs. Differential pressure sensors shall be located by the controls contractor for adequate

operation of the hydronic system.

c. For each system, provide two pumps in parallel each sized for 50% total flow and 100% total head. To ensure partial redundancy, the pump curve of a single pump in operation must intersect with the overall building system curve.
d. Controls shall be configured to allow for the rotation of the lead pump daily, monthly, based on runtime, or manually. The controls contractors shall coordinate with OSU regarding the programming of the alternation of the lead pump.
e. Provide valved connections across the pump and each strainer and provide a pressure gauge so that the inlet pressure, discharge pressure, differential pressure across each strainer, and differential pressure across the pump can be read from one pressure gauge based on the position of each valve.
f. Circulating pumps over two (2) HP shall be horizontally mounted.

j. Valves
   a. Provide valves where required by code.
   b. Control valves
      i. Provide a bypass to maintain the minimum required flow for pumps or other connected equipment. Bypass valves shall be fast-acting.
      ii. Use modulating two-way pressure-independent control valves at coils.
   c. Manual valves
      i. Valves less than or equal to 2½-inch in diameter shall be full-port ball valves.
      ii. Valves larger than 2½-inch in diameter shall be butterfly valves.
   d. Provide isolation valves at each floor, wing, riser, zone, or main branch. Each individual coil shall be provided with isolation valves.
   e. Systems requiring changeover valves shall not be used. Hydronic systems serving for both heating and cooling or dehumidification shall be four-pipe systems.
   f. Valves and flanges shall be insulated the same as piping.
   g. Valve handles and chain-operated valve stems shall be operable with appropriate handle/stem extensions. Chain operators shall be provided for valves located greater than seven (7) feet AFF in mechanical rooms.
   h. Provide drain valves for all hydronic coils. In mechanical rooms, provide permanent piping from the drain valve to the nearest floor drain or floor sink and terminate using an indirect connection.
   i. Drain valves are required at all local low points in piping.
   j. Where drain valves, pressure relief valves, or automatic air vents are piped to the drainage system, the engineer shall confirm that the drainage system is rated for the temperature of the discharged fluid.
   k. Gate valves are not allowed on hydronic systems.
   l. Valves shall be accessible. Coordinate with the architect for the required location of access panels.
   m. Triple duty valves are not allowed. For the discharge of pumps provide a check valve and an isolation valve. VFDs shall be used for balancing.
   n. Bypass valves
      i. Bypass valves are preferred for the following building elements for which a repair would require shut down of a building system: meters, control valves, pressure reducing valves, building tertiary pumps, and makeup water (quick fill).
      ii. For the main building entry, provide a bypass with a strainer. Provide the

necessary valves in the bypass line to prevent overpressure or the introduction of unfiltered water into the hydronic system.

k. Strainers
    a. Provide redundant strainers at critical systems as defined by OSU and at building entries. The engineer shall coordinate the location of redundant strainers with OSU.
    b. Strainers shall be equipped with blow-down valves and shall be installed upstream of all heat exchangers, steam traps, control valves, meters, and pumps.
    c. Strainers integral with suction diffusers are acceptable.
    d. Where Victaulic piping is used, provide Victaulic strainers as the basis of design.
l. Air vents
    a. Provide air vents at all high points in the piping including at the top of risers.
    b. Automatic air vents are allowed only in mechanical rooms. Provide manual air vents elsewhere.
    c. Vent piping shall be as per code and capable of handling the highest expected fluid temperature without degradation.
    d. Pipe air vents to the nearest mechanical room or janitor's closet drain, if possible.
    e. The engineer shall consider the location of air vents and provide freeze protection where vents are exposed to freezing temperatures.
    f. Provide a normally open full port isolation ball valve prior to the air vent.
m. Magnetic style flow meters are required for VPF systems or other systems requiring tight control of the chilled water flow rate.
n. Freeze protection
    a. Provide manufacturer's freeze protection where available for hydronic equipment located in an area subject to freezing.
    b. Provide heat trace for pipes and equipment subject to freezing where manufacturer's heat trace is not available.
    c. Consider providing heat trace and other freeze protection methods with backup or emergency power.
    d. Provide ethylene glycol protection to 5°F for stand-alone chilled water systems where piping or equipment served with chilled water is located exterior to the building or in an unheated area.
o. Coils
    a. Provide test ports for pressure and temperature upstream and downstream of hydronic coils.
p. Expansion tanks
    a. The engineer shall calculate the required size of the expansion tank and indicate the sizing on the drawings.
    b. Indicate the fill pressure and initial charge pressure on drawings and on the expansion tank.

C. Products
a. Piping
    a. Chilled and heating water shall be one of:
        i. Copper piping with flanged or sweated joints; copper shall not be used for piping greater than four (4) inches in diameter.
        ii. Black steel piping with flanged or welded joints.
        iii. Groove-ended black steel piping with mechanical couplings (allowed only in mechanical rooms or other exposed areas) and as approved by OSU.

iv. Chilled and heating water piping greater than 2½-inch shall be provided with welded or welded-flanged joints.

b. Insulation
   a. Chilled and heating water
      i. Use fiberglass and consider preformed insulation for piping.
   b. For locations where durability is a concern, provide polystyrene wrap and an aluminum jacket.
   c. For exterior piping, provide fiberglass insulation with a vapor barrier and a properly installed aluminum jacket.
c. Control valves shall be Belimo as the basis of design.
d. Gauges and thermometers
   a. Pressure gauges shall be permanently installed and glycol-filled.
   b. Thermometers shall be solar powered digital type.
e. Expansion tanks
   a. Expansion tanks shall be bladder-style.

D. Execution
a. Testing
   a. The system test pressure shall be the larger of 100 PSIG or 150% of the working pressure. The test pressure shall not exceed the pipe pressure rating.
b. Valves shall be oriented so that when the valve is open, the handle is oriented in the direction of flow.
c. Provide hydronic test and balance for all hydronic systems.
d. The piping installation at each coil shall allow for coil or tube pulling and shall be arranged for ease of maintenance. Isolation valves and unions shall be located outside the area of coil or tube removal. Permanently installed pipes or other items shall not be required to be removed for coil pull or other maintenance.
e. Install pressure gauges and thermometers so that the readouts are clearly visible within the mechanical room.
f. Hangers
   a. Multiple trades shall not use the same hangers unless the hangers are specifically engineered for that purpose.
   b. Provide insulated spacers for clamped insulated piping at each hanger. Provide a thermal and vapor barrier between the pipe and the hanger.
   c. Hangers used on bare copper pipe shall be brass or have an approved dielectric.

4-7. Steam Systems

Steam and steam condensate systems shall meet the following requirements.

A. Design
a. Connection to campus steam
   a. Refer to Section 2: Site Utilities for steam pressure available at the building connection.
   b. Reduce steam pressure to low pressure via two (2) parallel full capacity pressure reducing stations with 60% pressure reducing valves. No bypasses shall be installed.
b. Do not route high or medium pressure steam through occupied spaces unless otherwise approved by OSU for loads requiring medium/ high-pressure steam. Coordinate with

OSU regarding any steam loads in the building requiring high pressures (i.e. autoclaves, etc.)

c. Steam condensate
    a. Pump condensate from the building condensate receiver to the central plant. Refer to Section 2: Site Utilities for condensate pump requirements.
    b. Provide inlet and outlet isolation valves on the steam condensate receiver for servicing.
    c. Drip legs
        i. Provide drip legs at all low points in the system, at elevation changes, and at all expansion loops, ends of mains, and at least every 100-200 feet.
        ii. The drip leg diameter shall be equal to the steam diameter for steam piping up to four (4) inches, four (4) inches for steam piping up to eight (8), and one-half the steam piping diameter for greater than eight (8) inches.
        iii. The drip leg length shall be greater than 150% of the diameter of the drip leg and 18 inches and as per code.
d. Expansion joints
    a. Piping loops and bends are preferred for expansion joints. Flexible joints are not allowed.
    b. Use 60°F cold pipe temperature as the baseline for expansion calculations.
e. Piping design
    a. Steam branch lines shall be tapped off the top of the steam main.
    b. Use eccentric reducers for size changes. The flat side of the reducer shall be oriented downwards.
    c. Provide pressure gauges on the inlet and outlet of the steam coil.
f. Steam traps
    a. For constant pressure processes, use inverted bucket-type steam traps.
    b. For variable pressure processes, use float and thermostatic type steam traps.
    c. Size steam traps for the size of the coil or process outlet diameter.
    d. Provide a steam trap for each coil or process.
    e. Steam connection trains shall consist of the following:
        i. Provide gate valves for isolation of process or coil and for removal of all valves and accessories requiring servicing.
        ii. Provide pipe unions or flanges for removal of steam piping and accessories serving process or coils.
        iii. Provide a strainer with a blowdown valve upstream of the steam coil or process.
        iv. Provide a steam condensate trap for each steam coil or process.
        v. Provide a steam test tee downstream of the strainer with an isolation gate valve with a threaded end connection.
        vi. Provide a check valve downstream of the steam condensate trap if the steam pressure is modulating or if condensate backpressure is present.
g. Gate valves used in steam and steam condensate shall be of the rising stem type.

B. Products
    a. Steam piping shall be black steel piping, schedule 40 for steam, schedule 80 for steam condensate.
    b. Steam insulation shall be fiberglass insulation sized per IECC 2015.
    c. Steam pressure reducing valves shall be Armstrong or Spence as basis of design.

d. Steam condensate pumps shall be Armstrong as basis of design.
e. Steam traps shall be Armstrong as basis of design.
f. Steam appurtenances and valves shall be Armstrong as basis of design.

4-8. Refrigeration Systems

Refrigeration systems shall meet the following requirements.

A. Design
   a. ASHRAE Standard 15 and ASHRAE Standard 34 compliance
      a. The design shall comply with ASHRAE Standard 15 and ASHRAE Standard 34. Compliance shall include but not be limited to refrigerant monitoring, relief, and mechanical room ventilation.
      b. The engineer shall review ASHRAE Standard 15 and ASHRAE Standard 34 requirements for specific applications in OSU refrigerant systems. This includes a thorough review of the specific usage of the space and all hazards associated with the refrigerant system.
      c. Perform ASHRAE Standard 15 and ASHRAE Standard 34 calculations to determine that refrigerant volumes are compliant based on the smallest communicating space.
   b. Refrigerants systems shall be tested to 250 microns for 15 minutes or as required for the specific installation.
   c. Provide refrigerant monitoring and alarms where the refrigerant is present as required by code.
   d. Where refrigerant monitoring is required, provide exhaust fans controlled to operate upon detection of a refrigerant leak as required by code.
   e. Per the requirements of IMC, refrigerant circuit access ports located outdoors shall be fitted with locking-type tamper-resistant caps. Weatherproof covers conforming with OSU Key Shop lock requirements shall be required, or refrigerant access ports shall be located in a secure enclosure.

4-9. Closed-loop Ground Heat Exchangers

Closed-loop ground heat exchanger design shall meet the following requirements.

A. General requirements
   a. Design and installation shall be in accordance with the latest version of the IGSHPA Closed-Loop/Geothermal Heat Pump Systems: Design and Installation Standards.
   b. The engineer of record shall design the building geothermal condenser water system and the entire closed-loop ground heat exchanger layout and all other system requirements and controls.
   c. The engineer shall clearly indicate the design intent of the location, layout, depth, and all other aspects of the closed-loop ground heat exchanger on the contract documents. The contractor shall identify any conditions on-site that may require a variance to the design intent. Any variations proposed by the contractor shall be approved by the engineer and OSU prior to construction. The contractor shall provide detailed as-built markups including GPS coordinates of all vertical boreholes, to the engineer for record drawing documentation.
   d. The preferred working fluid for closed-loop heat exchangers shall not contain glycol.

Where the engineer proposes to use a glycol solution for the working fluid, the engineer shall coordinate with OSU and receive approval.

e. Size the ground-loop heat exchanger based on a maximum summer entering water temperature of 95°F and a minimum winter entering water temperature of 50°F with a 20-year life cycle unless otherwise required by OSU.

B. Design
   a. Soil properties
      a. For vertical bore closed-loop ground heat exchangers, a thermal conductivity test shall be performed to determine the thermal properties of the soil in the area proposed for the ground heat exchanger. The results of this test shall be used in designing the bore field.
   b. Borehole layout
      a. Vertical boreholes shall be spaced at a minimum distance of 20 feet on the center.
   c. Borehole size
      a. Vertical boreholes shall have a diameter large enough to accommodate the U-bend and the tremie pipe.
      b. Tremie pipes shall be one (1) inch in diameter minimum.
   d. Piping manifolds
      a. Piping manifolds shall include the following on both supply and return: pressure gauge, thermometer, purge ports with shut-off valve faced outwards. Provide isolation valves for supply and return branch circuits. Provide balancing valves on return branch circuits.
   e. The engineer shall calculate the purge flow rate (GPM) and pressure and clearly indicate the purge process in design documents. Supply and return circuits shall be flushed and purged with a minimum velocity of two (2) feet per second through all piping sections. The purge flow rate shall be maintained for a minimum of 15 minutes.

C. Products
   a. Piping
      a. All ground-loop heat exchanger pipe and heat-fused materials shall be one of the following:
         i. HDPE
         ii. PEX-A.
      b. SDR
         i. HDPE piping two (2) inches in diameter and smaller shall have a minimum dimension ratio of SDR11.
         ii. HDPE piping pipes three (3) inches in diameter and larger shall have a minimum dimension ratio of SDR13.
         iii. PEX-A piping shall have a minimum dimension ratio of SDR9.
      c. Joining methods
         i. HDPE piping shall be heat fused by butt, socket, sidewall, or electrofusion.
         ii. PEX-A piping shall use electro-fusion fittings in accordance with the piping manufacturer's requirements.
   b. Grout
      a. Grout thermal conductivity shall be a minimum of 0.75 BTU/hr-ft-°F.

D. Execution
   a. Installation
      a. The ground loop heat exchanger installer shall have current IGSHPA accreditation

and be trained by IGSHPA for heat fusion joining procedures.

b. Piping in trenches shall be spaced a minimum of 12 inches apart and located in a sand bed. Provide compacted backfill above the sand bed. Provide continuous tracer wire located no deeper than 24 inches.

b. Flushing and purging
   a. Flushing and purging shall be conducted per contract documents.

c. Testing
   a. The maximum test pressure shall be 150% of the design static pressure less the elevation hydrostatic head.

4-10. Controls

Automation equipment shall meet the following requirements. Note that where specific manufactures or products are indicated as 'basis of design", the engineer's design shall design selected systems around the noted product. The HVAC controls designs shall meet the following requirements.

A. Basis of design manufacturers
   a. The engineer shall include one of the following manufacturers as the basis of design for the following equipment. For specification purposes, other approved manufacturers shall be coordinated with OSU. Where equipment is not listed below, the engineer shall coordinate with OSU regarding the basis of the design equipment manufacturer. Only OSU Automation Systems can approve another manufacture.
   b. Field controllers
      a. Schneider Electric (MNL, MNB series controllers)
      b. Distech
      c. Niagara Edge
   c. Network controllers
      a. Tridium JACE 8000
      b. Vykon Edge
      c. Distech Boss
      d. Jenesys
   d. Laboratory Controls
      a. Phoenix controls
   e. Air Quality Controls
      a. Aircuity
   f. Airflow Monitoting Controls
      a. Paragon Controls

B. General requirements
   a. Provide DDC controls. DDC controls shall communicate via BACnet or (preferred) LoN protocol, or as an alternative, BACnet protocol. For BACnet installations, the instance number and network number shall be obtained from the OSU Automated System Group.
   b. The controls systems shall natively integrate with the existing OSU campus NIAGARA 4 system unless otherwise required by the existing systems and/or specific user requirements. JACE licenses shall have no "to" or "from" connectivity restrictions and must use engineering which is currently implemented by the OSU Automated System Group. JACE shall run the same Niagara version as the existing N4 server.

c. The graphic user interface labeling shall be coordinated with the OSU Automated System Group and OSU Geospatial Systems for point info and labels. Refer to the general equipment labeling requirements.
d. For renovations in existing buildings, new controls shall be compatible with the existing building BAS and systems specifications.
e. All new equipment shall be connected to the DDC and shown on the GUI.
f. Pneumatic controls are allowed only for renovations interfacing with existing pneumatic systems not currently required to be upgraded to DDC controls by OSU.
g. The engineer shall verify that the controls installation drawings do not call for redundant controls points.
h. Engineer shall state in Specifications that the Controls Contractor shall turn over controls scheduling responsibility once the CO has been issued.
i. New JACEs will have a 5-year software maintenance agreement.
j. The control cable for internal FM network communication shall be orange in color.

C. Design
  a. Setpoints
    a. Setpoints, unoccupied setbacks, and dead bands shall be coordinated with and provided by OSU.
    b. Clearly indicate all setpoints, setbacks, and dead bands on the controls drawings.
    c. The engineer shall coordinate with OSU regarding all locations where setpoints shall be user-adjustable or shall include occupant overrides.
  b. Operating modes and schedules
    a. Operating modes and schedules shall be coordinated with and provided by OSU.
    b. The engineer shall provide occupied/unoccupied sequences on controls drawings.
    c. Clearly indicate operating modes and schedules on controls drawings.
    d. Optimal start logic shall be provided for large central equipment serving large spaces or multiple spaces.
    e. Emergency shut-off
      i. The engineer shall coordinate with OSU regarding the requirement for an emergency shut-off for the HVAC system or parts of the HVAC system.
      ii. Where required, provide an emergency shut-off switch in the HVAC controls system to immediately shut down the air distribution system throughout the building, except where interior pressure and airflow control would more efficiently prevent the spread of airborne contaminants and/or ensure the safety of egress pathways.
      iii. The emergency shut-off switch shall be in a secure location to be easily accessible by facility operations personnel. Coordinate with OSU for the required location and quantity of switches.
      iv. In addition to the physical emergency shut-off switches, provide a software emergency shut-off switch at the front end.
      v. The engineer shall coordinate the emergency shut-off switch operation with the fire alarm system, lighting system, security system, and HVAC controls.
  c. Trending
    a. Coordinate with OSU for required points to be trended including the frequency of data recording.
  d. Graphics
    a. The GUI shall clearly indicate where required points are outside of acceptable ranges

(i.e. in an alarm condition).

b. Tridium N4 graphics package will be used. No third-party graphics package requiring usage licensing will be accepted.

e. Alarms
   a. Critical alarms shall be clearly indicated on controls drawings as separate from standard alarms. These critical alarms shall be provided with a separate notification class.
   b. Where mechanical systems related to detecting or addressing conditions hazardous to the occupants are present, provide signage and visible and/or audible alarms to alert occupants to unsafe conditions. Coordinate with the UA for all visible signage.
f. Laboratory controls
   a. Provide face velocity controllers and FCVs for all VAV hoods.
g. Hydronic controls
   a. Minimum flow rates
      i. The controls shall be designed to maintain minimum required flows for pumps, chillers, other equipment, and any other required minimum flow rates associated with the hydronic system.
      ii. Minimum flow rates shall be clearly indicated in project schedules.
   b. Sensor locations
      i. The engineer shall determine the location for differential pressure sensors to provide proper operation of variable flow systems.
      ii. The engineer shall review the piping layout and provide multiple sensors as necessary if multiple main branches could be the hydraulically most remote branch. The most remote sensor shall control the operation of the pump.
   c. Provide HOA switches for all pumps that are not provided with VFDs. Locate the HOA switch near the served equipment.
   d. Control valves
      i. All control valves indicated on the control drawings and specifications shall be consistent with HVAC details, legends, and HVAC specifications.
      ii. All control valves shall be connected to the DDC system.
      iii. Control valves shall be located as required by the manufacturer to provide for proper operation and control and shall be sized to prevent cavitation.
      iv. OSU has standardized the use of Belimo PICCV valves on AHU coils only. Use standard globe, butterfly, or ball valves in all other applications.
h. Air-side controls
   a. Constant volume systems
      i. Constant volume airflow systems shall avoid part-load short-cycling and resulting high humidity conditions.
      ii. The engineer should consider including multiple compressors or refrigerant circuits, hot gas reheat, multi-stage, digital scroll or variable compressors, and other short cycling limiting controls sequences or the engineer should consider providing a VAV design capable of controlling humidity independently of space temperature.
   b. Single-zone VAV systems
      i. For packaged rooftop equipment serving large open spaces, provide single-zone variable air volume sequences.
      ii. All required VFDs and controls shall be factory-mounted and programmed.

c. Demand control ventilation
    i. For new construction, use DCV for any space with an occupancy greater than 15 people. DCV shall be as per the requirements of ASHRAE 62.1.
    ii. For renovations, the engineer shall review the existing conditions of the air handling equipment and controls with OSU and coordinate the appropriate application of DCV or constant volume outside air introduction.
d. Provide factory-installed airflow monitoring stations where feasible on DOASs and central station AHUs to ensure minimum airflow is provided at all operating modes.
e. Fire alarm coordination
    i. All required interfacing of AHUs, EFs, HVLS fans, and other equipment with the FACP shall be clearly shown on the controls drawings.
    ii. Required shutdown relays from the FACP to HVAC equipment shall be noted and shown to be located within three (3) feet of the controlled device or circuit.
    iii. HVLS fans shall be provided with a shutdown relay or other method of interface with the FACP to shut down upon detection.
f. Economizing
    i. Include economizing as per the requirements of the latest OSU accepted version of ASHRAE 90.1.
    ii. Where economizing is applied, dual enthalpy type economizing is required.
    iii. The engineer shall confirm the building is provided with a method for pressure relief and any controls associated with relief are included on the controls drawings.
    iv. Economizing shall be locked out when the outside air temperature is greater than 70 (adjustable).
    v. Where energy recovery is used, follow the manufacturer's recommendations for controls relating to economizing.
g. Gas sensors and detection
    i. CO, CO2, and other gas or vapor detection systems panels and sensors shall be clearly indicated on contract documents.
    ii. The location of refrigerant gas monitor panels and sensors shall be clearly indicated on contract documents. Details of the requirements and operation of the refrigerant detection system shall be coordinated with the HVAC ventilation system controls and setpoints for alarms shall be clearly indicated. Refrigerant detection systems shall be in accordance with applicable codes and the latest version of ASHRAE Standard 15.
h. Sensor locations
    i. Locate duct humidity sensors at least 15 feet downstream of humidifiers or in accordance with the humidifier manufacturer’s requirement.
    ii. The engineer shall determine the location for differential pressure sensors to provide proper operation of variable flow systems. The engineer shall review the ductwork layout and provide multiple sensors, as needed, for any one of the multiple main branches that are hydraulically remote. The most remote sensor shall control the operation of the fan.
i. Field controllers and mechanical equipment shall be capable of operating in a stand-alone configuration should the network device (JACE) fail. The only logic which should reside on the JACE is that for schedules, alarms, resets, and setpoints. The controlling programs should reside in the field controllers.

j. HOAswitches
    i. Provide HOA switches for all main system fans (excluding small restroom fans, local exhaust fans, and fans in packaged unitary equipment) that are not provided with VFDs. Locate the HOA switch near the equipment that it serves.
k. All motorized dampers shall be connected to the DDC system.

D. Products
a. Thermostats
    a. To be used only in Residential Life areas and buildings not tied into the central building automation system.
    b. Thermostats shall be 7-day and weekday/weekend programmable and shall be equipped with LCD displays.
b. Sensors
    a. Buildings tied into the central building automation system should use sensors without displays.
c. Laboratory controls products
    a. FCVs shall be closed-loop, fast-acting, and pressure-independent types.
    b. FCVs shall be networkable DDC types unless otherwise approved by OSU.

E. Execution
a. General installation requirements
    a. Provide steel channel structural support for any actuators installed on less than 16 GA sheet metal.
    b. A 115V circuit shall be provided for each controls cabinet. Refer to Section 5: Electrical.
b. Testing
    a. Adequate test ports shall be installed for determining the required controls system temperatures, pressures, voltages, and any other data required to be collected during testing of the controls system.
    b. ASHRAE 110 fume hood tests shall be required for all laboratory fume hoods. Coordinate with OSU EHS for fume hood acceptance criteria.
    c. Test and balance shall include measurement of outside air. Outside air shall additionally be measured at all operating modes for VAV AHUs or other systems delivering outside air with variable-speed or multiple modes.
c. Demonstration
    a. The controls contractor shall demonstrate the following:
        i. All operational modes are functioning as required by the controls drawings.
        ii. Control valves are operating as required by the controls drawings.
        iii. Equipment required to be included on the DDC by the controls drawings is communicating correctly with the DDC system.
    b. The controls contractor shall also provide seasonal testing as required by the contract documents. The engineer shall include such seasonal testing in the project specifications where applicable.
d. Thermostat mounting heights
    a. In spaces other than those designated as ADA, occupant-adjustable thermostats shall be mounted at five (5) feet AFF or per other requirements of the contract documents.
    b. Where spaces are designated as ADA, thermostat mounting height for occupant-adjustable thermostats shall be as per the requirements of ADA.

e. Ethernet drops and IP addresses for JACEs will be provided by OSU.
f. Utility meters
    a. Engineer will clearly call out what utility meters the control contractor is to add to the system and what means of communication.
    b. OSU BTU meter
        i. The controls contractor will install the meter as shown on the mechanical drawing.
        ii. The mechanical contractor will install the temperature wells and flow meter.
        iii. OSU will provide connectivity.
g. Training
    a. The controls contractor shall provide training to OSU including, but not limited to, training regarding all operating modes, alarms, and automatic controls operations.
    b. Software and front-end training shall take place after functional tests are complete.
    c. The controls contractor shall provide both a preliminary facility walk-through (after installation of controls and prior to enclosing or covering equipment) and a final walk-through after installation is complete.

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Section 5: Electrical Guidelines

5-1. Introduction

The following section includes OSU Engineering Guidelines related to electrical systems and associated topics for 1000V or less (within buildings); this section does not include Medium Voltage Distribution. The engineer should review this section and the entirety of these Engineering Guidelines prior to beginning design.

A. Table of contents

B. Abbreviations
   a. AHJ – Authority Having Jurisdiction
   b. AIP – Abandon-In-Place
   c. BAS – Building automation system
   d. DLC – DesignLights Consortium®
   e. EMT – Electrical metal tubing
   f. FFE – Furniture, fixtures, and equipment
   g. GFCI – Ground-fault circuit interrupter
   h. HP – Horsepower
   i. HVAC – Heating, ventilation, and air conditioning
   j. IMC – International Mechanical Code
   k. IECC – International Energy Conservation Code
   l. IES – Illuminating Engineering Society
   m. IT – Information technology
   n. LED – Light-emitting diode
   o. NEC - National Electrical Code
   p. NEMA - National Electrical Manufacturers Association
   q. NRTL – Nationally Recognized Testing Laboratory
   r. PVC – Polyvinyl chloride
   s. RMC – Rigid metal conduit
   t. UA – OSU University Architect
   u. VFD – Variable frequency drive

5-2. General Electrical Engineering Requirements

The following general design requirements shall be incorporated into the engineering design. These guidelines are not all-inclusive. The engineer is required to understand both the content of these guidelines and the specific requirements of the project. Note that where specific manufacturers or products are indicated as the "basis of design," the engineer's design shall include those products where applicable. Equals will likely be allowed and shall be coordinated with OSU.

A. Demolition
   a. Abandoned conductors shall be removed back to the overcurrent device. The device shall then be labeled "SPARE."
   b. Abandoned accessible raceways shall be removed.
   c. Inaccessible raceways may be abandoned in place.
   d. Below-grade raceways shall be cut off flush with the floor or below-grade and grout filled. Mark and label "AIP".

B. Closeout
   a. An authorized manufacturer's representative shall program and configure electrical systems and shall train OSU personnel for the appropriate electrical systems including, but not limited to the following. Training shall be recorded by the contractor with audio and video and a digital copy shall be provided to OSU.
      a. Generator and transfer-switch
      b. Intelligent lighting controls (excludes manual switches and wall-box dimmers)
      c. Uninterruptable power supply
      d. VFDs.
   b. Contractor and or authorized manufacturer's representative shall provide testing of equipment and systems to confirm the operation in accordance with the manufacturer's requirements, the intent of the Contract Documents, and OSU's requirements.
   c. Infrared scanning is not required unless otherwise directed by OSU or unless the engineering analysis shows a potential for the presence of hot spots for existing systems.

C. Seismic
   a. Design shall be completed in accordance with an applicable seismic zone. Electrical engineer shall coordinate with the structural engineer and code.

D. General products requirements
   a. Electrical assemblies where required by code and electrical products shall be listed by an NRTL.
   b. Labeling
      a. Panel and circuit numbers shall be labeled on all junction boxes and wiring device cover plates. Labels shall be clear adhesive with ±3/16" letters. If products are visible to the public, label covers on the backside of the cover.
      b. Equipment labels shall be printed melamine or acrylic. At a minimum, include the equipment name and the panel which serves the equipment.
      c. Provide typed panelboard directories. All spare circuit breakers shall be labeled "spare" in erasable lettering and turned off.

E. Conductors/Cables
   a. Conductor material shall be copper.
   b. Conductor insulation coloring

a. Conductors shall be color-coded based on the following system:
    i. 120/208 Black, Red, Blue, White, and Green
    ii. 277/480 Brown, Orange, Yellow, Grey, Green
    iii. Switch legs and travelers to be provided with colors not listed above (i.e. purple, pink, etc.)
b. Note color-coding system on plans.
c. For conductors 8 AWG and smaller, conductor insulation coloring shall be factory integral.

c. MC cable is allowed only for lighting whips less than six feet long unless approved by OSU.
d. Direct burial cable is prohibited.

F. Grounding
a. Conduit shall not be used as ground. Provide a separate equipment ground conductor. RMC, IMC, and EMT are permitted to be used as ground per NEC 250.118 (2), (3), and (4) respectively.
b. Grounding electrode resistance shall be tested and shall not exceed 5 ohms. Chemically enhanced electrodes are prohibited.

G. Ampacities for Conductors Rated 0–2000 Volts shall be corrected and or adjusted in accordance with NEC 310.15, including:
a. Ambient Temperature Correction Factors: NEC 310.15 (B)(2).
b. Adjustment Factors for More Than Three Current-Carrying Conductors: NEC 310.15 (B)(3)(a).
c. Raceways and Cables Exposed to Sunlight on Rooftops: NEC 310.15 (B)(3)(c).

H. Multiwire branch circuits are prohibited. Furniture circuits are the only exception.

I. Raceways
a. Where EMT and PVC are used, the minimum size shall be 1/2”.
b. Where RMC is used, the minimum size shall be 3/4".
c. RMC shall be used for exterior above grade and where conductors are exposed to damage.
d. Use PVC coated or PVC half-lap tape wrapped RMC elbows below grade. Conduits below 1" do not require RMC below-grade elbows.
e. Use metallic surface raceway only where it is not possible to conceal.
f. Surface raceway is prohibited in new construction.
g. In new construction, provide a minimum of one (1) conduit (minimum one (1) inch diameter) in each direction from the interior electrical room to the outside of the building for future use.
h. Provide space above panels with space for a minimum of three (3) ¾-inch future conduits. Locate panels where additional conduits may be added later.
i. For all new recessed panelboard with unused knockouts, provide a conduit for each knockout in the top of the panel to six (6) inches above the nearest accessible ceiling

J. Conduit fill shall not exceed 40% of the cross-sectional conduit internal area.

K. Wiring Devices
a. Use metallic weatherproof in-use receptacle covers for exterior locations and metallic weatherproof not in-use or weatherproof in-use for interior wet locations.
b. Receptacles shall be 20A, commercial-grade minimum.
c. Receptacle ground pin shall be oriented downwards.
d. Coordinate wiring device color and wiring device cover plate color with the architect, interior designer, and or OSU.

L. It is preferred that a maximum of eight (8) receptacles be connected to a 20A circuit.

M. Furniture systems
   a. The engineer shall coordinate the wiring configuration with the selected FFE selection and manufacturer.
   b. Multiwire systems are allowed for furniture systems only.

N. Power to IT and control panels
   a. Provide at minimum a 20A 120V circuit for fire alarm power supply in each dedicated electrical room or where the fire alarm panel is located by fire alarm engineer or contractor. Connect the circuit to emergency power if required by code. The circuit breaker shall be provided with a red lock-on accessory.
   b. Provide at minimum a dedicated 20A 120V circuit for HVAC control power supply in each dedicated electrical room or where BAS panel is located by the mechanical engineer or contractor. Connect the circuit to emergency power if required by code.
   c. Coordinate with OSU regarding required IT room power.
   d. Provide at minimum a dedicated 20A 120V circuit for OSU furnished data logger (RSG45) at its installed location.

O. Specific outlet requirements
   a. TV outlets shall consist of a 4" square box and a 3/4" (minimum) conduit to accessible ceiling space. Conduit shall be provided with a bushing and pull string. A duplex receptacle shall be provided adjacent to the TV box. Consolidate all like boxes.
   b. Data/phone outlets shall consist of a 4" square box with a 3/4" (minimum) conduit to accessible ceiling space. Conduit shall be provided with a bushing and pull string. A duplex receptacle shall be provided adjacent to the data box. Consolidate all like boxes.
   c. Provide a data outlet at all meters required throughout these Guidelines or by OSU to be provided with a data connection to the BAS.
   d. Meeting rooms shall be provided with outlets per NEC 2017.
   e. Electric water coolers shall be provided with a readily accessible GFCI receptacle. A GFCI receptacle is preferred over a GFCI circuit breaker.
   f. All receptacles in mechanical rooms shall be GFCI type.

P. Exterior
   a. Use factory-furnished convenience receptacle in HVAC equipment where available and where installed in accordance with NEC Article 210.63.

Q. Lightning Protection
   a. If a lightning protection system (LPS) is required by OSU, the following shall apply:
      a. Copper conductors are preferred for lightning protection.
      b. The lightning protection contractor shall be certified and shall provide shop drawings showing the conductor path for review.
      c. With the exception of the lightning rod/point, all lightning protection components, including down leads, shall be concealed from view.
      d. Installed equipment shall be certified by UL.

R. Penetrations to Firewalls and Fire Rated Floors
   a. When electrical wiring, premise wiring, low voltage, and/or data/telecommunication cable must penetrate through firewalls and fire-rated floors constructed of concrete, gypsum or

      CMU, the designer shall specify as the basis of design the Hilti Firestop Speed Sleeve or Extended Sleeve system(s) to allow for re-penetrable cable management.

S. Junction Boxes, conduit bodies, and handhole enclosures to be readily accessible. Boxes,

conduit bodies, and handhole enclosures shall be installed so that the wiring contained in them can be rendered accessible without removing any part of the building or structure or, in underground circuits, without excavating sidewalks, paving, earth, or other substance that is to be used to establish the finished grade as per Code.

5-3. Interior Lighting

The electrical engineer shall use the following guidelines when designing lighting systems.

A. General requirements
   a. All fixtures shall be LED unless otherwise agreed to by OSU.
   b. Stairwell fixture shall be provided with sensor controls, the basis of design shall be Lutron 80/20.
B. Assemblies, such as light fixtures, shall be NRTL listed.
C. DLC-certified light fixtures are preferred.
D. Provide manufacturer's standard warranty for electrical equipment.
E. Interior lighting
   a. Typical Designs for Spaces:
      a. Offices: Toggle switch, dimmer, and vacancy sensor.
      b. Labs and Kitchens: Toggle switch, dimmer, and vacancy sensor.
      c. Conference Rooms: Toggle switch, dimmer, and vacancy sensor.
      d. Restrooms: Occupancy sensor.
      e. Hallways, Common Gathering, and Transition: Toggle switch and vacancy sensor.
      f. Classrooms: Toggle switch with multiple circuits, dimmers, and vacancy sensors.
      g. Where 2’x2’ or 2’x4’ troffers are used, refer to Appendix H for the basis of design. Designer shall determine appropriate lumens.
   b. Lighting design
      a. Foot-candle levels for interior lighting shall comply with the most current IES recommendations and code requirements.
      b. Light correlated color temperature shall be 4000K.
      c. Color rendering index shall be 80 CRI (minimum) for interior fixtures
   c. Lighting controls
      a. Analog lighting control is preferred, see above for typical Designs of space. OSU prefers behavior-based light control. If designed, the application of Digital lighting controls shall be simplistic with the programming understandable and maintainable locally by the end user. The ease of maintenance and reprogramming should be considered when selecting a system. The basis of design shall be the Lutron Vive™ Lighting Control System. All digital lighting control designs shall be reviewed and approved case by case by OSU.
      b. Automatic lighting control systems should not be connected to the BAS.
      c. Where dimmers are specified, provide 0-10V dimmers.
   d. Daylight harvesting is preferred where feasible and where required by the latest OSU-adopted version of IECC.
   e. 24-hour night lights shall not be used unless approved by OSU.
   f. Egress and exit signage
      a. Exit signage type shall be coordinated with the UA and AHJ. Basis of design for exit lights is Lithonia Lighting EDG W 2 G EL (green), Batter Back-up or EDG W 2 G (green), Non-Battery for Generator buildings.

b. The use of remote head egress fixtures shall not be used unless approved by Facilities Management.
c. The power source for egress and exit signage shall be the life safety generator if it is available for that use. If a life safety generator is not available, battery packs or inverters shall be used. In locations difficult to access, use inverters. Refer to Section 5.5: Distribution section of the Electrical Engineering guidelines for guidance determining when a life safety generator is required.
d. Foot-candle levels and exit/egress lighting locations (interior and exterior) shall be provided in accordance with the applicable codes, including the International Building Code.
e. Egress lighting shall use regular building fixtures, unless approved by Facilities Management. If egress lighting not on a generator and inverters or battery packs are used, and external test button is required.

g. Retrofit lighting kits may be used on renovation projects where approved by OSU.
h. Wrap all light and ceiling tile wire pigtails to prevent injury potential to above-ceiling workers. This shall apply to both new and renovation construction activities.

5-4. Exterior Lighting

The electrical engineer shall use the following guidelines when designing lighting systems.

A. General requirements
   a. All fixtures shall be LED unless otherwise agreed to by OSU.
   b. Refer to Appendix E for OSU roadway, pedestrian, bollard architectural light fixture standards for exterior lighting.
   c. Mechanical timeclock control of exterior fixtures is prohibited.
B. Assemblies, such as light fixtures, shall be NRTL listed.
C. DLC-certified light fixtures are preferred.
D. Provide manufacturer's standard warranty for electrical equipment.
E. Exterior
   a. Lighting design
      a. Refer to Appendix E for outdoor lighting standards.
      b. Foot-candle levels for exterior lighting not listed in Appendix E shall comply with the most current IES recommendations. All foot-candle levels shall comply with code requirements.
      c. Lighting calculations shall be provided to OSU for review. Refer to Appendix E for requirements for illumination plots.
      d. Color rendering shall be 70CRI (minimum) for exterior fixtures
      e. Utilize 4000K correlated color temperature (CCT) for all exterior fixtures not listed in Appendix E.
   b. Lighting controls
      a. One photocell per building via lighting contactor shall control all exterior lighting for the associated building. These shall not be tied to the BAS. Coordinate photocell usage with OSU.
   c. Lighting circuitry shall be as per the requirements of the code.
   d. All wiring shall be in Schedule 40 PVC conduit except street crossing shall have Schedule 80.
   e. The minimum depth requirement of conduits is 24" unless otherwise noted. All the other

specific locations shall comply with the NEC Table 300.5.

f. All lighting circuits around a building shall be fed from a building electrical panel. For new installations: Roadway and Parking Lot – 480 single-phase; Post Top and Bollard – 120V. Refer to Appendix E and Section 5: Electrical Guidelines for additional information.

5-5. Distribution

The electrical engineer shall use the following guidelines when designing distribution systems

A. All exterior equipment (e.g. transformers, sectionalizing switches, generators, etc.) shall be coordinated with the UA and OSU ES Utilities Engineering.
B. In new construction, provide space in the main electrical room for at least one future panel.
C. Panelboard directories shall be updated and typed.
D. Housekeeping pads are required for all floor-mounted electrical equipment including transformers and switchboards. Pads shall be six (6) inches tall (minimum) and shall extend a minimum of two (2) inches beyond the footprint of the equipment.
E. Bus ducts are prohibited.
F. Panelboards and breakers
    a. Panelboard bus material shall be either tin-plated aluminum or copper.
    b. Breakers
        a. Bolt-on-type circuit breakers are required for new construction and new panelboards.
        b. Twin circuit breakers are prohibited.
        c. Panelboard/circuit breakers shall be fully rated; series rated circuit breakers systems are prohibited.
        d. If adjustable trip circuit breakers are used, a coordination study must be completed. Breakers shall be adjusted according to the results of the study.
    c. Provide 20% space or spares and provide 35% additional load capacity in new panelboards.
    d. For new panelboards and breakers in existing buildings, the basis of products shall match the existing products in use in the building. Where multiple types of products are in use in an existing building, coordinate with OSU to determine the basis of design.
    e. Load centers shall not be used unless approved by OSU.
    f. Provide an arc flash study where required by code and provide labels on panelboards that represent the results of the study.
    g. Do not use handle-ties to provide required simultaneous disconnecting means; use 3- pole or 2-pole circuit breakers as appropriate.
G. Switchboards
    a. Switchboard bus material may be tin-plated aluminum or copper.
    b. Provide 20% space or spare capacity and for new construction provide 35% additional load capacity for future.
H. Disconnect switches shall be heavy-duty and lockable. Provide labels on the disconnect switch that represent the results of the arc flash study.
I. Motor starters shall be NEMA configuration.
J. Variable frequency drives (VFD)
    a. Manufacturers
        a. Basis of design shall be ABB ACH 580 ULH drive.

b. Do not include Yaskawa VFDs as the basis of design.

b. VFDs shall be installed indoors unless approved by OSU.

c. Provide internal disconnect.

d. OSU engineer's approval shall be gained before providing bypass or hand mode to the VFD application.

e. Provide internal line conditioning.

f. Provide motor shaft grounding on motors 20 HP or larger.

K. Provide surge protection on all electrical utilities at the demarcation, included but not limited to:

a. Service entrance of Electrical

b. Service entry of Telephone

c. Service entry of Data

L. Provide a means of arc energy reduction where required by code. The engineer shall determine the type of arc energy reduction required for the application.

M. Breaker and disconnect requirements

a. The switchboard main circuit breaker shall be in a section with a barrier separate from the branch breaker section.

b. Except for safety switches, where possible, use circuit breakers for overcurrent protection in lieu of fuses.

c. Coordinate with other trades to specify factory-installed equipment disconnects where they are available.

N. Panelboards shall be named per the following convention:

a. L/H, Floor #, alphabetic, (e.g. Low Voltage panel, floor three, first panel: "L3A").

b. For emergency generator panels add G prefix (e.g. Low Voltage Emergency panel, floor three, first panel: "GL3A")

c. Transformers shall use a similar naming convention to panels (e.g. "T3A").

O. Medium Voltage Transformers Distribution

a. Refer to Section 2: Site Utilities, Electrical Distribution section.

P. Generators

a. OSU prefers to include a life safety generator. The final requirement for a life safety generator to be provided shall be based on consultation with the OSU AHJ.

b. Life safety generators shall be used only for the purposes of life safety unless otherwise approved by OSU and allowed by code.

c. Manufacturers

a. Basis of design generators shall be by Cummins, Kohler, Cat, Generac, or MTU.

b. The generator manufacturer shall be the same as the transfer switch manufacturer unless otherwise approved by OSU.

d. Generators shall be UL 2200 listed per the requirements of IMC, and EPA certified. (EPA compliant is not acceptable).

e. Fuel

a. Generators shall be natural gas type. Confirm availability and dependability of natural gas sources.

b. Where diesel generators are approved by OSU or are existing, provide 24-hour minimum runtime or as required by code.

f. Startup

a. The generator/automatic transfer switch systems shall be provided with factory startup prior to substantial completion at the site. The contractor/manufacturer shall notify

OSU a minimum of two weeks prior to startup.

b. All generators shall be provided with a 4-hour load bank test.
c. The engineer shall confirm in design that access to the generator for load banks is maintained.
d. Contractor shall submit the results of the generator/ automatic transfer switch systems startup to OSU.

g. Transfer switches shall be installed inside the building unless approved by OSU
h. Provide a remote annunciator for life-safety generators. Locate annunciator in a monitored area.
i. BAS monitoring of generator is not required.
j. Generator may be installed outdoors if approved by OSU. Provide weatherproof enclosure for outdoor installation.
k. For generators installed outdoors, the color of the generator, the physical size of the generator, securement, and equipment yard design shall be approved by the UA.
l. The engineer shall specify the sound level.
m. Provide a sound attenuated weatherproof enclosure if the generator is located near a residential area or any other noise-sensitive area.
n. Generators located inside the building are not preferred.
o. Provide a minimum of one (1) duplex receptacle within 25 feet of the generator.
p. Transfer switch bypass is not required unless required by code or applicable to the installation.
q. Provide one (1) spare conduit from the interior electrical room to the generator.
r. High-leg Delta transformers are not permitted in new construction.