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DIVISION 41: MATERIAL PROCESSING AND HANDLING EQUIPMENT

DIVISION 42: PROCESS HEATING, COOLING, AND DRYING EQUIPMENT
DIVISION 43: PROCESS GAS AND LIQUID HANDLING, PURIFICATION, AND STORAGE

DIVISION 44: POLLUTION CONTROL EQUIPMENT

DIVISION 45: INDUSTRY-SPECIFIC MANUFACTURING EQUIPMENT

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01 74 00 – Cleaning and Waste Management

1. Introduction

The University, Durham County, and North Carolina are committed to reducing waste and the use of landfills. Waste reduction and recycling practices aren’t limited to routine day-to-day functions and events on campus; they also apply to construction and renovation activities. Construction waste management practices include deconstruction, reuse, salvage, recycling and disposal.

Proper waste management and waste avoidance are to be considered in decisions made during all stages of the capital project planning and the construction process. Those involved with the design and the construction of buildings on campus are to have the knowledge and resources needed to avoid waste and manage the resulting waste in a manner that allows for the least environmental impact.

A. This Construction and Design standard for cleaning and waste management provides an overview of University requirements for waste management and recycling requirements. This document is to be used in conjunction with other related sections listed below:

   01 74 16   Site Maintenance
   01 74 19   Construction Waste Management and Disposal

2. References

A. The site (http://deq.nc.gov/conservation/recycling) provides information regarding the management of recycling in North Carolina.

B. NC General Statute 130A-309.10(f).

C. Durham County Regulations.

D. University policy regarding hazardous materials.

E. Regulations pertaining to construction waste disposal.

F. The 1997 “Statement on Voluntary Measures to Reduce, Recover, and Reuse Building Construction Site Waste” released by the American Institute of Architects and the Associated General Contractors of America

G. EPA Comprehensive Procurement Guidelines (CPG)

3. Definitions

A. Clean: Untreated and unpainted; not contaminated with oils, solvents, caulk, or the like.
B. Commingling: Mixing recyclable Construction and Demolition material in one waste container. Materials Recovery Facilities (MRF) exists to sort and recycle commingled materials off-site.

C. Construction and Demolition Waste: Includes all non-hazardous solid wastes resulting from construction, renovations, alterations, repair, and demolition.

D. Hazardous: Exhibiting the characteristics of hazardous substances, i.e., ignitability, corrosiveness, toxicity or reactivity.

E. Material Recovery Facility (MRF): A processing facility designed to sort and separate recyclables based on market needs and material components.

F. Non-hazardous: Exhibiting none of the characteristics of hazardous substances, i.e., ignitability, corrosiveness, toxicity, or reactivity.

G. Nontoxic: Neither immediately poisonous to humans nor poisonous after a long period of exposure.

H. Recyclable: The ability of a product or material to be recovered at the end of its life cycle and remanufactured into a new product for reuse by others.

I. Recycling: The process of sorting, cleansing, treating and reconstituting solid waste and other discarded materials for the purpose of using the altered form. Recycling does not include burning, incinerating, or thermally destroying waste, but can be conducted on-site (as in the grinding of concrete and reuse on-site).

J. Return: To give back reusable items or unused products to vendors for credit.

K. Reuse: To reuse a construction waste material without altering its form on the Project site or elsewhere.

L. Salvage: To remove a waste material from the Project site to another site for resale or reuse by others.

M. Sediment: Soil and other debris that has been eroded and transported by storm or well production runoff water.

N. Source Separation: The act of keeping different types of waste materials separate beginning from the first time they become waste in order to reuse or recycle them.

O. Toxic: Poisonous to humans either immediately or after a period of exposure.

P. Trash: Any product or material unable to be reused, returned, recycled, or salvaged.

Q. Volatile Organic Compounds (VOCs): Chemical compounds common in and emitted by many building products over time through off-gassing: solvents in paints and other coatings; wood preservatives; strippers and household cleaners; adhesives in
particleboard, fiberboard, and some plywood; and foam insulation. When released, 
VOCs can contribute to the formation of smog and can cause respiratory tract problems, 
headaches, eye irritations, nausea, and damage to the liver, kidneys, and central 
nervous system, and possibly cancer.

R. Waste: Extra material or material that has reached the end of its useful life in its intended 
use. Waste includes salvageable, returnable, recyclable, and reusable material.

S. Waste Management Plan: A Project-related plan for the collection, transportation, and 
disposal of the waste generated at the construction site. The purpose of the plan is to 
ultimately prolong the useable life of waste materials and reduce the amount of material 
being landfilled.

4. Construction Waste Management Hierarchy

A. Building Materials and Components

1. Reuse in project
2. Reuse on campus
3. Recycle (grinding wood for mulch, metal shelves recycled)
4. Disposal (in accordance with state regulations)

Examples:

Marble bathroom partitions, slate roofing, mechanical equipment, stone, carpet, fixed 
furniture, auditorium seats, wall cabinets

B. Fixtures, Furniture and Equipment

1. Reuse by department
2. Reuse on campus (Surplus or Duke Recycles Free Store)
3. Disposal (in accordance with state regulations)

Examples:

Bulletin boards, clocks, pencil sharpeners, desks, chairs, lab equipment, A/V equipment, 
capital assets

C. Construction Waste Management: Project goals for recycling, the solid waste 
management plan, and reporting requirements

1. Waste Management Definition
2. Waste Management Goals
3. Waste Management Plan (See 01 74 19 Construction Waste Management and 
   Disposal)
4. Management Plan Implementation
5. Special Programs
D. Selective Demolition: Project and University requirements regarding disposal and removal of equipment and materials.

5. Specifications

The Contractor shall be responsible for knowing and complying with regulatory requirements - Federal, State and Local - pertaining to the legal disposal of all construction and demolition waste materials, including but not limited to the following:

A. N.C. General Statute 130A (Items Banned from NC Landfills)

1. Antifreeze – effective July 1, 1994
3. Beverage containers from ABC permit holders – effective January 1, 2008
4. Lead-acid batteries - effective January 1, 1991
5. Plastic bottles - effective October 1, 2009
6. Scrap (whole) tires – effective March 1, 1990
7. Wood pallets (may be disposed in C&D landfill) – effective October 1, 2009
8. Yard Waste – effective January 1, 1993
9. Motor Oil – effective October 1, 1990
10. Motor Oil Filters – effective October 1, 2009
11. Aluminum Cans – effective July 1, 1994 (also banned from disposal in incinerators)
13. Electronics (e.g. TVs, Computers, and Cell Phones) – effective July 1, 2011

B. Durham County Regulations

In 1997 Durham passed an ordinance making it unlawful to place target recyclables in the garbage. The ordinance applies to all waste generators – residential, commercial, and industrial. Target recyclables currently include:

1. Aluminum cans
2. Steel cans
3. Glass bottles and jars
4. Newspaper
5. Plastic bottles
6. Corrugated cardboard
8. Televisions – effective January 1, 2011

For additional information you can go to (http://durhamnc.gov/871/Recycling-Laws).

C. University policy regarding hazardous materials: Contact Duke’s Occupational & Environmental Safety Office for the current policy.

4. Suggested Waste Management Goals
Within the limits of the construction schedule, contract sum, and available materials, equipment, products and services, the Owner has established that this Project shall generate the least amount of waste possible and employ processes ensuring the generation of as little waste as possible.

The Contractor should develop, for the Architect's and owner's review, a Waste Management Plan for the Project consistent with these goals.

A. Minimize the amount of C&D (construction and demolition) waste initially generated by such methods as efficient use of materials, appropriate planning, proper storage, prevention of breakage and damage to materials, avoidance of excess packaging and source separation of waste.

B. Of the inevitable waste that is generated, as many of the waste materials as economically feasible shall be reused, salvaged, or recycled. Waste disposal in landfills shall be minimized. Consistent with LEED criteria, the project goal is to reuse, salvage, or recycle a minimum of 50% of the wastes generated by weight on demolition/renovation projects and 75% on new construction.

C. Use recycled, salvaged, renewable and recyclable building materials.

D. Designing buildings surrounded by green space is a guiding principle of campus planning at Duke. The University has demonstrated a strong commitment to infill buildings while preserving and creating green space. With regard to building planning, Duke has made significant commitments to green design and construction, including committing that all new construction and major renovations will achieve Leadership in Energy and Environmental Design (LEED) Certification Standards with a goal of LEED Silver. (http://sustainability.duke.edu/campus_initiatives/buildings/index.html)
01 74 19 – Construction Waste Management and Disposal

To meet the University’s waste management goals a Waste Management Plan should be developed. Components of an acceptable plan should contain, but are not limited to the following:

1. Waste assessment

   An analysis of the proposed jobsite wastes to be generated, including types and estimated quantities. This assessment includes salvageable materials as well as recyclables and trash.

   A. Materials for reuse in project: (Designer should modifies list as appropriate.)
      1. Slate roof
      2. Wood flooring
      3. Brick pavers
      4. Stone walls
      5. Architectural details
      6. Building equipment
      7. Program equipment

   B. Materials for reuse on campus: Contractor delivers to Owner. (Designer lists materials here)

   C. Materials which must be recycled by law:
      1. Beverage containers
      2. Cardboard
      3. Clean dimensional wood and pallets
      4. Scrap metal, including but not limited to metals from banding, stud trim, ductwork, piping, rebar, roofing, other trim, steel, iron, galvanized sheet steel, stainless steel, aluminum, copper, zinc, lead, brass, and bronze
      5. White goods

   D. Materials to be Recycled (project specific):
      1. Suggested Salvageable Materials - items to be considered include but are not limited to:
         a. Slate roof
         b. Wood flooring
         c. Brick pavers
         d. Stone walls
         e. Architectural details
         f. Building equipment
g. Program equipment

2. Other Recyclable Materials - items to be considered include but are not limited to:
   a. Asphalt
   b. Bricks
   c. Ceiling tile
   d. Concrete
   e. Concrete Masonry Units (CMU)
   f. Drywall
   g. Paint
   h. Plastic buckets

2. Landfill Options

   The name of the landfill(s) where trash will be disposed of, the applicable landfill tipping fee(s), and the estimated cost of disposing of all Project waste in the landfill(s). This estimate will be used as a baseline for recycling/salvage cost comparison.

3. Waste Diversion Economic Analysis

   A list of each material proposed to be salvaged, reused, or recycled during the course of the Project, the proposed local market for each material, and the estimated net cost savings or additional costs resulting from separating and recycling (versus landfills) each material. "Net" means that the following have been subtracted from the cost of separating and recycling:

   • Revenue from the sale of recycled or salvaged materials
   • Landfill tipping fees saved due to diversion of materials from the landfill
   • Replacement value of materials reused in the project

   The Sanitation and Recycling Office suggests once the Owner has determined which of the recycling options addressed in the Draft Waste Management Plan are acceptable, the Contractor should provide a Final Waste Management Plan.

   It is suggested that the Final Waste Management Plan should contain the following:

   A. Contact information: The name and contact information of who will be responsible for implementing the Solid Waste Management Plan.

   B. Meetings/instruction: A description of the regular meetings to be held to address waste management.

   C. Waste assessment: An analysis of the proposed jobsite wastes to be generated, including types and estimated quantities.
D. **Alternatives to landfilling:** A list of each material proposed to be salvaged, reused, or recycled during the course of the Project.

E. **Landfilling information:** The name of the landfill(s) where trash will be disposed of, the applicable landfill tipping fee(s), and the estimated quantity of waste to be landfilled.

F. **Materials Handling Procedures:** A description of the means by which any waste materials will be protected from contamination, and a description of the means to be employed in handling the materials consistent with requirements for acceptance by designated facilities.

G. **Transportation:** A description of the means of transportation of recyclable materials and waste (whether materials will be site-separated and self-hauled to designated centers, or whether mixed materials will be collected by a waste hauler and removed from the site) and destination of materials.

H. **Cost estimate summary:** The estimated cost of implementing the final solid waste management plan, broken down by material.

4. **Suggested Implementation and Documentation of Waste Management Plan**

A. **Manager:** The Contractor shall designate an on-site party (or parties) responsible for instructing workers and overseeing and documenting results of the Waste Management Plan for the Project.

B. **Distribution:** The Contractor shall distribute copies of the Waste Management Plan to the Job Site Foremen, Subcontractors, the Owner, the Architect, and the Sanitation and Recycling Office.

C. **Instruction:** The Contractor shall provide on-site instruction of appropriate separation, handling, and recycling, salvage, reuse, and return methods to be used by all parties at the appropriate stages of the Project.

D. **Separation facilities:** The Contractor shall designate and label a specific area to facilitate separation of materials for potential recycling, salvage, reuse, and return. Recycling and waste bin areas are to be kept neat and clean and clearly marked in order to avoid contamination of materials.

E. **Hazardous wastes:** Hazardous wastes shall be separated, stored, and disposed of according to local regulations.

F. **Documentation:** The Contractor shall submit a **Summary of Waste Generated** by the Project each time a progress report is made.

   1. Disposal information:
a. Amount (in tons or cubic yards) of material landfilled from the Project
b. Identity of the landfill
c. Total amount of tipping fees paid at the landfill
d. Total disposal cost (including transportation and container rental)
e. Weight tickets, manifests, receipts, and invoices (attach copies)

2. Recycling information:
   a. Amount (in tons or cubic yards)
   b. Date removed from the jobsite
   c. Receiving party
   d. Transportation cost
   e. Amount of any money paid or received for the recycled or salvaged material
   f. Net total cost or savings of salvage or recycling each material
   g. Manifests, weight tickets, receipts, and invoices (attach copies)

3. Reuse and salvage information:
   a. List of items salvaged for reuse on project or campus
   b. Amount (in tons or cubic yards)
   c. Receiving party or storage location
   d. Net savings (avoided tip fee and cost difference of item purchased new)

G. **Revenues:** Revenues or other savings obtained from recycled, reused, or salvaged materials shall accrue to contractor unless otherwise noted in the contract documents.
11 82 13 – Solid Waste Bins

1. Introduction

   A. This Construction and Design standard covers solid waste bins guidelines including equipment placement and access, pads, bollards, screening, drainage and lighting required for trash dumpsters, roll off containers and food bins. This document is to be used in conjunction with other related sections listed below:

   - 11 82 26 Waste Compactors and Destructors
   - 11 82 23 Recycling Equipment
   - A11 82 13 Solid Waste Bins Appendix

   B. Design considerations for waste and recycling containers must be based on the building’s usage and occupancy.

      1. Site dimensions and configurations should be adjusted accordingly. Ideally, the recycling carts and dumpsters will be on the same pad in the same enclosure.

      2. In some cases it is necessary for the dumpsters (or compactors) to be located on separate pads from the carts.

      3. A variety of programs, i.e., animal bedding, grease, and food waste collection can also utilize these stations.

      4. The Sanitation and Recycling Office should be contacted to help determine the number of solid waste bins needed, size and type of any additional equipment.

2. References

   A. This site [www.p2pays.org/food/main.oil.htm] provides information regarding fats, oils and grease (FOG) management in North Carolina.

   B. NC General Statute 130A-309.10(f).

   C. Durham County Regulations.

   D. University policy regarding hazardous materials.


3. Design Standards

   A. All buildings must have a trash dumpster or compactor.

   B. Trash Dumpsters

      1. Trash dumpsters must be accompanied by a unit for cardboard collection.
2. All food service dumpsters are required to have drains to a sanitary sewer.

3. The quantity, size, and type of dumpsters needed are dependent on the building use and size. When volume or special needs dictate a larger dumpster, compactors are recommended. These may be used for trash or cardboard.

4. Always try to use the largest container possible for the space while allowing for easy loading of materials by workers.

5. All dumpsters must meet or exceed these specifications.

C. Roll-off Containers

1. Theatres, art studios, and maintenance shops often produce bulky waste such as construction debris, pallets, scrap metal, etc. on a regular basis may include theatres (set striking debris) and maintenance shops (Athletics, Facilities Services, etc.) that cannot be collected in front load dumpsters. Open top roll-off containers must be sited in some instances.

2. Other areas utilize roll-off containers seasonally or temporarily for special events such as festivals, sporting events or student move-in and move-out.

3. Position the container pad such that the truck can back straight up to the compactor. To do this, take into consideration the turning radius, truck length, and angle of approach.

D. Food Bins

E. Placement and Access

1. Position the dumpster pad such that the truck can approach the containers head on. To do this, take into consideration the turning radius, truck length, and angle of approach.

2. Dumpsters are to be serviced by a front load truck.

3. If the design includes outdoor recycling bins, there must be a ramp at least 5’ wide for access to the recycling containers.

4. All containers shall be located on an accessible path of travel per the ADA and State Building Code.

F. Pads

1. The pad for the standard outdoor service area must be at least 12’ x 12’ for a single dumpster, and 14’ deep x 24’ wide to accommodate both dumpsters and outdoor recycling bins.
2. Each pad is to include a 5’ deep apron to support truck wheels. Slope pad such that water does not pool around dumpsters or carts.

3. The pad should be a minimum of 3,000 PSI concrete, with #4 bars at 12” on center each way, and 6” thick. Pour the pad on compacted earth with a minimum base of 4” ABC stone. These are minimum requirements.

4. Final structural design of the pad shall be based on project requirements.

5. Dumpster pads shall be designed to not allow any other surface drainage into sanitary sewer.

G. Bollards

1. Bollards are required for all dumpsters.
   a. Use bollards at the wall entrances by the dumpsters to protect the walls from being hit by the service truck.
   b. Use bollards behind the container to protect the walls from being hit by the dumpster.

2. Bollards are to be 6” in diameter and filled with concrete. These should be located 12” from the center of the bollard to the rear of the pad (or screen wall).

3. The bollards shall be 6’ 6” in total length with at least 2’ set in reinforced concrete.

4. Finish the bollards with one coat exterior metal primer, and two coats exterior safety yellow.

H. Screening

1. Where required, use enclosure walls to screen sites from public view with constructed elements and landscaping. An enclosure is required for all outdoor service areas unless exempted by the Architects Office.

2. The interior and exterior enclosure walls shall be determined by the University Architect or other appropriate person or office.

3. Match the exterior architectural finishes of the adjacent building(s).

4. Enclosure walls shall have weeps evenly spaced around the bottom edge to allow for drainage. The weeps and the grade of the floor shall direct the run-off into landscaped areas rather than onto concrete sidewalks and driveways.

5. The minimum recommended wall height to screen dumpsters is 7’ and to screen carts is 4’.
6. Consideration should be given to maintaining visibility for vehicular and pedestrian safety issues.

7. Priority should be given to any power requirements or drainage needs of the units.

8. Do not install any piping equipment, utility walls or access hatches inside the outdoor service area enclosure.

9. All walls should meet current building codes.

I. Drainage

1. Do not locate grease pit/traps for cafeterias inside the outdoor service area enclosure.

2. Pipe drain into sanitary sewer system and provide an oil water separator system. Drain size should be consistent. Please consult DUES to finalize drain sizes.

3. The floor of the enclosure (or the pad) shall slope 1/8” per foot to allow rainwater and other liquids to drain off without puddling.

4. If a grease pit/trap is necessary for the building, it shall have an enclosure separate from the outdoor service areas enclosure. The two may share a common wall, but they shall have their own enclosure walls and separate entrances.

J. Lighting

1. Provide sufficient lighting per Section 26 56 29 – Site Lighting for the security of the personnel and campus community using the sight at night and during the early morning hours.

2. Provide adequate illumination per Section 26 56 29 – Site Lighting inside and outside the enclosure and on the normal routes to/from the adjacent building(s).

3. Solar power and motion and daylight sensors may be used.

K. Paint

1. All trash dumpsters are to be painted BWE Chocolate Brown (FN007).

4. Documentation and Review Requirements

A. All equipment and receptor layout is to be submitted to the Sanitation and Recycling Office for approval. Contact the Sanitation and Recycling Office for assistance before ordering equipment to meet the needs for the specific building.

B. It is important to review the plan carefully to ensure the collection of all bins, dumpsters, etc. can be accessed by the associated truck in the designed location.
5. **Installation and Performance Requirements**

   A. Containers ordered as part of a capital project are to be installed by the project. For containers purchased outside of a capital project please contact the Sanitation and Recycling Office to coordinate installation.

6. **As-Built Requirements**

   A. Locations for all equipment and bins should be noted on the as-built drawings along with their use and size.

   B. Any changes to the layout, pads, ramps, or drainage should all be noted on the as-built drawings.
11 82 26 – Waste Compactors and Destructors

1. Introduction

A. This Construction and Design standard covers waste compactor guidelines including placement and access, pads, bollards, screening, drainage and lighting. This document is to be used in conjunction with other related sections listed below:

11 82 13  Solid Waste Bins
11 82 23  Recycling Equipment
A11 82 26  Waste Compactors and Destructors Appendix

B. Design considerations for waste and recycling containers must be based on the building’s usage and occupancy.

1. Site dimensions and configurations should be adjusted accordingly. Ideally, the recycling carts and dumpsters will be on the same pad in the same enclosure.

   a. In some cases it is necessary for the dumpsters (or compactors) to be located on separate pads from the carts.

   b. A variety of programs, i.e. animal bedding, grease, and food waste collection can also utilize these stations.

   c. Many locations requiring compactors may also require containers for grease, food waste or animal bedding.

2. The Sanitation and Recycling Office should be contacted to help determine the number of compactors needed, and size and type of any additional equipment that may be included.

2. References

A. This site [www.p2pays.org/food/main.oil.htm] provides information regarding fats, oils and grease (FOG) management in North Carolina.

B. NC General Statute 130A-309.10(f).

C. Durham County Regulations.

D. University policy regarding hazardous materials.

E. Marathon Equipment Standard Colors by Sherwin Williams.

3. Design Standards

A. Compactors
1. Compactors are considered part of the building and require that the equipment be designed into the project.

2. When necessary, doghouses and feeder chutes may need to feed material into the compactor.

3. The compactor should be located on ground level adjacent to the dock.

4. Provide an anti-freeze hydrant for wash down purposes at all sites using compactors.

B. Placement and Access

1. Position the compactor such that the truck can have a forward, straight approach to the compactor. To do this, take into consideration the turning radius, truck length, and angle of approach.

2. Compactors are to be serviced by a front load truck.

3. All containers shall be located on an accessible path of travel per the ADA and State Building Code.

4. If the design includes outdoor compactors, there must be a ramp at least 5’ wide for access to the recycling containers.

C. Pads

1. The pad for a 20-30 cubic yard horizontal compactor should be at least 12’ wide x 40’ long. Additional space may be needed for the electrical unit.

2. Elevation drawing and details for outdoor service areas must be shown on the plans.

3. The pad should be a minimum of 3,000 PSI concrete, with #4 bars at 12” on center each way, and 6” thick.

4. Pour the pad on compacted earth with a minimum base of 4” ABC stone. These are minimum requirements.

5. Final structural design of the pad shall be based on project requirements.

D. Bollards

1. Bollards are required for all compactors.
   a. Use bollards at the wall entrances by the compactor to protect the walls from being hit by the service truck.
   b. Use bollards behind the compactor to protect the walls from being hit.
2. Bollards at compactors are to be 6” in diameter and filled with concrete. These should be located 12” from the center of the bollard to the rear of the pad (or screen wall).

3. The bollards shall be 6’-6” in total length with at least 2’ set in reinforced concrete.

4. Finish the bollards with one coat exterior metal primer, and two coats exterior safety yellow.

E. Screening

1. Where required, use enclosure walls to screen sites from public view with constructed elements and landscaping. An enclosure is required for all outdoor service areas unless exempted by the Architects Office.

2. The interior and exterior enclosure walls shall:
   a. Be determined by the University Architect or other appropriate person or office.
   b. Match the exterior architectural finishes of the adjacent building(s).

3. Enclosure walls shall have weeps evenly spaced around the bottom edge to allow for drainage. These weeps and the grade of the floor shall direct the run-off into landscaped areas rather than onto concrete sidewalks and driveways.

4. The minimum recommended wall height to screen compactors is 7’.

5. Consideration should be given to maintaining visibility for vehicular and pedestrian safety issues.

6. Priority should be given to any power requirements or drainage needs of the units.

7. Do not install any piping equipment, utility walls or access hatches inside the outdoor service area enclosure.

8. All walls should meet current building codes.

F. Drainage

1. Do not locate grease pit/traps for cafeterias inside the outdoor service area enclosure.

2. Pipe drain into sanitary sewer system and provide an oil water separator system. Drain size should be consistent. Please consult Duke’s Engineering Utilities Services (DUES) to finalize drain sizes.

3. The floor of the enclosure (or the pad) shall slope 1/8” per foot to allow rainwater and other liquids to drain off without puddling.
4. If a grease pit/trap is necessary for the building, it shall have an enclosure separate from the outdoor service areas enclosure. The two may share a common wall, but they shall have their own enclosure walls and separate entrances.

5. In the event of a failure in the compactor seal or other malfunction, the site must be sloped for drainage into a drain located out from under the container.

G. Lighting

1. Provide sufficient lighting per Section 26 56 29 – Site Lighting for the security of the personnel and campus community using the sight at night and during the early morning hours.

2. Provide adequate illumination per Section 26 56 29 – Site Lighting inside and outside the enclosure and on the normal routes to/from the adjacent building(s).

3. Solar power and motion and daylight sensors may be used.

H. Paint

1. All compactors are to be painted Marathon Equipment Standard Colors by Sherwin Williams Dark Brown 07-009.

4. Documentation and Review Requirements

A. All equipment and receptor layout is to be submitted to the Sanitation and Recycling Office for approval. Contact the Sanitation and Recycling Office for assistance before ordering equipment to meet the needs for the specific building.

B. It is important to review the plan carefully to ensure the collection of all bins, compactors, etc. can be accessed by the associated truck in the designed location.

5. Installation and Performance Requirements

A. Building Wiring Information

1. The control box will be surface mounted.

2. The disconnect box must be located near the control box and should be wired for a 10 HP 3 phase motor with 480 V.

B. Electrical

1. Install operation switch sufficiently far from compactor to maintain safe operation.

2. Do NOT place where broom handles or other devices can be used to “lock” the switch in the operating position.
C. Containers ordered as part of a capital project are to be installed by the project. For containers purchased outside of a capital project please contact the Sanitation and Recycling Office to coordinate installation.

6. As-Built Requirements

A. Locations for all equipment and bins should be noted on the as-built drawings along with their use and size.

B. Any changes to the layout, pads, ramps, or drainage should all be noted on the as-built drawings.
12 93 23 – Trash and Litter Receptors

1. Introduction

A. This Construction and Design standard covers trash and litter receptor guidelines to be used in conjunction with other related sections listed below:

   a. Trash and Litter Receptors Appendix (A129323)

B. Design considerations for waste and recycling containers must be based on the building's usage and occupancy.

C. Contact the Sanitation and Recycling Office to help determine the number of receptors needed, size and type, and any additional equipment that may be included.

2. References

A. This site [www.p2pays.org/food/main.oil.htm] provides information regarding fats, oils and grease (FOG) management in North Carolina.

B. NC General Statute 130A-309.10(f).

C. Durham County Regulations.

D. University policy regarding hazardous materials.

3. Design Standards

A. Containers and Equipment

   1. Items which may need extra attention include (and are the responsibility of this project):

      a. It must be clear as to how the cabinets will be supplied – built by the project, or ordered from an outside millwork shop/recycling cabinet supplier or made by the Duke University or Medical Center carpentry shop.

      b. Making sure that the funds are reserved for equipment or the cost has been included in the project.

      c. Making sure details are provided in the drawings or that the equipment is ordered in time for occupancy.
2. When ordering these bins from outside suppliers or the Duke University or Medical Center carpentry shop:
   a. The project is responsible for designating space on the drawings, reserving the funds, selecting the laminates, ordering, receiving, and paying the invoice. (Outside suppliers and the carpentry shop will install the cabinets themselves.)

B. When bins are to be built as part of the project:
   1. The project is responsible for designating space on the drawings, providing detailed drawings of the cabinets (meeting the requirements listed here), and including specifications of the project manual. This is to include but is not limited to selecting the laminates, construction information, and installation instructions for the cabinets.
   2. Sanitation and Recycling will review the drawings to verify locations, dimensions, and details prior to building occupation. Sanitation and Recycling must be notified so we can provide bins for inside the cabinets, label the cabinets and get the location on a pick up schedule.
   3. It is the responsibility of the Project Manager to contact Sanitation and Recycling to get the most appropriate dimensions. Centralized recycling collection areas will vary depending on the size and use of the building.

C. Placement and Access
   1. All containers shall be located on an accessible path of travel per the ADA and State Building Code.

4. Documentation and Review Requirements
   B. All locations, dimensions, lid openings and finishes must be included in project documents and approved Sanitation and Recycling before construction documents are finalized.
   C. It is important to review the plan carefully to ensure the collection of all bins, dumpsters, etc. can be accessed by the associated truck in the designed location.

5. Installation and Performance Requirements
   A. Procurement
      1. When necessary, coordinate with the Sanitation and Recycling Office to make arrangements for assistance with ordering equipment and labeling.
B. Sanitation and Recycling must be notified when the cabinets have arrived for pick up, schedule coordination and labeling.

C. Containers ordered as part of a capital project are to be installed by the project. For containers purchased outside of a capital project please contact the Sanitation and Recycling Office to coordinate installation.

D. Labels:
   1. Upon installation, Sanitation and Recycling will apply stickers for Office Paper, Newspapers/Magazines, Bottles/Cans and Trash. Often buildings using built-in units will opt to have signs made to match. In this case it is the responsibility of the Project Manager to contact Sanitation and Recycling to ensure that the language on these signs conveys the same information as the standard recycling labels.
   2. Sanitation and Recycling must be notified so they label the cabinets and add the locations to the pickup schedule.

6. As-Built Requirements

   A. Locations for all equipment and bins should be noted on the as-built drawings along with their use and size.

   B. Any changes to locations should all be noted on the as-built drawings.
22 05 00 – Common Work Results for Plumbing

1. General
   
   A. Definitions:
      
      1. Plumbing: Building mechanical equipment, piping, and fixtures that provide domestic hot and cold water, sanitary and special waste drainage, and roof and other storm drainage.
      
      2. Point of Connection: The plumbing connection point for site distribution is usually located five feet (5') outside the building foundation. A careful study of existing site documentation and field verification should precede any detailed design efforts.
      
   B. Goal: To engineer a functional, economical and efficient plumbing system in compliance with applicable codes.
   
   C. System Conditions:
      
      1. Domestic Water Supply:
         
         a. Supply pressure: Minimum 50-80 PSIG, consultant to verify.
         
         b. Chemical Composition: Information regarding the chemical composition of the University water supply is available from the Operations and Maintenance Department.
      
      2. Liquid Waste Removal:
         
         a. The University Sanitary Sewerage System is connected to the City of Durham Waste Treatment System and must conform to the requirements of the City of Durham.
         
         b. Acid waste and other contaminated liquid wastes shall not discharge directly into the Sanitary Sewerage System. Specific methods of hazardous waste disposal shall be discussed with personnel from the DUES and OESO early in the design process.
      
      D. Fire Protection: Fire protection system supply water is taken from the building domestic water supply system. Refer to Section 21 13 13 Wet-Pipe Sprinkler Systems for details.
      
   E. Codes: All designs shall comply with the applicable requirements of the City of Durham and current version of the North Carolina Plumbing Code.

2. Design Submission Requirements
   
   A. General:
1. Design drawings, data and calculations at various stages of completion shall be submitted for each phase of the University's plan review process. The specific submittal requirements for each phase are outlined below.

2. Drawings shall provide location and size, of underground sewer, storm, and potable water service.

3. Drawings shall provide a schedule sheet for the following items:
   a. Plumbing fixtures: i.e., water closets, floor drains, sinks, BFP, hose bibs, sump pumps, eyewashes, showers, etc.
   b. Fixture unit riser stack calculations for each drainage system per UPC.

4. Drawings shall provide isometric riser diagrams for the waste and vent systems per UPC.

5. Drawings shall provide typical details for the following items:
   a. Single pipe hanger with sizing schedule and anchor bolt data.
   b. Multi-pipe trapeze hanger with sizing schedule and anchor bolt data.
   c. Expansion joint and fire stop sealant assemblies for walls, floors, and ceiling penetrations.
   d. Roof drainage assemblies, area drainage assemblies and overflow assemblies per the Roof and Waterproofing Standard of the NRCA and UBC Standard.
   e. Backflow preventer assemblies per Duke University, NC Plumbing Code, and ASSE Standards.
   f. Wall mounted trap primer assemblies per NC Plumbing Code.
   g. Restroom fixture assemblies detail schedule.

3. General Design Considerations

   A. General:

      1. Design shall be in accordance with applicable ASHRAE and ASPE handbooks.

      2. Maintenance shall be an important design consideration for all systems. Sectional valving shall be included, so that shutdown of parts of systems need not disrupt operation of entire building systems.

      3. Water and energy conservation shall be important design considerations for all systems. Review water conservation features with Duke Energy Management department.

5. Water distribution velocities shall be selected for minimal noise levels while maintaining adequate flow.

6. Careful attention shall be given to the prevention of water hammer in the design of water distribution systems. Devices used to limit water hammer such as shock arrestors shall be installed in areas accessible to maintenance personnel.

7. Cleanout locations and access shall be selected for service accessibility, as well as to minimize disturbance of occupant functions and building systems operation during cleanout servicing. Refer to 22 11 18 Plumbing Piping for details on cleanout location and height.

8. Routing of plumbing piping shall be planned such that pipe leakage would result in minimal damage to books, manuscripts, sensitive instruments and equipment, etc.

9. Coordination: The University expects careful design coordination between plumbing, process piping, HVAC, electrical, and fire protection systems. Scaling of drawings shall be coordinated between major disciplines to facilitate plan checks by the overlay method.

10. Provide floor drain (with trap and primer) in mechanical rooms, laundry rooms and other locations as required by Code.

11. Roof vents: Minimize roof penetrations through use of manifold sewer system roof vents.

B. Roof and Storm Drainage: Design criteria for storm drainage shall be carefully considered for each building to avoid flooding and related water damage. Roof and storm drains shall be designed for ease of maintenance.

C. Sanitary Waste: Sanitary waste systems shall be designed to allow for future addition of laterals to accommodate twenty (20%) percent expansion of system capacity.

D. Laboratory Waste

1. Laboratory waste systems shall be designed to allow for future addition of laterals to accommodate expansion of system capacity. Future capacity shall be as directed by the University Project Engineer.

2. DUES and OESO will work with the Project Engineer and Design Consultants to establish design criteria for acid disposal.

3. Laboratory waste systems shall be independent from sanitary waste system until point of exits from the building. Proper treatment required by DUES and OESO shall be obtained prior to tying into sanitary waste system.
E. Emergency Eyewash, Deluge Showers and Drench Hoses

1. Emergency Eyewash, Deluge Showers, and Drench hoses shall be provided in buildings as required by Duke OESO requirements.
22 05 09 – Meters and Gages for Plumbing

1. **General**
   
   A. Section includes:
      
      1. Positive displacement meters
      2. Pressure gages
      3. Pressure gage tap
      4. Thermometers
      5. Test Plugs

2. **Products**
   
   A. **Positive Displacement Meters (LIQUID)**
      
      a. Refer to 33 19 00 District Thermal and Water Utility Meters for specifications.

   B. **PRESSURE GAGES**
      
      1. Gage: ASME B40.1, UL 393 with bourdon tube, rotary brass movement, brass socket, front calibration adjustment, black scale on white background.
         
         a. Case: Cast aluminum or Stainless steel.
         
         b. Bourdon Tube: Brass or Type 316 stainless steel.
         
         c. Dial Size: 4 inch diameter.
         
         d. Mid-Scale Accuracy: One percent.
         
         e. Scale: Psi.

   C. **Pressure Gage Taps**
      
      1. Needle Valve:
         
         a. Brass or Stainless Steel, ¼ inch NPT for minimum 300 psi.

      2. Ball Valve:
         
         a. Brass or Stainless Steel, 1/4 inch NPT for 250 psi. Petcock valves are not acceptable.

      3. Pulsation Damper:
a. Pressure snubber, brass with ¼ inch NPT connections.

4. Siphon:
   a. Steel, Schedule 40 or Brass, ¼ inch NPT angle or straight pattern.

D. Stem Type Thermometers

1. Thermometer: ASTM E1, adjustable angle, red appearing mercury, lens front tube, cast aluminum case with enamel finish, cast aluminum adjustable joint with positive locking device.
   a. Size: 7 inch scale.
   b. Window: Clear glass.
   c. Stem: Brass, ¾ inch NPT, 3-1/2 inch long.
   d. Accuracy: ASTM E77 2 percent.
   e. Calibration: Both degrees F and degrees C.

E. Test Plugs

1. ¼ inch NPT or ½ inch NPT brass fitting and cap for receiving 1/8 inch outside diameter pressure or temperature probe with:
   a. Neoprene core for temperatures up to 200 degrees F.
   b. Nordel core for temperatures up to 350 degrees F.
   c. Viton core for temperatures up to 400 degrees F.

3. Execution

A. INSTALLATION

1. Install positive displacement meters in accordance with 33 19 00 District Thermal & Water Utility Meters, with isolating valves on inlet and outlet. Provide full line size bypass with globe valve for liquid service meters.

2. Install one pressure gage per pump, with taps before strainers and on suction and discharge of pump; pipe to gage.

3. Install gage taps in piping

4. Install pressure gages with pulsation dampers. Provide ball valve to isolate each gage. Extend nipples to allow clearance from insulation.
5. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inches for installation of thermometer sockets. Ensure sockets allow clearance from insulation.

6. Coil and conceal excess capillary on remote element instruments.

7. Install static pressure gages to measure across filters and filter banks, (inlet to outlet). On multiple banks, provide manifold and single gage.

8. Provide instruments with scale ranges selected according to service with largest appropriate scale.

9. Install gages and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.

10. Adjust gages and thermometers to final angle, clean windows and lenses, and calibrate to zero.

11. Locate test plugs as applicable.

12. Provide manual air vents at system high points and as indicated.

13. Provide drain and hose connection with valve on strainer blow down connection.

14. Provide pump suction fitting on suction side of base mounted centrifugal. Remove temporary strainers after cleaning systems.

15. Support pump fittings with floor mounted pipe and flange supports.

16. Provide relief valves on pressure tanks, low-pressure side of reducing valves, heat exchangers, and expansion tanks.

17. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.

18. Pipe relief valve outlet to nearest floor drain.
22 07 00 – Insulation for Plumbing Piping

1. Introduction
   A. This section covers insulation systems for plumbing piping systems, including, but not limited to:
      1. Domestic cold water piping
      2. Domestic hot water piping
      3. Non-potable water piping
      4. Sanitary sewer piping
      5. Storm water/roof leader piping
      6. Vent piping
      7. Natural gas piping
   B. Building Insulation Guidelines are listed in Division 07, Section 07 21 00 of the Duke University Design Guidelines.
   C. Designers should coordinate with Duke FMD to coordinate selection and execution requirements for insulation systems.

2. References
   A. ASHRAE Standard 90.1 – 2007
   B. NC State Energy Code, 2012
   C. NC State Plumbing Code, 2012
   D. USGBC LEED v3.0
   E. Duke University LEED+ Standard

3. Design Standards
   A. The following table illustrates desired insulation standards for different plumbing systems:
B. Insulation thickness should comply at minimum with requirements of current version of ASHRAE standards/requirements. Increased insulation thickness should be utilized if justifiable per project Life Cycle Cost Analysis.

C. Specific installation situations:

1. Any insulation installed outdoors must be jacketed and sealed to prevent moisture penetration.

2. All piping, equipment jacketing must adhere to Duke University Design Guideline regarding Identification of Plumbing Systems (see Section 3A of this section).

3. Underground utility piping insulation is not covered in this Design Guideline, as insulation of those systems is typically integral an engineered piping system and must be coordinated and engineered on a project-specific basis.

D. Documentation and Review Requirements:

1. Provide estimated energy usage calculation for all considered insulation systems. This calculation should compare energy usage and estimated costs for baseline (ASHRAE 90.1-compliant) insulation versus proposed higher efficiency models.
2. Insulation selection and specification must be reviewed by Duke FMD and the Commissioning Agent (when applicable) on a project-by-project basis.

3. Specifications shall include an insulation schedule in table format.

E. Installation and Performance Requirements:

1. Confirm installation responsibilities at outset of project. Installation services will be provided in-house or contracted out.

2. Coordinate all required tie-in points with Duke Utilities and Engineering Services (DUES).

3. Coordinate all commissioning efforts with DUES.

F. Piping Insulation:

1. All valves and fittings shall be insulated with preformed fitting insulation. Also provide preformed insulation for all cold and hot surfaces of equipment when available from the manufacturer. Extensions should be installed on small ball valves so that the handle is extended beyond the insulation and is visible and operational.
22 08 00 – Commissioning of Plumbing

1. GENERAL

A. GENERAL PROVISIONS

1. Drawings and general provisions of the Contract, including General Conditions and Division - 1 Specifications Sections, apply to Work of this section.

2. Provisions of Divisions 22 of the project specifications which are applicable to Commissioning of the Plumbing Systems are an integral part of this Section.

3. Commissioning is an important and integral part of the Contractor's Quality Control program.

B. WORK INCLUDED

1. “Active participation” in the Commissioning program as generally outlined in this section.

C. COMMISSIONING PROGRAM

1. Description

   a. The purpose of this section is to specify the Division 22 Contractor's responsibilities and participation in the commissioning process.

   b. Commissioning is primarily the responsibility of the Commissioning Authority and Owner, with support for start-up, testing and commissioning the responsibility of the Division 22 Contractors. The commissioning process does not relieve this Contractor from participation in the process, or diminish the role and obligations to complete all portions of work in a satisfactory and fully operational manner.

2. Work of Division 22 includes:

   a. Testing and start-up of the plumbing equipment.

   b. Assistance in functional testing to verify testing and balancing, and equipment/system performance.

   c. Providing qualified personnel to assist in commissioning tests, including seasonal testing.

   d. Completion and endorsement of pre-functional test checklists provided by the Commissioning Authority to assure that Division 22 equipment and systems are fully operational and ready for functional testing.
e. Providing equipment, materials, and labor necessary to correct deficiencies found during the commissioning process which fulfill contract and warranty requirements.

f. Providing operation and maintenance information and as-built drawings to the Commissioning Authority for their use in developing the Systems Manual.

g. Providing assistance to the Commissioning Authority to develop, edit, and document system operation descriptions.

h. Providing training for the systems specified in this Division with coordination by the Commissioning Authority. Prior to training, submit a training plan complete with syllabus and sample training material. The Commissioning Authority will review and approve the training plan.

3. Work of Division 22 specific to automation temperature control system includes:

a. The Owner will provide the controls, programming, point to point and functional testing. The Commissioning Authority will provide pre-functional checklists and functional test procedures for use by the owner.

4. Commissioning Coordinators for Plumbing

a. The Contractors shall assign qualified individuals from each discipline with at least ten (10) years of relevant experience in the installation, testing and startup of Plumbing systems.

D. RELATED WORK

1. All testing and start-up procedures and documentation requirements specified within Division 01, Division 22, and related portions of this project.

2. Commissioning procedures that require participation of Division 22 Contractors.

3. Cooperate with the Commissioning Authority in the following manner:

a. Install balancing cocks, access doors, test ports, and P&T taps as required by the Commissioner and/or the Owner for test and balance and functional testing.

b. Allow sufficient time before final completion dates so that test and balance and functional testing can be accomplished.

c. Provide labor and material to make corrections when required without undue delay.

d. Put all plumbing systems and equipment into full operation and continue the operation of the same during each working day of functional testing.
E. Scope: For coordination purposes, the Commissioning scope is generally outlined below:

1. Review contractor submittals for the systems included in the scope of commissioning.
2. Review training materials and agendas provided by the contractor and determine the adequacy of training. Verify training has been completed.
3. Document compliance with design intent of the Plumbing system
4. Verify that equipment and systems have been properly installed in accordance with the contract documents and manufacturer’s written installation instructions.
5. Verify that equipment has been placed into operation with the appropriate manufacturer’s oversight and approval.
6. Verify that adjusting, balancing and system testing has properly done.
7. Develop a Systems Manual
8. Document and review warranty start and end dates.
9. Perform an assessment of the first 10 months of building operations and include a plan for resolution and correction of outstanding commissioning items.

2. PRODUCTS
   
   A. TEST EQUIPMENT

   1. Standard test equipment for commissioning will be provided by the installing contractor or Owner (for TAB and controls).
   2. Division 22 shall provide standard and specialized test equipment as necessary to test and start up the plumbing equipment.
   3. Proprietary test equipment required by the manufacturer, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist the Commissioning Authority or Owner in the commissioning process.

3. EXECUTION
   
   A. PREPARATION OF COMMISSIONING PROGRAM

   1. The Commissioning program shall be prepared by the Commissioning Authority and submitted to the Engineer for approval.

   B. COMMISSIONING TEAM
1. The Commissioning Coordinator shall assemble the Commissioning Team which shall consist of the following persons:
   a. Commissioning Authority
   b. Plumbing Contractor and Trade Representative(s)
   c. HVAC Contractor and Trade Representative(s)
   d. Control System Trade Representative(s) (from Owner)
   e. Test, Adjust and Balance Trade Representative (from Owner)
   f. Electrical Contractor’s Representative
   g. Owner’s Project Manager
   h. Owner’s Maintenance staff
   i. Engineer of Record
   j. The Commissioning Team shall develop and generally follow a schedule of Commissioning events for the project.

C. RESPONSIBILITIES

1. Owner
   a. Assign appropriate staff and schedule them to participate in the various meetings, training sessions and inspections as follows:
   b. Pre-commissioning coordination and schedule of events meeting.
   c. Initial training session at initial placement of major equipment.
   d. Maintenance orientation and inspection at initial placement of major equipment.
   e. Maintenance orientation and inspection at connection of distribution systems.
   f. Piping and ductwork test and flushing verification meetings.
   g. Installation and programming of the BMS system, including point to point.
   h. Conduct Testing and Balancing of systems.
   i. Conduct Functional Testing of systems.
   j. Owners training and demonstration session(s).
   k. Review of operation and maintenance manuals and submittals for key components of the Plumbing systems.
1. Participate in final review and acceptance meeting.

2. Commissioning Authority

   a. Review all Commissioning requirements and intent of the Contract Documents. Assure all specialty Trade Subcontractors include their active participation in the Commissioning of Plumbing systems.

   b. Prepare the Commissioning program. Include input from Trade Representatives.

   c. Coordinate the implementation of the Commissioning program, through organization of all Commissioning meetings, tests, demonstrations, training events and performance verifications described in the Contract Documents and the Commissioning program.

   d. Review the plans and specifications with respect to their completeness in all areas as they relate to the Commissioning program.

   e. The plan and specification review by the Commissioning Authority does not include any responsibility for the system evaluation, adequacy of the system to meet design intent, capacity of the system or any of the other elements of the system design which are the strict responsibility of the Engineer of record.

   f. Schedule a pre-commissioning coordination meeting with the Commissioning Team within 45 days of the award of the contract, at a convenient location. This pre-commissioning meeting will be for the purpose of reviewing the complete Commissioning program and establishing tentative schedules for maintenance orientation and inspections, O&M submittals, training sessions, system flushing and testing, job completion, system start-up and test, adjust and balance work.

   g. Verify accessibility of equipment for maintenance and component replacement/repair.

   h. Conduct site installation verification visits to observe that equipment and systems are installed per the contract documents and applicable standards.

   i. Upon notification from the Plumbing Contractor that the Plumbing systems have been started, control systems have been started, tested, and adjusted that the systems and equipment is functioning as designed and specified, schedule the functional testing. Functional testing will be conducted by the Owner. Any Commissioning Team member may witness testing.

   j. Provide a final Commissioning Report and LEED letters.

3. Engineer of Record

   a. Provide clarification of any design intent questions raised by the Commissioning Team.
b. Attend and actively participate in initial pre-commissioning coordination meeting to be scheduled by the Commissioning Authority within 45 days of the award of the contract.

c. Review and approve Commissioning program.

d. Participate in sessions scheduled in the Commissioning program.

e. Receive and review operation and maintenance manuals as submitted by the Plumbing Contractor.

f. Attend Owner training sessions as appropriate.

g. Prepare record drawings for the project after receipt from the Plumbing Contractor.

D. WORK PRIOR TO COMMISSIONING

1. Complete all phases of work so the systems can be started, tested, and otherwise commissioned. Division 22 has primary start-up responsibilities with obligations to complete systems, including all sub-systems so they are functional. This includes the complete installation of all equipment, materials, pipe, duct, wire, insulation, controls, etc., per the contract documents and related directives, clarifications, change orders, etc.

2. A commissioning plan will be developed by the Commissioning Authority. Upon request of the Commissioning Authority, this Contractor shall provide assistance and consultation. The commissioning plan will be developed prior to completion of the installation. This Contractor is obligated to assist the Commissioning Authority in preparing the commissioning plan by providing all necessary information pertaining to the actual equipment and installation. If system modifications/ clarifications are incorporated to this and related sections of work, commissioning of this work will be made at no additional cost to the Owner. If Contractor-initiated system changes have been made that alter the commissioning process, the Commissioning Authority will notify the Architect, and the Contractor may be obligated to compensate the Commissioner to test the revised product, or confirm the suitability/unsuitability of the substitution or revision.

3. Specific pre-commissioning responsibilities of Division 22 are as follows:

   a. Normal start-up services required to bring each system into a fully operational state. This includes motor rotational check, cleaning, filling, purging, control sequences of operation, leak testing, full-load and part-load performance, etc. The Commissioning Authority will not begin the commissioning process until each system is complete, including normal contractor start-up.
b. The Contractor shall perform pre-functional tests on the following equipment and systems.

- Domestic Hot Water System and ancillary equipment
- Domestic Cold Water System and ancillary equipment
- Gray Water System and ancillary equipment

c. Acceptance phase should begin upon completion of all building systems. However, testing of individual systems can begin as long as it has been completely tested by the sub-contractor and it is in the best interests of the Owner. Commissioning activities and schedule will be coordinated with the Contractor. Start of commissioning before system completion will not relieve the Contractor from completing those systems as per the schedule.

E. PARTICIPATION IN COMMISSIONING

1. Provide skilled technicians to start-up and debug all systems within the division of work. These same technicians shall be made available to assist the Commissioning Authority/Owner in completing the commissioning program as it relates to each system and their technical specialty. Work schedules, time required for testing, etc., will be requested by the Commissioning Authority/Owner and coordinated by the Contractor. Contractor will ensure the qualified technician(s) are available and present during the agreed-upon schedules and of sufficient duration to complete the necessary tests, adjustments, and/or problem resolutions.

2. System problems and discrepancies may require additional technician time, Commissioning Authority/Owner time, redesign and/or reconstruction of systems, and system components. The additional technician time shall be made available for the subsequent commissioning periods until the required system performance is obtained.

3. The Commissioning Authority/Owner reserves the right to judge the appropriateness and qualifications of the technicians relative to each item of equipment, system, and/or sub-system. Qualifications of technicians include expert knowledge relative to the specific equipment involved, adequate documentation and tools to service/commission the equipment, and an attitude/willingness to work with the Commissioning Authority/Owner to get the job done. A liaison or intermediary between the Commissioning Authority/Owner and qualified factory representatives does not constitute the availability of a qualified technician for purposes of this work.

F. WORK TO RESOLVE DEFICIENCIES

1. In some systems, misadjustments, misapplied equipment, and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work will be completed under the direction of the
Architect/Engineer of Record, with input from the Contractor, equipment supplier, Owner and Commissioning Authority. Whereas all members will have input and the opportunity to discuss, debate, and work out problems, the Architect/Engineer of Record will have final jurisdiction on the necessary work to be done to achieve performance.

2. Corrective work shall be completed in a timely fashion to permit the timely completion of the commissioning process. Experimentation to render system performance will be permitted. If the Commissioning Authority/Owner deems the experimentation work to be ineffective or untimely as it relates to the commissioning process, the Commissioning Authority/Owner will notify the Architect/Engineer of Record indicating the nature of the problem, expected steps to be taken, and the deadline for completion of activities. If the deadline(s) passes without resolution of the problem, the Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner will be the Contractor's responsibility.

G. ADDITIONAL COMMISSIONING

1. Additional commissioning activities may be required after system adjustments, replacements, etc., are completed. The Contractor, suppliers, and Commissioning Authority shall include a reasonable reserve to complete this work as part of their standard contractual obligations.

H. SEASONAL COMMISSIONING AND OCCUPANCY VARIATIONS

1. Subsequent commissioning may be required under conditions of minimum and/or maximum occupancy or use. All equipment and systems affected by occupancy variations will be tested and commissioned at the minimum and peak loads to observe system performance. Each Contractor and supplier will be responsible to participate in the occupancy sensitive testing of systems to provide verification of adequate performance.

2. At 10 months into the warranty period, the Commissioning Authority and Owner will review the operation to date. The Contractors will be expected to be available to address any warranty related items that come out of this review.

I. TRAINING OF OWNER’S PERSONNEL

1. The Owner’s staff shall be given comprehensive training in the operation and maintenance of each major piece of equipment.

2. The Construction Manager/General Contractor in cooperation with the Commissioning Team will be responsible for scheduling and actively participating in the training. A training plan is to be submitted to the Commissioning Authority for review at least 60 days prior to training being scheduled.
3. Hands on training shall include start-up, operation in all modes possible, shut-down and any emergency procedures.

4. The manufacturer’s representative shall provide the instructions on each major piece of equipment. These sessions shall use the printed installation, operation and maintenance instruction material included in the operation and maintenance manuals and shall include a review of the written operation and maintenance manuals. Training will be included for all major pieces of equipment. Equipment training shall be done by qualified service representatives employed by the manufacturers.

5. Contractor will be required to participate in the training of the Owner's engineering and maintenance staff for each mechanical system and the related components. Training may be conducted in a classroom setting, with system and component documentation, and suitable classroom training aids, or in the field with the specific equipment. The type of training will be per the Owner's option.

J. SYSTEMS DOCUMENTATION

1. In addition to the requirements of Division 01, update Contract Documents to incorporate field changes and revisions to system designs to account for actual constructed configurations. All drawings shall be red-lined on two sets. Division 22 as-built drawings shall include updated architectural floor plans, and the individual Plumbing systems in relation to actual building layout.

2. Maintain as-built red-lines on the job site as required in Division 01. Given the size and complexity of this project, red-lining of the drawings at completion of construction, based on memory of key personnel, is not satisfactory. Continuous and regular red-lining and/or posting of drawings is considered essential and mandatory.

K. NOTIFICATION OF SYSTEM COMPLETION AND REQUEST FOR FINAL ACCEPTANCE OF THE PLUMBING SYSTEMS

1. When systems are ready for final acceptance, the Contractor shall certify to the Commissioning Team, in writing, that all systems are complete and fully functional.

2. Should the commissioning tests determine that the equipment is still not performing as specified or control operation is not acceptable on the second inspection, the time and expenses of the Commissioning Authority, Engineer of Record and Owner to make further verification shall be considered as additional cost of the Owner. The total sum of such costs shall be deducted from the final payment to the Plumbing Contractor.

L. REPORT REQUIREMENTS

1. The Commissioning Authority shall document each Commissioning event with meeting minutes or a report. The documents shall separately list deficiencies
observed or discovered during the event. The document shall be distributed to Commissioning Team members.

2. The Commissioning Authority shall prepare a final report to the Commissioning Team which will include a narrative in the form of an Executive Summary of the results of program, executed construction checklists/startup documentation, executed functional test procedures, project reports, issues log and other pertinent documents.
22 10 10 – Plumbing Pumps

1. Introduction

A. This section pertains to all pumps for use in building systems. Pump motors are discussed to the extent that they affect pump application. Applications include but are not limited to:

1. Domestic water booster pumps
2. Recirculation pumps
3. Dewatering sump pumps
4. Sewage ejectors

B. Designers should coordinate with Duke Office of Project Management and Duke Utilities & Engineering Services, Department of Planning & Engineering (DUES-Engineering) on all phases of projects requiring pumps and pumping equipment. These projects may include, but are not limited to:

1. New buildings
2. Renovations to the existing building
3. Replacement of existing equipment

C. Designers should coordinate with DUKE FMD to coordinate selection and execution requirements for pumping systems.

2. Design Standards

A. General Requirements:

1. Preferred manufacturers:
   a. Bell & Gossett
   b. Grundfos
   c. Zoeller
   d. Taco or owner approved equal

2. All pumping system designs must identify energy efficiency, reliability, serviceability, operational functionality and life-safety issues. This information will allow Duke to fully and accurately evaluate the project and its associated Life Cycle Cost (LCC).
3. All pumping systems except dewatering sump pumps should be designed with full N+1 redundancy, unless otherwise indicated during the design process.

4. All pumps for building services must be installed in dedicated mechanical equipment rooms. Pumps should not be housed in temporary structures or installed in unconditioned spaces.

5. Equip all pumps with suction- and discharge-side pressure gauges and isolation valves. *A single gauge, differential pressure sensing setup is not sufficient.*

6. All pumps must be equipped with proper isolation components, such that the pump may be maintained without service outage to the system.

7. Design all pumping systems with appropriate mechanisms for air separation, air venting and fluid expansion.

8. All equipment must be supported directly by structural members with adequate load-bearing capacity and material integrity, using appropriate anchoring/connection hardware. Under no circumstances may equipment be supported by connections to finish materials. For example, equipment hung from toggle bolts through plaster-on-lath, gypsum board or ACT ceilings is not acceptable.

B. Domestic Water Booster Pump Systems:

1. Domestic water booster pumps shall have N+1 capability for serviceability and maintenance

2. A bypass shall be installed with isolation valves and a check valve for automatic operation should a booster pump fail.

3. Pump type shall be variable speed, multi-stage vertical type construction

4. Each pump shall have individual fused disconnects

C. Recirculation pumps:

1. Pump shall be inline wet rotor; designed for potable water circulation

2. Body: 100% lead free bronze

3. Recirculation pump motors over 2 hp must be utilize variable-frequency drives (VFD), automatically controlled based on system differential pressure. Differential pressure sensor(s) should be placed in the furthest (highest head loss) location from the pump.

D. Building Dewatering (Sump) Pumps:
1. Sump pumps should be submersible, single-stage, end suction pump, close coupled to motor with cast iron casing. Pump must be provided with elevated legs for inlet suction flow and vertical discharge connection.

2. Pump system shall be duplex type unless otherwise approved by DUES.

3. Pump motors should be min. 1/2 hp, single phase 115V power.

4. Pump should be controlled via a mechanical float-type switch. Designers must provide a high water level alarm and provide control point to Siemens Insight campus automation system.

5. Sequence of operation for duplex system shall be as follows:
   a. Get from Sean Saunders

6. Sump pumps in areas that may receive hot water or steam condensate must be rated for high temperature operation, minimum of 140°F.
   a. Preferred Equipment:
      i. Zoeller Company Model M137
      i. Weil Pump Company model 1412 or approved equal

E. Sanitary Sewage (ejector) Pumps:

1. For new construction purposes, designers are encouraged to avoid the use of sewage (ejector) pumps wherever possible. However, where lack of gravity drainage capabilities necessitate the use of such a pump, follow the requirements below:
   a. Sewage pumps should be duplex-type, cast iron-bodied.
   b. Provide pumps with alternating lead-lag switching and high water alarm.
   c. Provide backup/emergency power to sewage pumps.

2. Sequence of operation for duplex system shall be as follows:
   a. Get from Sean Saunders

3. Documentation and Review Requirements

A. Documentation of factors used in equipment selection must be submitted for review at DD submittal and each subsequent submittal if conditions have changed. Summary of factors shall identify which factors are known and which are assumptions.

B. Detailed equipment selection, including expected sound levels.

C. Cost of operations and maintenance shall be included in system Life Cycle Cost Analysis. This information shall be reviewed at DD submittal.
4. **Installation and Performance Requirements**

A. All units shall be installed level.

B. Permanent installation methods must include provisions for isolating pump vibration from structure. Acceptable methods include:
   4. Spring mount vibration isolation
   5. Concrete housekeeping pads with fully-grouted base
   6. Flexible coupling connection to independently-supported system piping

C. All units shall be installed so that there is sufficient space to perform normal maintenance. This space shall be shown on project drawings.

D. Pump alignment must be performed for all shaft-coupled pumps. This must be performed prior to connecting any electrical power to the pump motor.

E. Coordinate all commissioning efforts with DUES. This includes all testing and balancing of systems, all functional performance tests and any other pertinent data obtained during the commissioning phase of the project.
22 11 18 - Plumbing Piping

1. Introduction
   A. This Design Guideline covers piping systems for building plumbing systems, including, but not limited to:
      1. Domestic cold water piping.
      2. Domestic hot water piping.
      3. Non-potable water piping.
      4. Sanitary sewer piping
      5. Storm water/rain water piping
      6. Vent piping
      7. Natural Gas piping

   B. Designers should coordinate with Duke FMD to coordinate selection and execution requirements for piping systems.

2. References
   A. North Carolina State Plumbing Code, 2012
   B. City of Durham Water Quality Division
   C. Duke University Design Guidelines, Section 22 07 00 Insulation for Plumbing Piping

3. Performance Requirements
   A. Piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:
      1. Domestic Water Piping: 100 psig at 250 deg F
      2. Non-potable Water Piping: 100 psig at 250 deg F
      3. Sanitary Waste and Vent Piping: 0 psig at 100 deg F
      4. Force Main Piping: 50 psig at 80 deg F
      5. Natural Gas Piping:
4. **Design Standards**

A. The following table illustrates desired piping standards for different plumbing systems:

<table>
<thead>
<tr>
<th>Service</th>
<th>Size</th>
<th>Fitting Connection</th>
<th>Pipe Connection</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic/Potable/Non Potable Water (Hot &amp; Cold)</td>
<td>Up to 2”</td>
<td>Solder (95/5) or Propress</td>
<td>Solder (95/5) or Propress</td>
<td>Type L copper, hard drawn</td>
</tr>
<tr>
<td></td>
<td>2” to 4”</td>
<td>Brazed or Propress, exception for Valves, Flanges, Unions may be Solder (95/5)</td>
<td>Brazed or Propress</td>
<td>Type L copper, hard drawn</td>
</tr>
<tr>
<td></td>
<td>6” and larger</td>
<td>Class 125 Flanged, or Brazed</td>
<td>Brazed</td>
<td>Type L copper, hard drawn</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>2” and smaller</td>
<td>Threaded (NPT)</td>
<td>Threaded</td>
<td>SCH 40, A53 Gr B Carbon Steel, Seamless</td>
</tr>
<tr>
<td></td>
<td>2-1/2” and larger</td>
<td>Class 150 Flange</td>
<td>Butt Weld</td>
<td>SCH 40, A 53 Gr B Carbon Steel, Seamless</td>
</tr>
</tbody>
</table>

1. Sanitary piping shall be installed per current North Carolina Plumbing Code with exception to piping installed above finished floor. Piping above finished floor shall be cast iron, hubless construction.

2. Storm and roof leader piping shall be installed per current North Carolina Plumbing Code.

3. Valves shall be installed in compliance with Duke University Design Guidelines 23 05 23 – General Duty Valves for Piping. All valves shall be equipped with valve tag and corresponding valve chart located at water entry or plumbing equipment room.

4. Piping shall be insulated in accordance with Duke University Design Guidelines 22 07 00 – Insulation for Plumbing Piping

5. Piping shall be supported in accordance with the North Carolina Plumbing Code.
   a. Pipe supports mounted to floor shall be grouted in place with non-shrink grout a minimum of 1” prevent rusting from flooding or standing water on floor.
   b. Wall supports shall be installed in a manner with a minimum of 1” gap between support and floor to prevent rusting from flooding or standing water on floor.
c. Each hanger/support shall be individually supported from above. Hangers may not be supported from other hangers unless it is designed as such and approved by Duke Utilities and Engineering Services.

6. T-Drill is not an acceptable form of fitting in any piping application.

7. Material use should be consistent throughout piping segment. Piping should not transition from one material to another unless previously approved by DUES. The use of dielectric fittings is not acceptable. Where dissimilar metals are joined, the use of a bronze/brass ball valve or fitting is preferred.

8. Valves to be located at all branch lines off risers. Drains shall be installed downstream of valve.

9. Vents shall be install at top of all risers to aid in air removal. If an automatic air vent is used, an isolation valve must be between the vent and piping.

10. All sensors and gauges shall be equipped with an isolation valve at the main to facilitate replacement without a system shut down.

11. Cleanouts
   a. Required on risers 18” above fixture flood rim
   b. Shall have access panels, escutcheon, or other trim device
   c. Test tees above sanitary tees must be accessible

5. Flushing & Testing
   A. Flushing and testing shall be done in accordance with City of Durham quality requirements.

6. Installation and Performance Requirements
   A. Documents shall include an existing conditions drawing. Existing conditions shall include piping size, location, capacity, etc.
   B. Confirm installation responsibilities at out-set of project. Installation services will be provided in-house or contracted out.
   C. Coordinate all required tie-in points with Duke Utilities and Engineering Services.
   D. Coordinate all commissioning efforts with Duke Utilities and Engineering Services.
   E. Documents shall include riser diagram as part of drawing set.
22 11 19 – Domestic Water Specialties

1. General
   A. This Section includes the following domestic water piping specialties:
      1. Backflow preventers
      2. Water pressure-reducing valves
      3. Temperature-actuated water mixing valves
      4. Hose spigots

2. Products
   A. Backflow Preventers
      1. General:
         a. For high hazard applications, use Reduced Pressure Zone (RPZ) devices.
         b. For low hazard applications, use Double Check Assemblies (with exception of vacuum breakers for hose spigots).
         c. Refer to North Carolina Plumbing Code and City of Durham Ordinance to determine hazard level for application. DUES must approve selection prior to installation.
         d. Design for two full sized backflow preventers in parallel for main building service and all critical equipment. Install one isolation valve on the high and low side of the parallel assemblies to allow for replacement of an entire assembly valve to valve.
         e. Backflow devices shall be tested by a Durham County certified tester. Testing shall be coordinated by contractor and completed prior to acceptance by Duke.
         f. Building service water line shall be flushed to City of Durham standards prior to testing backflow preventer. Full line size shall be flushed up to 4”. A 4” flush is acceptable for any piping 6” and larger.
         g. Strainers with blowdown valves must be installed upstream of all backflow preventers with exception of fire protection lines.
         h. Provide 2-1/2” ball valve connection with NFT and plug between first building isolation valve and backflow device for emergency water connection.
2. Reduced-Pressure-Principle Backflow Preventers suitable for continuous pressure application, consisting of two positive-seating check valves with intermediate relief valve, and test locks:
   a. Manufacturers: Watts, Apollo, or owner approved equal
   c. Operation: Continuous-pressure applications.
   d. Body: Bronze for NPS 2 and smaller; cast iron or steel with interior lining complying with AWWA C550 or that is FDA approved, or stainless steel for NPS 2-1/2 and larger.
   e. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
   f. Configuration: Designed for horizontal, straight through, or vertical inlet, horizontal center section, and vertical outlet flow as indicated.
   g. Valves: Ball type with threaded ends on inlet and outlet of NPS 4 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 6 and larger.

B. Double-Check Backflow-Prevention Assemblies:
   a. Manufacturers: Watts, Apollo, or owner approved equal.
   c. Operation: Continuous-pressure applications, unless otherwise indicated.
   d. Pressure Loss: 7 psig maximum, through middle 1/3 of flow range.
   e. Body: Ductile iron
   f. End Connections: Flanged
   g. Configuration: Designed for horizontal, straight through flow.
   h. Valves: Outside screw and yoke gate-type with flanged ends on inlet and outlet of.
D. Water Pressure Reducing Valves

1. Water Regulators:
   
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      

E. Temperature Actuated Mixing Valves

1. Manufacturer and model shall be Powers Intellistation.
2. Control shall be +/- 2 degrees F.

3. Provide full size bypass with isolation valves to station for service

4. Must be able to fail to cold water position.

5. Mixing valve stations shall be installed on all domestic hot water systems regardless of supply temperature.

F. Hose Spigots

1. Approved manufacturers include: Provide Woodford, Smith, or Zurn

2. General:
   a. One exterior freeze protected hose spigot shall be provided for each façade of the building
   b. Each mechanical room and housekeeping closet shall have a minimum of one hose spigot. Sink faucet/spigot does not constitute hose bib.
   c. Consideration must be given for cleaning equipment for coils or other similar equipment. Spigot shall be located within 50 of such equipment
   d. If equipment is located on roof or penthouse, provide hose spigot within 50 feet of such equipment.
   e. Provide frost-proof devices
   f. Provide vacuum breakers on all hose spigots.
22 30 00 - Domestic Hot Water Systems

1. Introduction
   A. Domestic hot water systems are critical to all building types on the University campus: residential, administrative, laboratory/research, classroom and athletic facilities. This standard identifies the design criteria and guidelines for domestic hot water systems. This includes all non-HVAC systems with operating temperatures from 100°F to 140°F for potable and non-potable use.
   B. Designers should coordinate with Duke Utilities & Engineering Services (DUES) on all phases of projects requiring domestic hot water service. Particular attention must be paid to any retrofit projects that may require evaluation of past and future hot water needs for a particular system.

2. References
   A. North Carolina Plumbing Code 2012
   B. Duke University Design Guidelines, Section 22 00 00. General Plumbing Requirements
   C. Duke University Design Guidelines, Section 22 07 00, Insulation for Plumbing Piping
   D. Duke University Design Guidelines, Section 23 22 13, Medium and Low Pressure Steam Systems
   E. ASHRAE Standard 90.1 – 2007

3. Design Standards
   A. All domestic hot water system designs must identify energy efficiency, reliability, serviceability, operational functionality and life-safety issues such that Duke University may fully and accurately evaluate the project.
   B. Detailed documentation is required with regard to existing conditions. This may include, but is not limited to, documentation of existing steam-fired equipment, analysis of building steam loads and evaluation of building distribution piping.
   C. All equipment must be supported directly by structural members with adequate load-bearing capacity and material integrity, using appropriate anchoring/connection hardware. Under no circumstances may equipment be supported by connections to finish materials. For example, equipment hung from toggle bolts through plaster-on-lath, gypsum board or ACT ceilings is not acceptable.
   D. Potable Hot Water Systems:
1. Preferred manufacturers:
   a. Aerco
   b. Cemline

2. Design temperature for potable systems is 120°F.

3. Design temperatures for kitchen systems is 140°F.

4. Where feasible, pumped recirculation loops should be utilized.
   a. Refer to Duke Design Guidelines section 22 10 10 Plumbing Pumps for details regarding recirculation pumps.

5. Piping
   a. Hot water piping should be installed per Duke University Design Guidelines, section 22 11 18 Plumbing Piping.
   b. Pipe should be insulated per Duke University Design Guidelines, section 22 07 00 Insulation for Plumbing Piping.
   c. Pipe should be hung per NC Plumbing Code.
   d. Hot water systems should include isolation valves at all major branch connections and at equipment terminations per Duke University Design Guidelines, section 23 05 23 General Duty Valves for Piping.
   e. A drain valve shall be installed downstream of all branch isolation valves.

6. Hot Water Generating Equipment
   a. Selection of the water heater firing method is subject to DUES review and approval on a case-by-case basis. Consultants should contact DUES for guidance on selection of the hot water heating system.
   b. Multiple heat exchangers are required to provide redundancy. Units shall be selected at 50% of peak calculated load. In a case where more than 2 units are required, the units shall be selected so the sum of their load equals the peak calculated load. Example: If 3 units are required, each should be selected at 33% of peak load.
   c. Mixed-use facilities with highly diverse domestic hot water usage profiles should utilize multiple hot water generating systems. For example, a café kitchen within a classroom building should be designed with a dedicated hot water system.
   d. When steam service is available, steam-fired, semi-instantaneous type hot water heaters are generally preferred. Where steam service is unavailable or in
facilities that are slated to be disconnected from steam service as part of the long-term Steam to Hot Water Conversion project, acceptable alternative firing methods include electrical and natural gas firing.

e. When distributed heating water is available, a double wall, plate and frame, water to water heat exchanger is preferred for large domestic water load requirements.

   (1) Plate and frame heat exchanger shall be equipped with a bypass to keep heating water hot at the inlet of the unit.

   (2) A globe valve shall be installed in the bypass to control how much heating water is bypassed.

   (3) Full size taps shall be installed between the heat exchanger isolation valves and the unit for flushing and cleaning purposes.

f. Steam-fired semi-instantaneous type water heaters should be factory-assembled, skid-mounted, vertical tank type with integral controls and tank circulation pump. Controls must have the ability to interface with campus building automation system for alarming and control. Tank should be fabricated per ASME Pressure Vessel code, rated for 150 psig shell pressure, with grade 316 stainless steel internals and cupro-nickel alloy tube bundle.

g. In situations where domestic hot water loads are not significant, a commercial electric hot water heater is preferred.

h. The use of large volume hot water storage tanks in combination with instantaneous shell-and-tube type heat exchangers (or in-tank tube bundles) is generally discouraged except where this equipment provides the most efficient means of hot water provision. Examples may include kitchens, gymnasiums and laundry facilities with consistently high hot water demand Non-Potable Hot Water Systems.

i. Thermostatic mixing valves should only be used where consistent hot water temperature is extremely critical. The type of mixing valve shall be reviewed with DUES prior to selection.

E. Non-Potable Hot Water Systems

1. Non-potable hot water systems include any non-HVAC hot water system for industrial, laboratory, medical usage or other specialized non-domestic use.

2. In all cases, non-potable water systems should be protected from contaminating potable water systems with backflow prevention devices and dedicated heating and pumping equipment.
3. Non-potable systems may have varying service temperature requirements; design according to specific project needs.

4. Where feasible, recirculation loops should be utilized.

5. **Hot Water Generating Equipment**
   
a. Selection of the water heater firing method is subject to DUES review and approval on a case-by-case basis. Consultants should contact DUES for guidance on selection of the hot water heating system. The system must conform to requirements described in the Duke University Design Guidelines, Section 23 22 13, Medium and Low Pressure Steam Systems.

b. When steam service is available, steam-fired, semi-instantaneous type hot water heaters are generally preferred. Where steam service is unavailable or in facilities that are slated to be disconnected from steam service as part of the long-term Steam to Hot Water Conversion project, acceptable alternative firing methods include electrical and natural gas firing.

c. Steam-fired semi-instantaneous type water heaters should be factory-assembled, skid-mounted, vertical tank type with integral controls and tank circulation pump. Controls must have the ability to interface with campus building automation system for alarming and control. Tank should be fabricated per ASME Pressure Vessel code, rated for 150 psig shell pressure, with grade 316 stainless steel internals and cupro-nickel alloy tube bundle.

d. Where instantaneous-type heat exchangers are used, steam flow must be controlled via parallel control valves sized for proper control at low flow and peak flow requirements.

F. **Monitoring and Control**

1. All systems and equipment must be integrated with existing Siemens Insight building automation system.

2. Hot water system should include, at minimum, following monitoring and control points:
   
a. Supply temperature

b. Return temperature

c. Mixed temperature (if tempered with thermostatic mixing device)

d. Supply pressure

e. Loop differential pressure
f. Circulation motor current/power draw

3. Supply and return temperatures shall be read independently from equipment controls.

4. Documentation and Review Requirements
   A. Analysis of the building domestic hot water systems should be considered in the Life Cycle Cost analysis required for project approval.
   B. Provide estimated energy loss calculation for all distribution piping.

5. Installation and Performance Requirements
   A. Confirm installation responsibilities at outset of project. Installation services will be provided in-house or contracted out.
   B. Coordinate all required tie-in points with Duke Utilities and Engineering Services.
   C. Coordinate all commissioning efforts with Duke Utilities and Engineering Services.
22 40 00 – Plumbing Fixtures

1. General
   A. Definitions
      1. Section includes
         a. Water closets and urinals
         b. Lavatories, sinks, and service sinks
         c. Electric water coolers, drinking fountains,
         d. Showers
         e. Trap Primers
      Refer to campus sustainability documents for water efficiency targets before selecting fixtures.

   2. Approved plumbing fixture manufactures include: American Standard, Crane, Eljer, Kohler, Zurn, Toto, or owner approved equal.

B. References
   1. ARI 1010 (Air-Conditioning and Refrigeration Institute) - Drinking Fountains and self-contained Mechanically Refrigerated Drinking Water Coolers.
   
   2. ASME A112.6.1 (American Society of Mechanical Engineers) - Supports for Off-the-Floor Plumbing Fixtures for Public Use.
   
   
   4. ASME A112.19.2 (American Society of Mechanical Engineers) - Vitreous China Plumbing Fixtures.
   
   5. ASME A112.19.3 (American Society of Mechanical Engineers) - Stainless Steel Plumbing Fixtures (Designed for Residential Use).
   
   6. ASME A112.19.4 (American Society of Mechanical Engineers) - Porcelain Enameled Formed Steel Plumbing Fixtures.
   
   7. ASME A112.19.5 (American Society of Mechanical Engineers) - Trim for Water-Closet Bowls, Tanks, and Urinals.

2. Products
C. FLUSH VALVE WATER CLOSETS

1. Bowl: ASME A112.19.2; wall mounted, siphon jet, vitreous china closet bowl, with elongated rim, 1-½ inch top back spud, china bolt caps.

2. Exposed Flush Valve: ASME A112.18.1; exposed chrome plated, diaphragm type with oscillating handle, escutcheon, seat bumper, integral screwdriver stop and vacuum breaker 1.28 gallon flush volume.

3. Sensor Operated Flush Valve: ASME A112.18.1; concealed rough brass, diaphragm type with low voltage operated solenoid operator, infrared sensor and over-ride button in chrome plated plate, wheel handle stop and vacuum breaker 1.28 gallon flush volume.


5. Wall Mounted Carrier: ASME A112.6.1; adjustable cast iron frame, integral drain hub and vent, adjustable spud, lugs for floor and wall attachment, threaded fixture studs with nuts and washers.

D. TANK TYPE WATER CLOSETS

1. Tank type water closets should only be used when directed by Duke project manager. Fixture selection shall be reviewed by project manager and facilities.

2. Bowl: One piece ASME A112.19.2 floor mounted, siphon jet, vitreous china closet bowl with elongated rim.

3. Gravity feed 1.28 gallon per flush tank.


E. WALL HUNG URINALS

1. Urinal: ASME A112.19.2; vitreous china, wall hung washout urinal with shields, integral trap, removable stainless steel strainer, 3/4 inch back spud, steel supporting hanger.

2. Exposed Flush Valve: ASME A112.18.1; exposed chrome plated, diaphragm type with oscillating handle, escutcheon, integral screwdriver stop, vacuum breaker; maximum 1/8th gallon flush volume standard or approved equal.

3. Sensor Operated Flush Valve: ASME A112.18.1; exposed chrome plated, diaphragm type with low voltage battery operated solenoid operator, infrared sensor and over-ride button in chrome plated plate, wheel handle stop and vacuum breaker; maximum 1/8th gallon flush volume.
4. Approved flush valve manufacturers include: Sloan, Zurn, Toto, or owner approved equal.

5. Wall Mounted Carrier: ASME A112.6.1; cast iron and steel frame with tubular legs, lugs for floor and wall attachment, threaded fixture studs for fixture hanger, bearing studs.

F. LAVATORIES

1. Vitreous China Wall Hung Basin: ASME A112.19.2; vitreous china wall hung lavatory high back, drillings on 8 inch centers, rectangular basin with splash lip, front overflow, and soap depression.

2. Steel Counter Top Basin: ASME A112.19.4; porcelain on steel self-rimming counter top lavatory, with drillings on 8 inch centers, front overflow, soap depression, seal of putty, caulking, or concealed vinyl gasket.

3. Vitreous China Counter Top Basin: ASME A112.19.2; vitreous china self-rimming counter top lavatory, 8 inch centers, front overflow, soap depression, seal of putty, caulking, or concealed vinyl gasket.

4. Fittings: ASME A112.18.1; chrome plated combination supply, open grid strainer, water economy aerator with maximum 0.5gpm flow, indexed handles. Pop-up wastes, and chain and plug drains may only be used in residential applications.

5. Sensor Faucet: ASME A112.18.1; chrome plated metered mixing faucet with low voltage operated solenoid operator and infrared sensor, aerator and cover plate, open grid strainer. Power supply shall be photovoltaic panel or turbine coupled with rechargeable battery. Maximum flow rate shall be 0.5 gpm.

6. Approved faucet manufacturers include: Kohler, Delta, Sloan, T&S, Chigaco

7. Approved lab faucet manufacturers include: Chicago, Water Saver, or T&S

8. Accessories:
   a. Chrome plated 17 gage brass P-trap with clean-out plug and arm with escutcheon.
   b. Offset waste with perforated open strainer.
   c. Screwdriver stops.
   d. Flexible supplies.

9. Clean-outs: All clean-outs must be accessible and those behind walls must be piped so that the bottom of the pipe is 18” above the fixture flood rim level to avoid spillage of effluent into wall cavity when pipe is opened to clear blockages.
10. Wall Mounted Carrier: ASME A112.6.1; cast iron and steel frame with tubular legs, lugs for floor and wall attachment, threaded studs for fixture hanger, bearing plate and studs.

G. SINKS (kitchens)

1. Single Compartment Bowl: ASME A112.19.3; 20 gage thick, Type 316 stainless steel. Self-rimming and undercoated, with 2-½ inch chromed brass drain 3-1/2 inch crumb cup and tailpiece; ledge back drilled for trim.

2. Double Compartment Bowl: ASME A112.19.3; outside dimensions 20 gage thick, Type 316 stainless steel. Self-rimming and undercoated, with 1-1/2 inch chromed brass drains 3-1/2 inch crumb cups and tailpieces, ledge back drilled for trim.

3. Trim: ASME A112.18.1; chrome plated brass supply with high rise swing spout, vandal proof water economy aerator with maximum 2.2 gpm flow, indexed lever handles.

4. Accessories: Chrome plated 17 gage brass P-trap with clean-out plug and arm with escutcheon, screwdriver stop, and flexible supplies.

H. SHOWERS

1. Trim: ASME A112.18.1; concealed shower supply with pressure balanced thermostatic mixing valves, integral service stops, bent shower arm with flow control and adjustable spray ball joint shower head with maximum 1.75gpm flow, and escutcheon.

2. Showerhead: ASME A112.18.1; chrome plated vandal-proof institutional head with integral wall bracket, built-in 1.75gpm flow control.

I. ELECTRIC WATER COOLERS

1. Fountain:
   a. ARI 1010; recessed handicapped mounted electric water cooler with stainless steel top, stainless steel body, elevated anti-squirt bubbler with stream guard, automatic stream regulator, push button, mounting bracket, refrigerated with integral air cooled condenser [and stainless steel grille].

b. Electrical: Per design

c. Clean out in "P" tray and at wall.

d. Equipped with bottle filling station

e. Approved manufacturers include: Elkay or Halsey-Taylor

J. SERVICE SINKS
1. Bowl: Stainless steel with concealed hanger, stainless steel strainer, stainless steel rim guard, cast iron P-trap with adjustable floor flange.

2. Trim: ASME A112.18.1 exposed wall type supply with lever handles, spout wall brace, vacuum breaker, non-threaded spigot spout, strainers, eccentric adjustable inlets, integral screwdriver stops with covering caps and adjustable threaded wall flanges.

3. Accessories:
   a. 5 feet of ½ inch diameter plain end reinforced rubber hose.
   b. Hose clamp hanger.
   c. Mop hanger.
   d. Separate threaded spigot connected to cold water only adjacent to sink
   e. In-line check valve should be installed on mop sink faucets and hose bibs
   f. In-line ball valves should be installed upstream of the mop sink faucets

K. Trap Primers

1. Automatic trap primers shall be used to prevent p-traps from drying out in areas where drains may not be used regularly.

2. Trap primers shall be equipped with a simple flow switch on the incoming water feed.
   a. Switch shall be tied in to BAS system and programmed to send alarm if switch is made for more than 5 minutes. This setting shall be adjustable.
22 60 00 – Gas and Vacuum Systems for Laboratory & Healthcare Facilities

1. General
   A. Furnish and test the following systems:
      1. Oxygen (O2)
      2. Vacuum (Vac)
      3. Medical/clinical compressed air (MA)
      4. Nitrous Oxide (N2O)
      5. Nitrogen (N2)
      6. Carbon Dioxide (CO2)
      7. Evacuation / WAGD / AGE
   B. Work includes outlets, valve boxes, valves, alarm systems, pressure and vacuum switches and miscellaneous accessories for complete systems.
   C. Work also includes pressure testing, precertification testing and final testing, including purging and analyzing.
   D. Work described in this section does not include electrical wiring for alarms and electrical accessories associated with the system.
   E. All equipment must be supported directly by structural members with adequate load-bearing capacity and material integrity, using appropriate anchoring/connection hardware. Under no circumstances may equipment be supported by connections to finish materials. For example, equipment hung from toggle bolts through plaster-on-lath, gypsum board or ACT ceilings is not acceptable.

2. Code Compliance / Quality Assurance
   A. Install in compliance NFPA 99, Chapter 4 as required and enforced by Authority having Jurisdiction (AHJ).
   B. Comply with local, state and federal codes applicable in this jurisdiction.
   C. Employ only qualified journeymen for this work. Employ a competent qualified mechanic/piping foreman who has satisfactorily completed at least five other similar installations for this work.
   D. All medical gas brazers must be certified according to NFPA 99. A copy of the certification must be available upon request.
3. **Coordination**

A. Coordinate with other trades to assure timely installations and to avoid conflicts and interference.

B. Work closely with the metal stud partition installer and/or mason to assure that anchors, sleeves and similar items are provided in sufficient time to avoid delays; chases and openings are properly sized and prepared.

C. Coordinate layout of medical gas systems in all spaces and identify all piping accurately and in accordance with Section 9 of this guideline.

4. **Qualifications of Manufacturers**

A. Pipeline System Components:

   1. One manufacturer shall supply the medical gas piping system equipment to include outlets, valves, manifolds, gauges, valve boxes and alarm boxes.

   2. Component manufacturer shall have a pipeline system engineer or product specialist available to periodically check with the Contractor during installation of pipeline system equipment and provide a service organization to certify the system.

   3. Provide ongoing service support to the Owner after acceptance of system.

5. **Piping Materials**

A. Piping: Seamless Type K (ASTM 88) copper tubing, in accordance with NFPA 99 Chapter 4. Piping shall be precleaned and plugged by supplier before shipment to jobsite. Piping shall be labeled according to NFPA 99.

B. Fittings: Wrought copper, brass or bronze designed expressly for brazed connection.

C. Brazing alloy: Melting point of at least 1000°F.

D. Flux: Do not use for copper-to-copper joints. Use flux for joining copper to brass or bronze. In those cases where flux is used, exercise particular care in applying the flux to avoid leaving any excess inside the completed joints.

E. Isolation of copper tubing from dissimilar metal shall be accomplished either through use of copper tear drop hangers or plastic isolators. Duct tape shall not be used. Vibra-clamps or tube clamps shall be used with Unistruts (with appropriate isolator).

F. The vacuum piping shall be 3/4 inch ID to the outlet extension.

G. On-site cleaning: Shall be limited to re-cleaning surfaces in the immediate vicinity of the joints that have become contaminated prior to brazing. Surfaces shall be cleaned by washing in a clean, hot water/alkaline solution, such as sodium carbonate or tri-sodium
phosphate (1 lb to 3 gal of potable water). Interior surfaces shall be thoroughly scrubbed and rinsed with clean, hot, potable water.

1. Any on-site cleaning shall be supervised by DUMC personnel.

2. Clean brushes, rubber gloves, towels and bags shall be used. After rinsing and drying the surfaces, the fittings, valves, etc. shall be placed in a clean bag until installation (to avoid recontamination).

H. Where three (or more) piping systems are run together, Unistruts shall be used to support the pipes. These piping systems shall be spaced appropriately so that valves shall not interfere with or obstruct each other.

6. Laboratory Vacuum Systems

A. Vacuum system including pump and venting must be determined and engineered on a project specific basis.

B. Provide system traps in each lab

C. HEPA filtration may be required in some labs utilizing lab vacuum systems

7. Medical Gas Outlet Stations

A. Recessed Wall Outlets:

1. Outlets shall be UL listed and conform to applicable NFPA and CGA Standards. Outlets shall consist of separate rough-in and finish assemblies and be modular in design.

2. The rough-in assembly shall be corrosion resistant with a secondary check valve and a permanent pin-keying system for each specific gas. The copper tubing inlet shall rotate 360 degrees to allow connection from any direction. The assembly shall allow pressure testing without additional labor to remove plug or adapter after testing.

3. The DISS finishing assembly shall be designed in accordance with CGA V-5 Standards for diameter index safety system and containing a primary check a minimum of 2.5 square inches of color coding and incorporate an automatic primary check valve plaster adjustment up to 1/2 inch over standard 1/2 inch wall finish. Quick-release mechanism shall not be incorporated into the outlet. Outlet design shall be such as to insure absolutely no gas flow until the correct adapter is fully engaged. Each assembly shall have a separate cover plate for each gas for ease of service without preventing use of other outlets.

4. Each vacuum outlet shall have an adjacent slide for supporting vacuum bottle assembly. Each vacuum slide shall be ganged together and roughed-in along with the other gases.
B. Other Outlets:

1. All other outlets and/or outlet connections shall be DISS (columns, hose drops, etc.)

8. Medical Gas Valving

A. Main and Base of Riser Valves (valves not in boxes)

1. Valves and tubing shall be specially prepared for oxygen service and shall conform in all particulars to NFPA 99.

2. Valves shall be ball-type with Teflon seats and adjustable stem packing gland with Teflon stem seal, through 2 inches. 2-1/2 to 3 inch valves shall have Teflon seats and double Teflon stem seal. 4 inch valves shall have Buna-N ball seats.

3. Ball valves shall be rated at 400 psig, actuate from full “ON” to full “OFF” by 90 degrees turn of vinyl gripped valve handle. Factory installed copper tubing shall be extended sufficiently to help prevent valve seat damage during soldering.

4. Unless specifically noted or obviously required, main and riser valves located in non-public areas are not required to be installed in box.

5. Quantities and sizes as indicated on drawings.

6. All service (main, riser, and branch) valves shall be lockable (any valves not located within a valve box.)

7. All valves shall be labeled according to NFPA 99.

8. Valves shall be quarter-turn ball type and three-piece design with full size ports.

B. Area/Zone Valves (valves in boxes)

1. Zone valve boxes shall be constructed of extruded aluminum or 18-gauge sheet steel with air-dried lacquer finish. The cover frame shall be made of an anodized aluminum and attached to the box by concealed screws. The finished assembly shall be substantially dust-tight. The frame assembly shall be capable of adjusting for variances in wall thickness up to one inch. The frame assembly shall contain an easily removable cover window with pull ring. The window shall conceal exposed piping and valves within the box and shall be labeled “Caution - Medical Gas Control Valves - Close Only in Emergency”. Tinted transparent window shall be provided to display the gas service, the area controlled by the valve, and pressure gauges on units so equipped.

2. Frames for valve boxes shall have uniform width for balanced appearance. Manufacturer shall provide color-coded self-adhesive gas service labels for compliance with NFPA 99 labeling requirements. Apply labels to each valve within
the assembly or proper gas service identification according to the manufacturer’s instructions.

3. Placement of the valve within the zone valve box shall be such that the removable window cannot be replaced when any valve is closed. Factory installed Type K copper pipe extensions shall extend three (3) inches outside the valve box. Design of the valve box shall be such that valves may be removed prior to brazing, without disassembly of the box, to permit field rearrangement of valves if necessary. Valves shall be ball type, cleaned for oxygen service, supplied with capped ends and shall operate full open to closed position with 90 degree handle rotation.

4. Valve boxes shall include 1-1/2 inch pressure gauges reading 0-100 psig for oxygen, nitrous oxide and air; 0-300 psi for nitrogen and 0-30 inHg for vacuum or evacuation vacuum. The gauge port shall be equipped with removable plug for pressure testing prior to final assembly of gauge. Gases at nonstandard operating pressures shall have gauges that meet the requirements of NFPA 99.

5. Gauge model zone valve box assemblies shall read pressure downstream (upstream for vacuum) of the valve per NFPA 99.

9. Medical Gas Alarm Systems

A. Area/Zone Alarm Digital (IASII)

1. Digital area alarm panels shall be designed to meet the requirements of NFPA and CSA standards. Alarms shall be UL listed as an assembly and shall include all necessary gauges, factory wiring, transformers and circuitry requiring only 120 or 240 volt primary power. Internal voltage shall be stepped down to 12 or 24 volt closed, control circuit power. Wiring to external switches shall also be at the stepped down voltage.

2. Furnish and install the alarm. Coordinate the power wiring with work by the Electrical Subcontractor.

B. Area/Zone Alarms

1. Digital area alarm panels shall be modular in design and shall consist of a central module which is identical to master alarm central module and of alarm modules which plug into the central module and attach to the wall with two screws. The central module shall operate with up to ten alarm modules.

2. The alarm modules shall have a digital display of each gas monitored per NFPA 99. Units utilizing a single display for multiple gases are not acceptable.

3. The signal for alarm modules shall be from pressure sensors installed in the area being monitored. Sensor for master alarm and area alarm shall be identical and shall be installed in gas specific check valves for ease of servicing.
C. Alarms General

1. Central modules shall be capable of operating with any combination of ten point alarm modules (master alarm) and digital alarm modules (area alarm) so that separate panels are not required.

2. All alarms shall have the capability of communicating over a synapse cable so that when so programmed, hospital personnel may monitor conditions at remote panels.

10. Medical Piped Gas Identification

A. Medical piped gas labels shall contain flow arrows and be color coded according to NFPA. Medical piped gases shall be labeled at 10 foot intervals. Piping shall contain labels before and after all wall penetrations and all piping turns. Piping shall be labeled at least once in each room.

11. Medical Piped Gas Installation

A. Pre-clean and prepare copper pipe, tubing, valves and fittings for medical gas service in accordance with Chapter 4 of NFPA 99, except those supplied especially prepared for such service by the manufacturer and received sealed on the job. Copper tubing shall be pre-cleaned, degreased and delivered sealed to the jobsite.

B. Joints in the piping, except those at equipment requiring screwed connections, shall be made with silver brazing alloy or similar high melting point (at least 1000°F) brazing metal.


1. Silver brazing alloy composition: 15% silver, 80% copper and 5% phosphorus. No cadmium.

2. Minimum of 1000°F liquid melting point with ASTM rating of “BCuP5”.

3. The use of flux is prohibited for the making of joints between copper-to-copper pipes and fittings. Appropriate flux similar to “Stay-Silv-Black Flux” or “Stay-Silv-White Flux” is required between dissimilar metals such as copper to brass or bronze material, when parts are heated over a prolonged period.

D. During the brazing of pipe connections, the interior of the pipe shall be purged continuously with oil-free, dry nitrogen. The outside of the tube and fittings shall be cleaned by washing with hot water after assembly.

E. Threaded joints in piping systems shall be made up with polytetrafluoroethylene (such as Teflon) tape or other thread sealants suitable for oxygen service. Apply sealants to the male threads only.
F. Support piping with pipe straps or hangers at appropriate intervals and do not support from other piping. Piping shall be supported from the building structure. Under no circumstances shall piping or other equipment be suspended from finish materials such as dropped ACT ceilings or plaster lath.

1. Isolate copper piping from dissimilar metals. Duct tape shall not be used as an isolation material.

G. Threaded joints in distribution piping shall be limited to the connection of gauges, switches and similar devices.

H. Use flux with a silver (BAg series) brazing filler material. Some flux may contain compounds objectionable for oxygen service and shall not be employed.

I. Pipe shall be prepared, fit together and brazed within the same 24-hour period to avoid contamination of the pipe. During intervals within the work where work is incomplete, end caps (sized according to pipe) shall be installed over the ends of the pipe and taped to avoid contamination.

J. Fittings, valves and other components shall remain sealed until installation onto the system. Bags shall remain closed and sealed when not in use.

K. On-site cleaning: Shall be limited to re-cleaning surfaces in the immediate vicinity of the joints that have become contaminated prior to brazing. Surfaces shall be cleaned by washing in a clean, hot water/alkaline solution, such as sodium carbonate or tri-sodium phosphate (1 lb to 3 gal of potable water). Interior surfaces shall be thoroughly scrubbed and rinsed with clean, hot, potable water.

1. Any on-site cleaning shall be supervised by DUMC personnel.

2. Clean brushes, rubber gloves, towels and bags shall be used. After rinsing and drying the surfaces, the fittings, valves, etc. shall be placed in a clean bag until installation (to avoid recontamination).

L. After installation of the piping but before installation of the outlet valves, blow lines clear by means of oil-free, dry nitrogen.

M. Piping exposed to physical damage shall be adequately protected.

N. While being brazed, joints shall be purged with inert gas (nitrogen NF) per NFPA 99.

O. Uninstalled piping shall be kept on a pipe rack. This piping shall also be kept separate from other copper piping to avoid incorrect usage.

12. Installer Performance Testing

A. Testing shall be performed with oil-free, dry nitrogen. The installing Contractor shall perform the following steps:
1. **Blow Down**  
   NFPA 99, 1999  4-3.4.1.2(a)

2. **Initial Pressure Test**  
   NFPA 99, 1999  4-3.4.1.2(b)

3. **Cross-Connection Test**  
   NFPA 99, 1999  4-3.4.1.2(c)

4. **Piping Purge Test**  
   NFPA 99, 1999  4-3.4.1.2(d)

5. **Standing Pressure Test**  
   NFPA 99, 1999  4-3.4.1.2(e)
   
   a) Due to time schedules during construction, sections of piping systems can be tested so that walls can be closed-in. When sections of piping have been tested, the entire system must again be tested before final precertification and certification of the system.

   b) Test apparatus shall be leak tested and found leak free before the start of the 24-hour test.

B. All items in this section shall be documented in a report by Contractor per NFPA 99.

### 13. System Verification and Certification

A. Testing shall be performed with oil-free, dry nitrogen. The installing Contractor shall perform the following steps: Cross connection testing and precertification of the medical gas system must be performed by a party technically competent and experienced in the field of medical gas pipeline testing. A party other than the installing Contractor shall perform the following testing:

1. **Cross-connection Test**  
   NFPA 99, 1999  4-3.4.1.3(a)

2. **Valve Test**  
   NFPA 99, 1999  4-3.4.1.3(b)

3. **Outlet Flow Test**  
   NFPA 99, 1999  4-3.4.1.3(c)

4. **Alarm Testing**  
   NFPA 99, 1999  4-3.4.1.3(d)

5. **Piping Purge Test**  
   NFPA 99, 1999  4-3.4.1.3(e)
6. **Piping Purity Test**  
   NFPA 99, 1999  4-3.4.1.3(f)

B. Medical gas system shall be tested in accordance with NFPA 99, latest edition and these specifications.

C. Obtain and present to the Owner a complete bond report of pipeline precertification from the equipment manufacturer. This letter of precertification shall indicate:

1. That the system is free of crossed connections.
2. That all system components perform to the manufacturer’s design specifications.
3. That all system components, particularly the alarm system, have been installed in accordance with the manufacturer’s recommendations.

D. This report must be submitted to Engineering and Operations (E&O) a minimum of 48 hours before the desired date of the tie-in. E&O, Administration and Respiratory Therapy will coordinate the tie-in with the contractor.
23 00 00.10 – Mechanical Equipment Room Design

1. Introduction

   A. Mechanical equipment rooms (MERs) shall be designed to achieve:

      1. Equipment, piping, and ductwork layout which allow proper operation of the systems, including straight runs required upstream or downstream of meters and control elements.

      2. Safe access to all equipment maintenance points without undue contortions, and with space to use the proper tools.

      3. Provide access to all piping and conduit runs so that repair may be done if needed.

      4. Containment of equipment and system noise within the mechanical space so as not to produce objectionable noise levels in occupied areas.

      5. A travel path for the single largest component of the equipment so that it may be replaced without alterations to walls or structure.

   B. Mechanical equipment room layouts shall be reviewed with DUES during the design development stage of the design process and again at the construction documents phase.

2. References

   A. North Carolina State Building Codes, 2009

3. Design Standards

   A. Access to MER

      1. Locate MERs so that they can be accessed without passing through the occupied areas of the building.

         a. Exception: MERs located in a penthouse or mezzanine level.

      2. Where MERs are located on the roof, at least one elevator and one stairwell shall serve the roof level. Locate the MER so that workmen may reach it without climbing ladders or other means.
3. There shall be a path from the outside of the building into the MER with clearances so that the single largest component of any of the equipment in the MER may be removed without taking it apart. This includes doorways, stairwells, and elevator cars. Paths which require demolition or alteration of the structure or permanent partitions are unacceptable.

B. Location

1. Mechanical rooms with vibrating equipment may not be located adjacent (either horizontally or vertically) to occupied spaces where the noise from the equipment will be objectionable.

2. Mechanical rooms containing air handling units with outside air requirements will be located on an exterior wall or under a roof which allows for intake of outside air.

3. Do not locate MERs adjacent to electrical rooms or telecom rooms, to avoid interference between duct mains and distribution conduits and cable trays.

4. Equipment on the roof shall be in an MER, not exposed on the roof. Where MER is above occupied space, floor shall be epoxy coated and all penetrations shall be curbed. Mechanical room shall be treated as one large auxiliary drain pan to prevent fluids from dripping to the floors below.

C. Separation of services

1. The high pressure steam (HPS) building entry and pressure reducing valves shall be in a separate room from other mechanical equipment and equipped with two means of egress from the room.

D. Locations of equipment etc.

1. Floor drains shall be located where they may be seen. They shall not be located below large equipment or between equipment and wall or between pieces of equipment where they cannot be easily accessed.

2. In general, equipment serving one system should be located together to simplify maintenance, TAB, and routings.

3. Group pipes running in the same direction at the same elevation.

4. Assign elevations to each direction for pipes and for duct. In general, ductwork shall be above pipes.
5. Pipe and duct elevations shall be high enough so that additional pipes may be added in the future.

6. Do not locate pipes close together such that there is no room for installation and maintenance of valves and take-offs.

7. Show required maintenance clearances for all equipment on drawings.

8. In steam rooms, in case there is a rupture of any of the components, provide a clear path of egress from all points in the room. Path of egress shall be outlined in safety yellow marking tape or paint.

9. Leave a clear walkway around equipment, with a minimum 7'-0" head height. This path shall be identified on the floor by tape or paint.

10. MERs floors shall be painted or epoxy coated. Coordinate with Duke FMD.

4. Documentation and Review Requirements

A. Mechanical room floor plans shall be drawn at ¼" = 1'-0" scale or larger

B. Elevations/sections are required for all MERs unless otherwise specified by DUES.

C. Piping larger than 2" shall be drawn double line.

D. All ductwork shall be drawn double line.

E. Indicate all equipment maintenance access clearances on the drawings, including coil pull and pump, fan, or motor removal.

F. Indicate on drawings walkways to be kept clear.

G. At least one section shall be drawn of each MER, at ¼" = 1'-0" scale or larger, showing structure, equipment, pipes and ductwork, large valves, piping and conduit of other trades. In complex spaces, draw section for each area where several services are crossing or where ductwork or piping must cross tall equipment.

H. MER drawings shall be submitted to DUES for review not later than 50% CDs, with sufficient detail to establish safe travel paths, equipment access areas and elevations for main pipe and duct runs.

I. For larger projects, SD submittal shall include all major equipment, to scale, and main duct and pipe routings. DD submittal shall include all equipment, at ¼" = 1'-0" scale, and all pipe and ductwork. A preliminary section shall be submitted at DD. The
designer shall establish with DUES, at the beginning of the design phase, which MER drawings will be submitted.
23 05 23 – General-Duty Valves for Piping

1. Introduction

   A. This Construction Standard covers valves for building plumbing and mechanical systems, including, but not limited to:

      1. Hot-water heating.
      2. Steam and Condensate.
      3. Chilled-water.
      4. Condenser-water.
      5. Glycol cooling-water.
      6. Potable water.
      7. Non Potable water.

   B. Designers should coordinate with Duke FMD to coordinate selection and execution requirements for piping systems.

2. References

   A. NC State Mechanical Code, 2012

   B. NC State Plumbing Code, 2012

   C. Duke University Construction Standards, Section 22 07 16 Plumbing Equipment Insulation

   D. Duke University Construction Standards, Section 23 07 16 HVAC Equipment Insulation

   E. Duke University Construction Standards, Section 33 63 00 Steam Energy Distribution

   F. Duke University Construction Standards, Section 33 61 00 Hydronic Energy Distribution

   G. Duke University Construction Standards, Section 23 00 00.01 Requirements for Drawings

3. Performance Requirements

   A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:

      1. Hot-Water Heating: 150 psig at 250 deg F

      2. Steam & Condensate: 150 psig at 366 deg F
3. Chilled-Water: 200 psig at 75 deg F
4. Condenser-Water: 150 psig at 100 deg F
5. Glycol Cooling-Water: 100 psig at 150 deg F
6. Potable Water: 80 psig at 75 deg F
7. Potable Hot Water: 80 psig at 160 deg F
8. Non Potable Water: 80 psig at 75 deg F
9. Blowdown-Drain (Non Steam): 225 deg F
10. Air-Vent: 200 deg F

4. Design Standards

A. The following table illustrates desired piping standards for different mechanical systems:

<table>
<thead>
<tr>
<th>Service</th>
<th>Service</th>
<th>Size</th>
<th>Type</th>
<th>Pipe Connection</th>
<th>Class/Rating</th>
<th>Material/Construction</th>
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<td>High Pressure Steam</td>
<td>Isolation</td>
<td>2&quot; and smaller</td>
<td>Gate</td>
<td>Socket Weld</td>
<td>800</td>
<td>Carbon Steel Body, OS&amp;Y, Velan Forged Steel Valve or Equivalent</td>
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<td>Gate</td>
<td>Butt Weld</td>
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<td>Cast Carbon Steel, OS&amp;Y, Velan Cast Carbon Steel API 600 or Equivalent</td>
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<td>Socket Weld</td>
<td>800</td>
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<tr>
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<td>Globe</td>
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<td>300</td>
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<td>Butt Weld</td>
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<td>Cast Carbon Steel, OS&amp;Y, Velan Cast Carbon Steel API 600 or Equivalent</td>
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<td>Socket Weld</td>
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<td>Service</td>
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<td>Type</td>
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<td>Butt Weld</td>
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<td>Socket Weld</td>
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<td>Stainless Steel Body, Stainless Internals, Spring Assisted non-slam</td>
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<td></td>
<td>2&quot; and smaller</td>
<td>Swing</td>
<td>Sweat</td>
<td>200 CWP</td>
<td>Bronze Body, Bronze Disc Apollo 161S or equivalent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-1/2&quot; and larger</td>
<td>Wafer</td>
<td>Flanged</td>
<td>125/150</td>
<td>Cast Iron, spring assisted, non-slam, Crane Duo-Chek or equivalent</td>
</tr>
</tbody>
</table>

**Chilled Water Condenser Water Heating Hot Water**

**Potable & Non Potable Water (Hot & Cold)**

**Equipment Drains, Isolation**

**2" and smaller** | Ball | Threaded | 600 CWP | Bronze Body, Stainless Internals, Apollo 70-100 Series or equivalent
1. Valves shall be insulated in accordance with Duke University Construction Standards, Section 22 07 16 Plumbing Equipment Insulation and 23 07 16 HVAC Equipment Insulation.

2. If necessary, balancing valves shall be provided to facilitate system testing and balancing not isolation. Isolation valves shall be installed in addition to balancing valves. Triple duty valves shall not be used on variable volume systems. The use of balancing valves is not required for hydronic systems operating with Variable Frequency Drives.

3. Valve identification tags shall be provided for all valves. Identification tags shall be manufactured from either brass or stainless steel. A valve identification chart referencing each installed valve shall be provided in the mechanical room in which the valves are installed. If a valve identification chart is already present, the chart should be updated to reflect the installation of new valves.

4. **Installation and Performance Requirements**

   A. Confirm installation responsibilities at out-set of project. Installation services will be provided in-house or contracted out.

   B. Coordinate all commissioning efforts with Duke Utilities and Engineering Services (DUES).
23 05 93 – Testing, Adjusting and Balancing for HVAC

1. Introduction
   A. This section contains the requirements for inspecting, testing, adjusting and balancing of HVAC systems.
   B. The Contractor shall be AABC or NEBB certified and shall furnish all labor, tools and equipment required to complete the work.

2. References
   A. ASHRAE
   B. AABC
   C. NEBB
   D. SMACNA

3. Design Standards
   A. For constant volume supply and exhaust systems, the entire system shall be rebalanced after every project. This includes lab fume hood exhaust systems.
   B. Requirements and recommendations for acoustical and indoor air quality (IAQ) testing shall be considered and discussed with FMD during design.
   C. Building pressurization verification shall be considered. To determine offset airflow and building pressurization, the overall building outside air supply and exhaust quantities for minimum and maximum airflow operating conditions shall be tabulated and documented by the Engineer of Record.

4. Documentation and Review Requirements
   A. TAB strategies, procedures and reporting format shall be submitted for review and approval by FMD and design engineer before TAB work begins. The submittal shall include:
      1. Specific systems listed clearly identifying each piece of equipment to be included in TAB work with appropriate test procedures and measurements to be taken.
      2. Instrument calibration records shall be provided on forms shown in NEBB, AABC or SMACNA with manufacturer’s specified accuracy listed.
      3. Schematic diagrams and/or floorplans for all airflow and hydronic systems.
4. Locations of all airflow and pressure readings on schematic diagram(s).

5. Air Handling Unit data shall include a static pressure profile diagram.

6. Equipment nameplate and motor data.

7. VFD maximum and “as-left” speed frequency setting. Include a list of all “as-left” VFD configuration parameters for all VFD’s included in TAB report.

8. Static pressure set points for all supply and exhaust fans.


B. Additional requirements for renovations affecting existing systems:

1. Existing conditions TAB data for air and hydronic systems are required during design phase. Coordinate scope of TAB work with Duke FMD.

5. Installation and Performance Requirements

A. Prior to TAB work, the Contractor must verify the following: systems have been installed and are operating as specified, all balancing devices have been installed, all duct leakage tests have been completed and clean filters have been installed.

B. All equipment shall be vibration tested and documented after installation.

C. All instrumentation used for testing shall be calibrated within 6 months of use. Accuracy of the instrumentation shall not be less than what is specified by the instrument manufacturer.

D. Balancing devices shall be marked by the Contractor to indicate final settings.

E. Airflow tolerances

1. Office areas: -5%, +10%

2. Classrooms: -5%, +10%

3. Laboratories
   a. Supply: -0%, -10%
   b. Exhaust: -0%, +10%

4. Residences: +/- 10%

5. Kitchens: -5%, +10%

6. Heat Removal Ventilation: -5%, +10%
7. Heating Ventilation: -0%, +10%

F. Engineer of Record shall review all balancing reports to verify performance compliance with system design and overall building pressurization. Engineer shall communicate results with FMD DUES and project commissioning agent to resolve non-compliant performance issues.

6. As-Built Requirements

A. Final report shall include a summary describing test methods, test results and major corrective actions taken.

B. Any system changes and/or modifications implemented after project TAB work intended to achieve project design requirements shall be re-tested and re-documented to reflect the most current system performance.
23 07 16 - HVAC Equipment Insulation

1. Introduction
   A. This section covers insulation systems for building HVAC systems, including, but not limited to:
      1. Steam system piping
      2. Chilled water system piping
      3. Heating hot water
      4. HVAC ductwork
      5. Mechanical equipment
   B. Building Insulation Guidelines are listed in Division 07, Section 07 21 00 of the Duke University Design Guidelines.
   C. Designers should coordinate with Duke FMD to coordinate selection and execution requirements for insulation systems.

2. References
   A. ASHRAE Standard 90.1 – 2007
   B. NC State Energy Code, 2012
   C. NC State Mechanical Code, 2012
   D. USGBC LEED v3.0
   E. Duke University LEED+ Standard
   F. Duke University Design Guidelines, Section 33 63 00 Steam Energy Distribution
   G. Duke University Design Guidelines, Section 33 61 00 Hydronic Energy Distribution

3. Design Standards
   A. The following table illustrates desired insulation standards for different mechanical systems:

<table>
<thead>
<tr>
<th>Service</th>
<th>Marker</th>
<th>Size</th>
<th>Location</th>
<th>Material</th>
<th>Thickness</th>
<th>Finish</th>
<th>Color</th>
</tr>
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</table>

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<table>
<thead>
<tr>
<th>Service</th>
<th>Marker</th>
<th>Size</th>
<th>Location</th>
<th>Material</th>
<th>Thickness</th>
<th>Finish</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Pressure Steam</td>
<td>HPS</td>
<td>3&quot; and smaller</td>
<td>all</td>
<td>Flexible Aerogel</td>
<td>20 mm</td>
<td>Aluminum jacket</td>
<td>none</td>
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<tr>
<td></td>
<td></td>
<td>4&quot; and larger</td>
<td>all</td>
<td>Fiberglass, Mineral Wool, or Flexible Aerogel</td>
<td>30 mm</td>
<td>Aluminum jacket</td>
<td>none</td>
</tr>
<tr>
<td>Medium Pressure Steam</td>
<td>MPS</td>
<td>3&quot; and smaller</td>
<td>all</td>
<td>Fiberglass, Mineral Wool, or Flexible Aerogel</td>
<td>2&quot;</td>
<td>Aluminum jacket</td>
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</tr>
<tr>
<td></td>
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<td>4&quot; and larger</td>
<td>all</td>
<td>Fiberglass, Mineral Wool, or Flexible Aerogel</td>
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<td>Aluminum jacket</td>
<td>none</td>
</tr>
<tr>
<td>Low Pressure Steam</td>
<td>LPS</td>
<td>3&quot; and smaller</td>
<td>all</td>
<td>Fiberglass, Mineral Wool, or Flexible Aerogel</td>
<td>2&quot;</td>
<td>Aluminum jacket</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4&quot; and larger</td>
<td>all</td>
<td>Fiberglass, Mineral Wool, or Flexible Aerogel</td>
<td>2&quot;</td>
<td>Aluminum jacket</td>
<td>none</td>
</tr>
<tr>
<td>High Pressure Condensate</td>
<td>HPC</td>
<td>2&quot; and smaller</td>
<td>all</td>
<td>Flexible Aerogel</td>
<td>20 mm</td>
<td>Aluminum jacket</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-1/2&quot; and larger</td>
<td>all</td>
<td>Fiberglass, Mineral Wool, or Flexible Aerogel</td>
<td>30 mm</td>
<td>Aluminum jacket</td>
<td>none</td>
</tr>
<tr>
<td>Medium Pressure Condensate</td>
<td>MPC</td>
<td>2&quot; and smaller</td>
<td>all</td>
<td>Fiberglass, Mineral Wool, or Flexible Aerogel</td>
<td>1-1/2&quot;</td>
<td>Aluminum jacket</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-1/2&quot; and larger</td>
<td>all</td>
<td>Fiberglass, Mineral Wool, or Flexible Aerogel</td>
<td>2&quot;</td>
<td>Aluminum jacket</td>
<td>none</td>
</tr>
<tr>
<td>Low Pressure Condensate</td>
<td>LPC</td>
<td>2&quot; and smaller</td>
<td>all</td>
<td>Fiberglass, Mineral Wool, or Flexible Aerogel</td>
<td>1-1/2&quot;</td>
<td>Aluminum jacket</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-1/2&quot; and larger</td>
<td>all</td>
<td>Fiberglass, Mineral Wool, or Flexible Aerogel</td>
<td>2&quot;</td>
<td>Aluminum jacket</td>
<td>none</td>
</tr>
<tr>
<td>Relief Vent</td>
<td>VENT</td>
<td>All</td>
<td>all</td>
<td>Fiberglass, Mineral Wool, or Flexible Aerogel</td>
<td>n/a</td>
<td>Color-coded PVC</td>
<td>gray</td>
</tr>
<tr>
<td>Chilled Water</td>
<td>CHW</td>
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<td>all</td>
<td>closed-cell elastomeric</td>
<td>1&quot;</td>
<td>Color-coded PVC</td>
<td>blue</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2&quot; and larger</td>
<td>all</td>
<td>polyisocyanurate</td>
<td>2&quot;</td>
<td>Color-coded PVC</td>
<td></td>
</tr>
<tr>
<td>Condenser Water</td>
<td>CW</td>
<td>All</td>
<td>all</td>
<td>none</td>
<td>n/a</td>
<td>enamel paint</td>
<td>green</td>
</tr>
<tr>
<td>Heating Water</td>
<td>HHW</td>
<td>1-1/2&quot; and smaller</td>
<td>all</td>
<td>Fiberglass or Mineral Wool</td>
<td>1&quot;</td>
<td>Color-coded PVC</td>
<td>red</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2&quot; and larger</td>
<td>all</td>
<td>polyisocyanurate</td>
<td>2&quot;</td>
<td>Color-coded PVC</td>
<td></td>
</tr>
<tr>
<td>Reclaim/re-use/gray water</td>
<td>RECLAIM</td>
<td>All</td>
<td>all</td>
<td>none</td>
<td>n/a</td>
<td>enamel paint</td>
<td>gray</td>
</tr>
<tr>
<td>CHW Drain</td>
<td>DRAIN</td>
<td>All</td>
<td>all</td>
<td>closed-cell elastomeric</td>
<td>1”</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Ductwork</td>
<td>n/a</td>
<td>16&quot; x 16&quot; and larger</td>
<td>exposed</td>
<td>fiberglass board</td>
<td>1&quot;</td>
<td>Color-coded PVC or canvas</td>
<td>per architect</td>
</tr>
<tr>
<td>Service</td>
<td>Marker</td>
<td>Size</td>
<td>Location</td>
<td>Material</td>
<td>Thickness</td>
<td>Finish</td>
<td>Color</td>
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<td>-------------------------</td>
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<td>----------</td>
<td>---------------------------------</td>
<td>-----------</td>
<td>--------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Ductwork (cont.)</td>
<td>All</td>
<td>Outside</td>
<td>polyisocyanurate Foam board</td>
<td>2”</td>
<td>EPDM</td>
<td>per architect</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>Mech. Rm.</td>
<td>fiberglass board</td>
<td>2”</td>
<td>Color-coded PVC</td>
<td>white</td>
<td></td>
</tr>
<tr>
<td>Refrigerant</td>
<td>n/a</td>
<td>All</td>
<td>all</td>
<td>closed-cell elastomeric</td>
<td>1”</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Process Water</td>
<td>PCHW</td>
<td>All</td>
<td>all</td>
<td>closed-cell elastomeric</td>
<td>TBD</td>
<td>Color-coded PVC</td>
<td>light blue</td>
</tr>
</tbody>
</table>

B. Insulation thickness should comply at minimum with requirements of current version of ASHRAE standards/requirements. Increased insulation thickness should be utilized if justifiable per project Life Cycle Cost Analysis.

C. Removable / Reusable Insulation:

1. Components requiring frequent maintenance should be covered with re-usable insulation jackets. Jackets should be fabricated of non-porous Teflon-impregnated woven Nomex cloth, with double wove stitching. Blankets should contain fiberglass mat suitable for service temperature range. Thermal conductivity ratings should be sufficient to maintain a surface temperature of no more than 120°F with an ambient temperature of 80°F.

   Applications for removable insulation jackets may include:
   
   a. Steam pressure reducing valves
   b. Pressure-powered pumps
   c. Control valves
   d. Small-volume receiver and flash vessels
   e. Ultrasonic flow meters
   f. Other components or equipment for which pre-formed insulation block shapes are not available.

2. Removable jackets should be equipped either with D-links and strapping material. Jacket must draw tight when installed, leaving no gaps. No wire draw material is acceptable for enclosing removable jackets.

D. Specific installation situations:

1. Any insulation installed outdoors must be jacketed and sealed to prevent moisture penetration.

2. Outside ductwork must be installed with EPDM rubber covering and sealed for weather protection.
3. Generally, interior ductwork and piping must be concealed in finished spaces. Flexible HVAC ducts must always be concealed. Exposed interior piping and rigid ductwork are permissible only when specified by the Architect for aesthetic effect and approved by the Owner.

4. Fiberglass insulation board applied on HVAC ductwork must utilize weld pins as for attaching the insulation to ductwork. Any changes to this method must be approved by DUES.

5. Closed-cell elastomeric insulation must be mitered at changes of direction in piping or tubing. Do not bend insulation.

6. The use of HVAC duct liner is generally discouraged. If liner must be used, only closed cell material approved by FMD should be selected.

7. All piping, ductwork and equipment jacketing must adhere to Duke University Design Guideline regarding Identification of Mechanical Systems (see Section 3A of this section).

8. Underground utility piping insulation is not covered in this Design Guideline, as insulation of those systems is typically integral an engineered piping system and must be coordinated and engineered on a project-specific basis.

E. Documentation and Review Requirements:

1. Analysis of the thermal systems insulation should be considered in the Life Cycle Cost analysis required for project approval.

2. Provide estimated energy usage calculation for all considered insulation systems. This calculation should compare energy usage and estimated costs for baseline (ASHRAE 90.1-compliant) insulation versus proposed higher efficiency models.

3. Insulation selection and specification must be reviewed by Duke FMD and the Commissioning Agent (when applicable) on a project-by-project basis.

4. Specifications shall include an insulation schedule in table format.

F. Installation and Performance Requirements:

1. Confirm installation responsibilities at outset of project. Installation services will be provided in-house or contracted out.

2. Coordinate all required tie-in points with Duke Utilities and Engineering Services (DUES).

3. Coordinate all commissioning efforts with DUES.
4. Provide identifying list for all valves. Coordinate with DUES for formatting and compliance with existing recordkeeping.

5. Provide identifying list for all steam traps. Coordinate with DUES for formatting and compliance with existing recordkeeping.

G. Piping Insulation:

1. The Consultants shall evaluate thermal insulation properties and moisture migration to prevent surface condensation. Piping that carries chilled water is often subject to surface sweating. To decrease vapor permeability for chilled water piping, polystyrene or polyisocyanurate insulation shall be used for piping 2 inches in diameter and larger. Piping under 2 inch diameter shall be insulated with Armaflex or equal or polyisocyanurate. Fiberglass insulation is not acceptable for chilled water piping.

2. All valves and fittings shall be insulated with preformed fitting insulation. Also provide preformed insulation for all cold and hot surfaces of equipment when available from the manufacturer. Extensions should be installed on small ball valves so that the handle is extended beyond the insulation and is visible and operational.
23 08 00 – Commissioning of HVAC Systems

1. GENERAL

A. GENERAL PROVISIONS

1. Drawings and general provisions of the Contract, including General Conditions and Division - 1 Specifications Sections, apply to Work of this section.

2. Provisions of Divisions 23 and 26 of the project specifications which are applicable to Commissioning of the HVAC Systems are an integral part of this Section.

3. Commissioning is an important and integral part of the Contractor's Quality Control program.

B. WORK INCLUDED

1. “Active participation” in the Commissioning program as generally outlined in this section.

C. COMMISSIONING PROGRAM

1. Description

   a. The purpose of this section is to specify the Division 23 Contractor's responsibilities and participation in the commissioning process.

   b. Commissioning is primarily the responsibility of the Commissioning Authority and Owner, with support for start-up, testing and commissioning the responsibility of the Division 23 Contractors. The commissioning process does not relieve this Contractor from participation in the process, or diminish the role and obligations to complete all portions of work in a satisfactory and fully operational manner.

2. Work of Division 23 includes:

   a. Testing and start-up of the mechanical equipment.

   b. Assistance in functional testing to verify testing and balancing, and equipment/system performance.

   c. Providing qualified personnel to assist in commissioning tests, including seasonal testing.

   d. Completion and endorsement of pre-functional test checklists provided by the Commissioning Authority to assure that Division 23 equipment and systems are fully operational and ready for functional testing.
e. Providing equipment, materials, and labor necessary to correct deficiencies found during the commissioning process which fulfill contract and warranty requirements.

f. Providing operation and maintenance information and as-built drawings to the Commissioning Authority for their use in developing the Systems Manual.

g. Providing assistance to the Commissioning Authority to develop, edit, and document system operation descriptions.

h. Providing training for the systems specified in this Division with coordination by the Commissioning Authority. Prior to training, submit a training plan complete with syllabus and sample training material. The Commissioning Authority will review and approve the training plan.

3. Work of Division 23 specific to automation temperature control system includes:

a. The Owner will provide the controls, programming, point to point and functional testing. The Commissioning Authority will provide prefunctional checklists and functional test procedures for use by the owner.

4. Commissioning Coordinators for HVAC

a. The Contractors shall assign qualified individuals from each discipline with at least ten (10) years of relevant experience in the installation, testing and start up of HVAC systems.

D. RELATED WORK

1. All testing and start-up procedures and documentation requirements specified within Division 1, Division 23, and related portions of this project.

2. Commissioning procedures that require participation of Division 23 Contractors.

3. Cooperate with the Commissioning Authority in the following manner:

a. Install balancing dampers/balancing cocks, access doors, test ports, and P&T taps as required by the Commissioner and/or the Owner for test and balance and functional testing.

b. Allow sufficient time before final completion dates so that test and balance and functional testing can be accomplished.

c. Provide labor and material to make corrections when required without undue delay.
d. Put all heating, ventilating, and air conditioning systems and equipment into full operation and continue the operation of the same during each working day of testing and balancing and functional testing.

e. Include the costs of dampers, replacement sheaves and belts as required, to obtain satisfactory system performance, as requested by the Owner or the Commissioning Authority.

f. Provide test holes in ducts and plenums where directed or necessary for pitot tubes for taking air measurements and to balance the air systems. Test holes shall be provided with an approved removable plug or seal. At each location where ducts or plenums are insulated, test holes shall be provided with an approved extension with plug fitting.

4. Scope: For coordination purposes, the Commissioning scope is generally outlined below:

a. Review contractor submittals for the systems included in the scope of commissioning.

b. Review training materials and agendas provided by the contractor and determine the adequacy of training. Verify training has been completed.

c. Document compliance with design intent of the HVAC system

d. Verify that equipment and systems have been properly installed in accordance with the contract documents and manufacturer’s written installation instructions.

e. Verify that equipment has been placed into operation with the appropriate manufacturer’s oversight and approval.

f. Verify that adjusting, balancing and system testing has properly done.

g. Develop a Systems Manual

h. Document and review warranty start and end dates.

i. Perform an assessment of the first 10 months of building operations and include a plan for resolution and correction of outstanding commissioning items.

2. PRODUCTS

A. TEST EQUIPMENT

1. Standard test equipment for commissioning will be provided by the installing contractor or Owner (for TAB and controls).

2. Division 23 shall provide standard and specialized test equipment as necessary to test and start up the mechanical equipment.
3. Proprietary test equipment required by the manufacturer, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist the Commissioning Authority or Owner in the commissioning process. The test equipment will become the property of the Owner.

3. **EXECUTION**

A. **PREPARATION OF COMMISSIONING PROGRAM**

1. The Commissioning program shall be prepared by the Commissioning Authority and submitted to the Engineer for approval.

B. **COMMISSIONING TEAM**

1. The Commissioning Coordinator shall assemble the Commissioning Team which shall consist of the following persons:
   a. Commissioning Authority
   b. Plumbing Contractor and Trade Representative(s)
   c. HVAC Contractor and Trade Representative(s)
   d. Control System Trade Representative(s) (from Owner)
   e. Test, Adjust and Balance Trade Representative (from Owner)
   f. Electrical Contractor's Representative
   g. Owner's Project Manager
   h. Owner's Maintenance staff
   i. Engineer of Record
   j. The Commissioning Team shall develop and generally follow a schedule of Commissioning events for the project.

C. **RESPONSIBILITIES**

1. Owner
   a. Assign appropriate staff and schedule them to participate in the various meetings, training sessions and inspections as follows:
   b. Pre-commissioning coordination and schedule of events meeting.
   c. Initial training session at initial placement of major equipment.
d. Maintenance orientation and inspection at initial placement of major equipment.

e. Maintenance orientation and inspection at connection of distribution systems.

f. Piping and ductwork test and flushing verification meetings.

g. Installation and programming of the BMS system, including point to point.

h. Conduct Testing and Balancing of systems.

i. Conduct Functional Testing of systems.

j. Owners training and demonstration session(s).

k. Review of operation and maintenance manuals and submittals for key components of the HVAC systems.

l. Participate in final review and acceptance meeting.

2. Commissioning Authority

a. Review all Commissioning requirements and intent of the Contract Documents. Assure all specialty Trade Subcontractors include their active participation in the Commissioning of HVAC systems.

b. Prepare the Commissioning program. Include input from Trade Representatives.

c. Coordinate the implementation of the Commissioning program, through organization of all Commissioning meetings, tests, demonstrations, training events and performance verifications described in the Contract Documents and the Commissioning program.

d. Review the plans and specifications with respect to their completeness in all areas as they relate to the Commissioning program.

e. The plan and specification review by the Commissioning Authority does not include any responsibility for the system evaluation, adequacy of the system to meet design intent, capacity of the system or any of the other elements of the system design which are the strict responsibility of the Engineer of record.

f. Schedule a pre-commissioning coordination meeting with the Commissioning Team within 45 days of the award of the contract, at a convenient location. This pre-commissioning meeting will be for the purpose of reviewing the complete Commissioning program and establishing tentative schedules for maintenance orientation and inspections, O&M submittals, training sessions, system flushing and testing, job completion, system start-up and test, adjust and balance work.

g. Verify accessibility of equipment for maintenance and component replacement/repair.
h. Conduct site installation verification visits to observe that equipment and systems are installed per the contract documents and applicable standards.

i. Schedule a meeting with the Owner prior to test, adjust and balance (TAB). This meeting should be attended by the Commissioning Team. The Owner’s TAB Representative will outline the TAB procedure and get concurrence from the Engineer of Record and Commissioning Coordinator.

j. Upon notification from the HVAC Contractor that the HVAC systems have been started, that all air, water and control systems have been started, tested, adjusted and balanced and that the systems and equipment is functioning as designed and specified, schedule the functional testing. Functional testing will be conducted by the Owner. Any Commissioning Team member may witness testing.

k. Provide a final Commissioning Report and LEED letters.

3. Engineer of Record

a. Provide clarification of any design intent questions raised by the Commissioning Team.

b. Attend and actively participate in initial pre-commissioning coordination meeting to be scheduled by the Commissioning Authority within 45 days of the award of the contract.

c. Review and approve Commissioning program.

d. Participate in sessions scheduled in the Commissioning program.

e. Receive and review operation and maintenance manuals as submitted by the HVAC Contractor.

f. Attend meetings with Owner’s TAB Representative as scheduled by Commissioning Authority.

g. Attend Owner training sessions as appropriate.

h. Review TAB report from Owner against design assumptions and system requirements. Issue a report noting deficiencies requiring correction to the Commissioning Team.

i. Prepare record drawings for the project after receipt from the HVAC Contractor.

D. WORK PRIOR TO COMMISSIONING

1. Complete all phases of work so the system can be started, tested, balanced, and otherwise commissioned. Division 23 has primary start-up responsibilities with
obligations to complete systems, including all sub-systems so they are functional. This includes the complete installation of all equipment, materials, pipe, duct, wire, insulation, controls, etc., per the contract documents and related directives, clarifications, change orders, etc.

2. A commissioning plan will be developed by the Commissioning Authority. Upon request of the Commissioning Authority, this Contractor shall provide assistance and consultation. The commissioning plan will be developed prior to completion of the installation. This Contractor is obligated to assist the Commissioning Authority in preparing the commissioning plan by providing all necessary information pertaining to the actual equipment and installation. If system modifications/clarifications are incorporated to this and related sections of work, commissioning of this work will be made at no additional cost to the Owner. If Contractor-initiated system changes have been made that alter the commissioning process, the Commissioning Authority will notify the Architect, and the Contractor may be obligated to compensate the Commissioner to test the revised product, or confirm the suitability/unsuitability of the substitution or revision.

3. Specific pre-commissioning responsibilities of Division 23 are as follows:

a. Normal start-up services required to bring each system into a fully operational state. This includes motor rotational check, cleaning, filling, purging, control sequences of operation, leak testing, full-load and part-load performance, etc. The Commissioning Authority will not begin the commissioning process until each system is complete, including normal contractor start-up.

b. The Contractor shall perform pre-functional tests on the following equipment and systems.

- Supply/Exhaust Fans
- Pressurization Fans
- Air Handling Units
- Kitchen Fans
- Terminal Units
- Baseboard Radiation
- Chiller Plant
- Boiler Plant
- Sump pumps
- Split Systems
- Unitary Heaters

c. Acceptance phase should begin upon completion of all building systems. However, testing of individual systems can begin as long as it has been completely tested by the sub-contractor and it is in the best interests of the
Owner. Commissioning activities and schedule will be coordinated with the Contractor. Start of commissioning before system completion will not relieve the Contractor from completing those systems as per the schedule.

E. PARTICIPATION IN COMMISSIONING

1. Provide skilled technicians to start-up and debug all systems within the division of work. These same technicians shall be made available to assist the Commissioning Authority/Owner in completing the commissioning program as it relates to each system and their technical specialty. Work schedules, time required for testing, etc., will be requested by the Commissioning Authority/Owner and coordinated by the Contractor. Contractor will ensure the qualified technician(s) are available and present during the agreed-upon schedules and of sufficient duration to complete the necessary tests, adjustments, and/or problem resolutions.

2. System problems and discrepancies may require additional technician time, Commissioning Authority/Owner time, redesign and/or reconstruction of systems, and system components. The additional technician time shall be made available for the subsequent commissioning periods until the required system performance is obtained.

3. The Commissioning Authority/Owner reserves the right to judge the appropriateness and qualifications of the technicians relative to each item of equipment, system, and/or sub-system. Qualifications of technicians include expert knowledge relative to the specific equipment involved, adequate documentation and tools to service/commission the equipment, and an attitude/willingness to work with the Commissioning Authority/Owner to get the job done. A liaison or intermediary between the Commissioning Authority/Owner and qualified factory representatives does not constitute the availability of a qualified technician for purposes of this work.

F. WORK TO RESOLVE DEFICIENCIES

1. In some systems, misadjustments, misapplied equipment, and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work will be completed under the direction of the Architect/Engineer of Record, with input from the Contractor, equipment supplier, Owner and Commissioning Authority. Whereas all members will have input and the opportunity to discuss, debate, and work out problems, the Architect/Engineer of Record will have final jurisdiction on the necessary work to be done to achieve performance.

2. Corrective work shall be completed in a timely fashion to permit the timely completion of the commissioning process. Experimentation to render system performance will be permitted. If the Commissioning Authority/Owner deems the
experimentation work to be ineffective or untimely as it relates to the commissioning process, the Commissioning Authority/Owner will notify the Architect/Engineer of Record indicating the nature of the problem, expected steps to be taken, and the deadline for completion of activities. If the deadline(s) passes without resolution of the problem, the Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner will be the Contractor's responsibility.

G. ADDITIONAL COMMISSIONING

1. Additional commissioning activities may be required after system adjustments, replacements, etc., are completed. The Contractor, suppliers, and Commissioning Authority shall include a reasonable reserve to complete this work as part of their standard contractual obligations.

H. SEASONAL COMMISSIONING AND OCCUPANCY VARIATIONS

1. Seasonal commissioning pertains to testing under full-load conditions during peak heating and peak cooling seasons, as well as part-load conditions in the spring and fall. Initial commissioning will be done as soon as contract work is completed regardless of season. Subsequent commissioning may be undertaken at any time thereafter to ascertain adequate performance during the different seasons.

2. All equipment and systems will be tested and commissioned in a peak season to observe full-load performance. Heating equipment will be tested during winter design extremes. Cooling equipment will be tested during summer design extremes, with a fully occupied building. Each Contractor and supplier will be responsible to participate in the initial and the alternate peak season test of the systems required to demonstrate performance.

3. Subsequent commissioning may be required under conditions of minimum and/or maximum occupancy or use. All equipment and systems affected by occupancy variations will be tested and commissioned at the minimum and peak loads to observe system performance. Each Contractor and supplier will be responsible to participate in the occupancy sensitive testing of systems to provide verification of adequate performance.

4. At 10 months into the warranty period, the Commissioning Authority and Owner will review the operation to date. The Contractors will be expected to be available to address any warranty related items that come out of this review.

I. TRAINING OF OWNER’S PERSONNEL

1. The Owner’s staff shall be given comprehensive training in the operation and maintenance of each major piece of equipment.
2. The Construction Manager in cooperation with the Commissioning Team, will be responsible for scheduling and actively participating in the training. A training plan is to be submitted to the Commissioning Authority for review prior to training being scheduled.

3. Hands on training shall include start-up, operation in all modes possible, shut-down and any emergency procedures.

4. The manufacturer’s representative shall provide the instructions on each major piece of equipment. These sessions shall use the printed installation, operation and maintenance instruction material included in the operation and maintenance manuals and shall include a review of the written operation and maintenance manuals. Training will be included for all major pieces of equipment. Equipment training shall be done by qualified service representatives employed by the manufacturers.

5. Contractor will be required to participate in the training of the Owner's engineering and maintenance staff for each mechanical system and the related components. Training may be conducted in a classroom setting, with system and component documentation, and suitable classroom training aids, or in the field with the specific equipment. The type of training will be per the Owner's option.

J. SYSTEMS DOCUMENTATION

1. In addition to the requirements of Division 1, update Contract Documents to incorporate field changes and revisions to system designs to account for actual constructed configurations. All drawings shall be red-lined on two sets. Division 23 as-built drawings shall include updated architectural floor plans, and the individual mechanical systems in relation to actual building layout.

2. Maintain as-built red-lines on the job site as required in Division 1. Given the size and complexity of this project, red-lining of the drawings at completion of construction, based on memory of key personnel, is not satisfactory. Continuous and regular red-lining and/or posting of drawings is considered essential and mandatory.

K. NOTIFICATION OF SYSTEM COMPLETION AND REQUEST FOR FINAL ACCEPTANCE OF THE HVAC SYSTEMS

1. When systems are ready for final acceptance, the Contractor shall certify to the Commissioning Team, in writing, that all systems are complete and fully functional.

2. Should the commissioning tests determine that the equipment is still not performing as specified or control operation is not acceptable on the second inspection, the time and expenses of the Commissioning Authority, Engineer of Record and Owner to make further verification shall be considered as additional cost of the Owner. The
total sum of such costs shall be deducted from the final payment to the HVAC Contractor.

L. REPORT REQUIREMENTS

1. The Commissioning Authority shall document each Commissioning event with meeting minutes or a report. The documents shall separately list deficiencies observed or discovered during the event. The document shall be distributed to Commissioning Team members.

2. The Commissioning Authority shall prepare a final report to the Commissioning Team which will include a narrative in the form of an Executive Summary of the results of program, executed construction checklists/startup documentation, executed functional test procedures, project reports, issues log and other pertinent documents.
23 09 10 - HVAC Operational Sequences

A. GENERAL

1. The HVAC operational sequences in this guideline are commonly used by Duke University. They are being provided as a preferred design base reference. They are not meant to be used as the only permitted sequences. Exceptions for HVAC systems other than those provided in this guideline may be allowed with FMD approval.

B. INDEX

1. Economizer
2. Economizer with Demand CO2 Ventilation
3. AHU Supply Fan VFD

C. OPERATIONAL SEQUENCES

1. Economizer
   a. Initiate economizer mode operation when outdoor air enthalpy reaches \(28 \text{ Btu/lb}\) (adjustable) and disable economizer mode when outdoor air enthalpy increases to \(29 \text{ Btu/lb}\). Enthalpy information shall be gathered via broadcast outdoor temperature, humidity and enthalpy calculation supplied by duke.

   When the unit is in economizer mode the return and outside air damper shall modulate to maintain a mixed air setpoint equal to the supply air set point minus \(5 \text{ Deg}\) (adjustable). Return, exhaust and outside air dampers shall each have a separate signal from the BAS. The exhaust damper shall track to outdoor air damper and the return shall modulate opposite the outdoor air damper. If the outdoor air damper is fully open and supply air setpoint is not maintained, the chilled water valve shall modulate to maintain the supply temp setpoint.

   Outdoor air damper shall maintain a minimum outside cfm air setpoint (adjustable) set by the air balance company. A drop in mixed air temp below the mixed air low limit setpoint of \(45 \text{ Deg}\) (adjustable) will override economizer, minimum outdoor air, and CO2 to maintain mixed air temp above low limit setpoint.

2. Economizer with Demand CO2 Ventilation
   a. Initiate economizer mode operation when outdoor air enthalpy reaches \(28 \text{ Btu/lb}\) (adjustable) and disable economizer mode when outdoor air enthalpy increases to \(29 \text{ Btu/lb}\). Enthalpy information shall be gathered via broadcast outdoor temp, humidity and enthalpy calculation supplied by duke.
When the unit is in economizer mode the return and outside air damper shall modulate to maintain a mixed air setpoint equal to the supply air setpoint minus 5 deg (adjustable). Return, exhaust and outside air dampers shall each have a separate signal from the BAS. The exhaust damper shall track to outdoor air damper and the return shall modulate opposite the outdoor air damper. If the outdoor air damper is fully open and supply air setpoint is not maintained, the chilled water valve shall modulate to maintain the supply temp setpoint.

Outdoor air dampers shall maintain a minimum outside cfm air setpoint (adjustable) set by the air balance company. A drop in mixed air temp below the mixed air low limit setpoint of 45 deg (adjustable) will override economizer, minimum outdoor air, and CO2 to maintain mixed air temp above low limit setpoint.

b. System will monitor CO2 via air handler return sensor and/or space CO2 sensor located in a high occupancy area. The system should sample the level every 10 min (adjustable) and trigger a “high CO2 mode” when the level reaches greater the 1100 ppm. When in high CO2 mode the outside air damper shall modulate to maintain 1000 ppm. When CO2 level drops to less than 950 ppm the system will turn off the high CO2 mode. Outside air cfm should be limited to 40% of the total supply unless there are special considerations. If any sensor reads less than 1600 ppm, that sensor should be ignored by the DCV sequence and an alarm should be set. The number of sensors used in the DCV sequence should be minimized to only what is necessary. At no time should the DCV sequence override the mixed air low temp limit.

c. Summary of OA Damper Control Modes

1) System not in Economizer or High CO2 Mode:

OA damper shall control to the minimum OA damper settings and the mixed air low limit loop output.

2) System in Economizer but not in High CO2 Mode:

Damper shall control to the minimum of the economizer mixed air loop output, minimum OA damper setting and the mixed air low limit loop output.

3) System in CO2 Mode but not Economizer Mode:

OA damper shall control to the maximum of the CO2 loop output and minimum and minimum OA damper setting, with mixed air low limit loop output overriding.

4) System in Economizer and High CO2 Mode:
OA damper shall control to the maximum of the economizer mixed air loop output, CO2 loop output, and minimum OA damper setting, with the mixed air low limit loop output overriding.

3. AHU Supply Fan VFD
   a. On startup, the static pressure set point shall be ramped from 0 to the design set point over a period of 3 minutes to prevent high static trips.
   b. The supply fan(s) VFD shall modulate to maintain supply duct static pressure via sensor located approximately 2/3 downstream in ductwork at the static pressure set point determined during air balance.
23 21 13 - Hydronic Piping

1. Introduction
   A. This Design Guideline covers piping systems for building mechanical systems, including, but not limited to:
      1. Hot-water heating piping.
      2. Chilled-water piping.
      3. Condenser-water piping.
      4. Glycol cooling-water piping.
      5. Makeup-water piping.
      6. Condensate-drain piping.
      8. Air-vent piping.
   
   B. Designers should coordinate with Duke FMD to coordinate selection and execution requirements for piping systems.

2. References
   A. NC State Mechanical Code, 2009
   B. Duke University Design Guidelines, Section 230700 Mechanical Systems Insulation
   C. Duke University Design Guidelines, Section 336300 Underground Steam and Condensate System
   D. Duke University Design Guidelines, Section 336100 Chilled Water Distribution

3. Performance Requirements
   A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:
      1. Hot-Water Heating Piping: 150 psig at 250 deg F
      2. Chilled-Water Piping: 200 psig at 75 deg F
      3. Condenser-Water Piping: 150 psig at 100 deg F
      4. Glycol Cooling-Water Piping: 100 psig at 150 deg F
      5. Makeup-Water Piping: 80 psig at 75 deg F
      6. AHU Condensate-Drain Piping: 75 deg F
7. Blowdown-Drain Piping (Non Steam): 225 deg F

8. Air-Vent Piping: 200 deg F

9. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

4. Design Standards

A. The following table illustrates desired piping standards for different mechanical systems:

<table>
<thead>
<tr>
<th>Service</th>
<th>Size</th>
<th>Fitting Connection</th>
<th>Pipe Connection</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilled Water</td>
<td>2” and smaller</td>
<td>Steel - Threaded (NPT), Copper – Propress, PP-R - Fusion</td>
<td>Steel - Threaded (NPT), Copper – Propress, PP-R - Fusion</td>
<td>SCH 80, A53 Gr. B Carbon Steel, ERW or Type L copper hard drawn or Polypropylene (PP-R)</td>
</tr>
<tr>
<td>Condenser Water</td>
<td>2-1/2” and larger</td>
<td>Steel - Class 125/150 Flange, copper – Brazed or Propress (up to 4”), PP-R - Fusion</td>
<td>Steel - Butt Weld, copper – Brazed or Propress (up to 4”), PP-R - Fusion</td>
<td>SCH 40, A 53 Gr. B Carbon Steel, ERW or Type L copper hard drawn, Polypropylene (PP-R)</td>
</tr>
<tr>
<td>Heating Hot Water</td>
<td>Up to 2”</td>
<td>Solder (95/5) or Propress</td>
<td>Solder (95/5) or Propress</td>
<td>Type L copper, hard drawn</td>
</tr>
<tr>
<td>Process Water</td>
<td>2” to 4”</td>
<td>Brazed or Propress, exception for Valves, Flanges, Unions may be Solder (95/5)</td>
<td>Brazed or Propress</td>
<td>Type L copper, hard drawn</td>
</tr>
<tr>
<td>Domestic/Potable/Non Potable Water (Hot &amp; Cold)</td>
<td>6” and larger</td>
<td>Class 125 Flanged, or Brazed</td>
<td>Brazed</td>
<td>Type L copper, hard drawn</td>
</tr>
<tr>
<td>Reclaim/re-use/gray water</td>
<td>2” and smaller</td>
<td>Threaded (NPT), PP-R - Fusion</td>
<td>Threaded, PP-R - Fusion</td>
<td>SCH 40, A53 Gr B Carbon Steel, Seamless or Polypropylene (PP-R)</td>
</tr>
<tr>
<td></td>
<td>2-1/2” and larger</td>
<td>Class 150 Flange, PP-R - Fusion</td>
<td>Butt Weld, PP-R - Fusion</td>
<td>SCH 40, A 53 Gr B Carbon Steel, Seamless or Polypropylene (PP-R)</td>
</tr>
<tr>
<td>Service</td>
<td>Size</td>
<td>Fitting Connection</td>
<td>Pipe Connection</td>
<td>Material</td>
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<td>----------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Equipment Drain</td>
<td>2&quot; and smaller</td>
<td>Threaded (NPT) or Propress, PP-R - Fusion</td>
<td>Threaded or Propress, PP-R - Fusion</td>
<td>SCH 40, A53 Gr B Carbon Steel, Seamless or Type L copper hard drawn or Polypropylene (PP-R)</td>
</tr>
<tr>
<td></td>
<td>2-1/2&quot; and larger</td>
<td>Class 150 Flange, PP-R - Fusion</td>
<td>Butt Weld, PP-R - Fusion</td>
<td>SCH 40, A 53 Gr B Carbon Steel, Seamless or Polypropylene (PP-R)</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>2&quot; and smaller</td>
<td>Threaded (NPT)</td>
<td>Threaded</td>
<td>SCH 40, A53 Gr B Carbon Steel, Seamless</td>
</tr>
<tr>
<td></td>
<td>2-1/2&quot; and larger</td>
<td>Class 150 Flange</td>
<td>Butt Weld</td>
<td>SCH 40, A 53 Gr B Carbon Steel, Seamless</td>
</tr>
</tbody>
</table>


2. Piping shall be insulated in accordance with Duke University Design Guidelines 23 07 00 – Mechanical Systems Insulation

3. Piping shall be supported in accordance with the North Carolina Mechanical Code. Piping supports for thermal systems requiring expansion shall not restrict growth or movement of piping.
   a. Pipe supports mounted to floor shall be grouted in place with non-shrink grout a minimum of 1” prevent rusting from flooding or standing water on floor.
   b. Wall supports shall be installed in a manner with a minimum of 1” gap between support and floor to prevent rusting from flooding or standing water on floor.
   c. Each hanger/support shall be individually supported from above. Hangers may not be supported from other hangers unless it is designed as such and approved by Duke Utilities and Engineering Services.

4. Where possible, piping shall be grouped and stacked vertically and racked together on a structural support rather than spacing horizontally. When stacking piping vertically, the largest pipe diameter is on top, the smallest diameter is on bottom. **This should be noted on the construction drawings for contractors to coordinate.**

5. T-Drill is not an acceptable form of fitting in any hydronic piping application.

6. Material use should be consistent throughout piping segment. Piping should not transition from one material to another unless previously approved by DUES. The
use of dielectric fittings is not acceptable. Where dissimilar metals are joined, the use of a bronze/brass ball valve or fitting is preferred.

7. Brass nipples shall be used on CHW systems. Carbon steel nipples will not be accepted.

8. Valves to be located at all branch lines off risers. Drains shall be installed downstream of valve.

9. Vents shall be install at top of all risers to aid in air removal. If an automatic air vent is used, an isolation valve must be between the vent and piping.

10. All sensors and gauges shall be equipped with an isolation valve at the main to facilitate replacement without a system shut down.

5. Testing

A. Chilled water and heating water system welds shall be tested 10% or a minimum of 5, whichever is more by means of radiograph by an approved third party testing agency. Welds shall be inspected in accordance with ASME B31.9 Building Service Piping code requirements. Each system shall be tested independently.

1. If any welds are found to be defective, the weld must be cut out and re-welded. Repair of defective welds by adding weld material over the defect, or by peening shall not be permitted. Welders responsible for the defective welds shall be re-qualified before performing additional welding on the job. Any failed weld shall be retested by radiograph at the contractor’s expense.

   a. For any welding failures, 10% of remaining welds must be tested and pass. Additional testing will be at the contractor’s expense.

      (1) Example: Chilled water system has 50 welds, which 5 welds would be tested. One weld fails testing. The failed weld would be reworked and retested. The remaining 45 welds would be tested at 10%. An additional 5 welds would need to be tested and pass before the testing procedure would be complete. If another weld failed, the process repeats until 10% of remaining welds pass.

2. Hydrostatic testing is required on all interior carbon steel piping systems at 1-1/2 times working pressure for 2 hours.

3. Chilled water and heating water systems shall be flushed and chemically treated with cleansers and inhibitors {insert Chemtreat’s procedure here}

4. Refer to 401000 - Building Steam & Condensate Systems design guidelines for testing and flushing procedures for steam and condensate piping.
5. Refer to 336300 - *Underground Steam and Condensate System* design guidelines for testing and flushing procedures for direct buried steam and condensate piping.

6. **Flushing**

   **B. Chilled Water**

   1. Prior to connecting any piping to the Campus Chilled Water Loop at Duke University, a flushing plan must be approved by FMD. The following steps must be followed.

   2. Specifications shall require the contractor to provide a flushing plan prior to starting work. The preferred method of flushing is as follows:

      a. Terminal devices need to be equipped with flushing bypass loop during construction. Terminal devices are to be disconnected and isolated from flushing procedure (providing a bridge bypass and isolating equipment with valves is not acceptable). After flushing is complete, bypass loop shall be removed and terminal device connected to permanent piping system. Any deviation from this must be approved prior by FMD and outlined on the flushing plan.

   3. System shall be cleaned using chemical cleaner appropriate for metallurgies in system. System must be circulated for sufficient time to allow complete cleaning to occur.

   4. System shall be flushed until virtually all the cleaner has been removed from the system.

   5. To determine if flushing has been sufficient, the system should be field tested and compared to a city water sample collected as close to the system make up source as possible. System water must meet all of the following criteria to move on to Step 6. If it does not, flushing must continue until it does.

      a. Conductivity within 20 micromhos of city water conductivity.
      b. pH within 0.3 of city water pH
      c. Visibly show no signs of cleaner or contaminants.

   6. System shall be tested by ChemTreat prior to proceeding with chemical treatment.

   7. Prior to connecting to the campus chilled loop, the following chemistry dosages must be added to the system and circulated for 48 hours to ensure proper passivation and mixing in the new piping.

      a. Benzo triazole > 25 PPM
      b. Silicate (as SiO2) > 40 PPM
      c. Sodium Erythorbate to deliver an ORP of -200 mV or less
      d. Blue dye at a sufficient concentration to match or exceed level of blue tint in campus chilled loop
8. Following 48 hours of circulation of all chemicals listed above, a sample must be taken sent to an ISO certified analytical lab. Lab report should include at least:

   a. Conductivity
   b. BZT
   c. Silicate (as SiO2)
   d. Soluble Iron
   e. Total Iron
   f. Copper

9. Lab analysis should be provided to DUES/. Once received, DUES will arrange a time to conduct final the field test of system water with ChemTreat. If the system water passes the field tests, ChemTreat will notify DUES the system is approved to be tied in to the Campus Chilled Loop.

10. Upon receipt of the approval email, the contractor shall issue an email to all parties copied on the ChemTreat email detailing the contractor’s plan to tie in the new piping including date(s).

11. DUES will then issue the final approval to allow the tie in to commence.

C. Heating Water

1. Prior to connecting any piping to the Campus Hot Water Loop at Duke University (or Building Hot Water System), a flushing plan must be approved by FMD. The following steps must be followed.

2. Terminal devices need to be equipped with flushing bypass loop during construction. Terminal devices are to be disconnected and isolated from flushing procedure (providing a bridge bypass and isolating equipment with valves is not acceptable). After flushing is complete, bypass loop shall be removed and terminal device connected to permanent piping system. Any deviation from this must be approved prior by FMD.

3. System must be leak tested. Any leaks must be fixed before advancing to Step 4.

4. System must be cleaned using chemical cleaner appropriate for metallurgies in system. System must be circulated for sufficient time to allow complete cleaning to occur.

5. System must be flushed until virtually all the cleaner has been removed from the system.

6. To determine if flushing has been sufficient, the system should be field tested and compared to a city water sample collected as close to the system make up source as possible. System water must meet all of the following criteria to move on to Step 7. If it does not, flushing must continue until it does.
a. Conductivity within 20 micromhos of city water conductivity.

b. pH within 0.3 of city water pH

c. Visibly show no signs of cleaner or contaminants.

7. System shall be tested by ChemTreat prior to proceeding with chemical treatment.

8. Prior to putting the loop into service or connecting to an existing hot water loop, the following chemistry dosages must be added to the system and circulated for 48 hours to ensure proper passivation and mixing in the new piping.

   a. Benzotriazole > 20 PPM
   b. Sodium Nitrite > 600 PPM

9. Following 48 hours of circulation of all chemicals listed above, a sample must be taken sent to an ISO certified analytical lab. Lab report should include at least:

   a. Conductivity
   b. BZT
   c. Sodium Nitrite
   d. Soluble Iron
   e. Total Iron
   f. Copper

10. Lab analysis should be provided to DUES/. Once received, DUES will arrange a time to conduct final the field test of system water with ChemTreat. If the system water passes the field tests, ChemTreat will notify DUES the system is approved to be tied in to the Heating Water system.

11. Upon receipt of the approval email, the contractor shall issue an email to all parties copied on the ChemTreat email detailing the contractor’s plan to tie in and/or start up the new piping system including date(s).

12. DUES will then issue the final approval to allow the tie in to commence.

7. Installation and Performance Requirements

   A. Documents shall include an existing conditions drawing. Existing conditions shall include piping size, location, capacity, etc.

   B. Confirm installation responsibilities at out-set of project. Installation services will be provided in-house or contracted out.

   C. Coordinate all required tie-in points with Duke Utilities and Engineering Services.

   D. Coordinate all commissioning efforts with Duke Utilities and Engineering Services.
E. Documents shall include riser diagram as part of drawing set.
23 21 13 - Hydronic Piping

1. Introduction
   
   A. This Design Guideline covers piping systems for building mechanical systems, including, but not limited to:
      
      1. Hot-water heating piping.
      2. Chilled-water piping.
      3. Condenser-water piping.
      4. Glycol cooling-water piping.
      5. Makeup-water piping.
      6. Condensate-drain piping.
      8. Air-vent piping.
   
   B. Designers should coordinate with Duke FMD to coordinate selection and execution requirements for piping systems.

2. References
   
   A. NC State Mechanical Code, 2009
   
   B. Duke University Design Guidelines, Section 15080 Thermal Systems Insulation
   
   C. Duke University Design Guidelines, Section 02802 Underground HPS Distribution
   
   D. Duke University Design Guidelines, Section 02803 Underground CHW Distribution

3. Performance Requirements
   
   A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:
      
      1. Hot-Water Heating Piping: 150 psig at 250 deg F
      2. Chilled-Water Piping: 200 psig at 75 deg F
      3. Condenser-Water Piping: 150 psig at 100 deg F
      4. Glycol Cooling-Water Piping: 100 psig at 150 deg F
      5. Makeup-Water Piping: 80 psig at 75 deg F
      6. AHU Condensate-Drain Piping: 75 deg F
      7. Blowdown-Drain Piping (Non Steam): 225 deg F
8. Air-Vent Piping: 200 deg F

9. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

4. Design Standards

A. The following table illustrates desired piping standards for different mechanical systems:

<table>
<thead>
<tr>
<th>Service</th>
<th>Size</th>
<th>Fitting Connection</th>
<th>Pipe Connection</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Pressure Steam</td>
<td>2&quot; and smaller</td>
<td>Socket Weld</td>
<td>Socket Weld</td>
<td>SCH 80, A106 Carbon Steel, Seamless</td>
</tr>
<tr>
<td></td>
<td>2-1/2&quot; and larger</td>
<td>Butt Weld</td>
<td>Butt Weld</td>
<td>SCH 40, A106 Carbon Steel, Seamless</td>
</tr>
<tr>
<td>Medium Pressure Steam</td>
<td>2&quot; and smaller</td>
<td>Threaded (NPT)</td>
<td>Socket Weld or Threaded (1&quot; and smaller)</td>
<td>SCH 80, A106 Carbon Steel, Seamless</td>
</tr>
<tr>
<td></td>
<td>2-1/2&quot; and larger</td>
<td>Class 150 Flange</td>
<td>Butt Weld</td>
<td>SCH 40, A106 Carbon Steel, Seamless</td>
</tr>
<tr>
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<td>Socket Weld or Threaded (1&quot; and smaller)</td>
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</tr>
<tr>
<td></td>
<td>2-1/2&quot; and larger</td>
<td>Class 150 Flange</td>
<td>Butt Weld</td>
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</tr>
<tr>
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<td>Socket Weld</td>
<td>Socket Weld</td>
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</tr>
<tr>
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</tr>
<tr>
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<td>Socket Weld or Threaded (1&quot; and smaller)</td>
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</tr>
<tr>
<td></td>
<td>2-1/2&quot; and larger</td>
<td>Class 150 Flange</td>
<td>Butt Weld</td>
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</tr>
<tr>
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<td>2&quot; and smaller</td>
<td>Threaded (NPT)</td>
<td>Socket Weld or Threaded (1&quot; and smaller)</td>
<td>SCH 80, A106 Carbon Steel, Seamless</td>
</tr>
<tr>
<td></td>
<td>2-1/2&quot; and larger</td>
<td>Class 150 Flange</td>
<td>Butt Weld</td>
<td>SCH 80, A106 Carbon Steel, Seamless</td>
</tr>
<tr>
<td>Service</td>
<td>Size</td>
<td>Fitting Connection</td>
<td>Pipe Connection</td>
<td>Material</td>
</tr>
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<td>-------------------------------</td>
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<tr>
<td>Continuous Vent</td>
<td>2&quot; and smaller</td>
<td>Threaded (NPT)</td>
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</tr>
<tr>
<td></td>
<td>2-1/2&quot; and larger</td>
<td>Class 150 Flange</td>
<td>Butt Weld</td>
<td>SCH 40, A53Gr. B Carbon Steel, Seamless</td>
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<tr>
<td>Steam Relief Vent</td>
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<td>Socket Weld or Threaded (1&quot; and smaller)</td>
<td>SCH 80, A106 Carbon Steel, Seamless</td>
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<tr>
<td></td>
<td>2-1/2&quot; and larger</td>
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<td>Butt Weld</td>
<td>SCH 40, A106 Carbon Steel, Seamless</td>
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<td>Chilled Water Condenser Water</td>
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<tr>
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<td>Butt Weld</td>
<td>SCH 40, A 53 Gr. B Carbon Steel, ERW</td>
</tr>
<tr>
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<td>Type L copper, hard drawn</td>
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<tr>
<td>Cold)</td>
<td>8&quot; and larger</td>
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<td>Class 125 Flanged</td>
<td>Ductile Iron</td>
</tr>
<tr>
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<td>Type L copper, hard drawn</td>
</tr>
<tr>
<td></td>
<td>8&quot; and larger</td>
<td>Class 125 Flanged</td>
<td>Class 125 Flanged</td>
<td>Ductile Iron</td>
</tr>
<tr>
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<td>Threaded</td>
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</tr>
<tr>
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<td>Class 150 Flange</td>
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</tr>
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<td>Butt Weld</td>
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</tr>
<tr>
<td></td>
<td>2-1/2&quot; and larger</td>
<td>Class 150 Flange</td>
<td>Butt Weld</td>
<td>SCH 40, A 53 Gr B Carbon Steel, Seamless</td>
</tr>
</tbody>
</table>

2. Piping shall be insulated in accordance with Duke University Design Guidelines 15080 – Thermal Systems Insulation

3. Piping shall be supported in accordance with the North Carolina Mechanical Code. Piping supports for thermal systems requiring expansion shall not restrict growth or movement of piping.
   a. Pipe supports mounted to floor shall be grouted in place with non-shrink grout a minimum of 1” prevent rusting from flooding or standing water on floor.
   b. Wall supports shall be installed in a manner with a minimum of 1” gap between support and floor to prevent rusting from flooding or standing water on floor.
   c. Each hanger/support shall be individually supported from above. Hangers may not be supported from other hangers unless it is designed as such and approved by Duke Utilities and Engineering Services.

4. Where possible, piping shall be grouped and stacked vertically and racked together on a structural support rather than spacing horizontally. When stacking piping vertically, the largest pipe diameter is on top, the smallest diameter is on bottom. **This should be noted on the construction drawings for contractors to coordinate.**

5. **Testing**
   A. Chilled water and heating water system welds shall be tested 10% or a minimum of 5, whichever is more by means of radiograph by an approved third party testing agency. Welds shall be inspected in accordance with ASME B31.9 Building Service Piping code requirements. Each system shall be tested independently.

   1. If any welds are found to be defective, the weld must be cut out and re-welded. Repair of defective welds by adding weld material over the defect, or by peening shall not be permitted. Welders responsible for the defective welds shall be re-qualified before performing additional welding on the job. Any failed weld shall be retested by radiograph at the contractor’s expense.

      a. For any welding failures, 10% of remaining welds must be tested and pass. Additional testing will be at the contractor’s expense.

(1) Example: Chilled water system has 50 welds, which 5 welds would be tested. One weld fails testing. The failed weld would be reworked and retested. The remaining 45 welds would be tested at 10%. An additional 5 welds would need to be tested and pass before the testing procedure would be complete. If
another weld failed, the process repeats until 10% of remaining welds pass.

2. Hydrostatic testing is required on all interior carbon steel piping systems at 1-1/2 times working pressure for 2 hours.

3. Chilled water and heating water systems shall be flushed and chemically treated with cleansers and inhibitors {insert Chemtreat’s procedure here}

4. Refer to 15210 - Medium Pressure and Low Pressure Steam Systems design guidelines for testing and flushing procedures for steam and condensate piping.

5. Refer to 02802 - Underground Steam and Condensate System design guidelines for testing and flushing procedures for direct buried steam and condensate piping.

6. **Flushing**

   A. **Chilled Water**

      1. Prior to connecting any piping to the Campus Chilled Water Loop at Duke University, the following steps must be followed.

      2. System shall be cleaned using chemical cleaner appropriate for metallurgies in system. System must be circulated for sufficient time to allow complete cleaning to occur.

      3. System shall be flushed until virtually all the cleaner has been removed from the system.

      4. To determine if flushing has been sufficient, the system should be field tested and compared to a city water sample collected as close to the system make up source as possible. System water must meet all of the following criteria to move on to Step 5. If it does not, flushing must continue until it does.

         a. Conductivity within 20 micromhos of city water conductivity.
         b. pH within 0.3 of city water pH
         c. Visibly show no signs of cleaner or contaminants.

      5. System shall be tested by ChemTreat prior to proceeding with chemical treatment.

      6. Prior to connecting to the campus chilled loop, the following chemistry dosages must be added to the system and circulated for 48 hours to ensure proper passivation and mixing in the new piping.

         a. Benzotriazole > 25 PPM
         b. Silicate (as SiO2) > 40 PPM
         c. Sodium Erythorbate to deliver an ORP of -200 mV or less
         d. Blue dye at a sufficient concentration to match or exceed level of blue tint in campus chilled loop
7. Following 48 hours of circulation of all chemicals listed above, a sample must be taken sent to an ISO certified analytical lab. Lab report should include at least:
   a. Conductivity
   b. BZT
   c. Silicate (as SiO2)
   d. Soluble Iron
   e. Total Iron
   f. Copper

8. Lab analysis should be provided to DUES/. Once received, DUES will arrange a time to conduct final the field test of system water with ChemTreat. If the system water passes the field tests, ChemTreat will notify DUES the system is approved to be tied in to the Campus Chilled Loop.

9. Upon receipt of the approval email, the contractor shall issue an email to all parties copied on the ChemTreat email detailing the contractor's plan to tie in the new piping including date(s).

10. DUES will then issue the final approval to allow the tie in to commence.

7. Heating Water

A. Prior to receiving approval on any hot water loop at Duke University, whether or not it is tying into an existing system, the following steps must be followed.

1. System must be leak tested. Any leaks must be fixed before advancing to Step 2.

2. System must be cleaned using chemical cleaner appropriate for metallurgies in system. System must be circulated for sufficient time to allow complete cleaning to occur.

3. System must be flushed until virtually all the cleaner has been removed from the system.

4. To determine if flushing has been sufficient, the system should be field tested and compared to a city water sample collected as close to the system make up source as possible. System water must meet all of the following criteria to move on to Step 5. If it does not, flushing must continue until it does.
   a. Conductivity within 20 micromhos of city water conductivity.
   b. pH within 0.3 of city water pH
   c. Visibly show no signs of cleaner or contaminants.

5. System shall be tested by ChemTreat prior to proceeding with chemical treatment.
6. Prior to putting the loop into service or connecting to an existing hot water loop, the following chemistry dosages must be added to the system and circulated for 48 hours to ensure proper passivation and mixing in the new piping.
   a. Benzotriazole > 20 PPM
   b. Sodium Nitrite > 600 PPM

7. Following 48 hours of circulation of all chemicals listed above, a sample must be taken sent to an ISO certified analytical lab. Lab report should include at least:
   a. Conductivity
   b. BZT
   c. Sodium Nitrite
   d. Soluble Iron
   e. Total Iron
   f. Copper

8. Lab analysis should be provided to DUES/. Once received, DUES will arrange a time to conduct final the field test of system water with ChemTreat. If the system water passes the field tests, ChemTreat will notify DUES the system is approved to be tied in to the Heating Water system.

9. Upon receipt of the approval email, the contractor shall issue an email to all parties copied on the ChemTreat email detailing the contractor’s plan to tie in and/or start up the new piping system including date(s).

10. DUES will then issue the final approval to allow the tie in to commence.

8. Installation and Performance Requirements
   A. Confirm installation responsibilities at out-set of project. Installation services will be provided in-house or contracted out.
   B. Coordinate all required tie-in points with Duke Utilities and Engineering Services.
   C. Coordinate all commissioning efforts with Duke Utilities and Engineering Services.

9. As-Built Requirements
   A. Designer must provide drawings showing all as-built piping, equipment, and manhole locations. Drawings must include final site plan layout and elevation profile, details of pertinent equipment (such as typical steam trap stations, manhole layouts, etc.), details of all building connection points, as well as anchorage points, cross-over/under of other utilities, obstructions, and other pertinent data. USGS coordinates for all major pipe intersections, elevation changes, and manhole locations are required.
   B. Provide identifying list for all manholes. Coordinate with Duke Utilities and Engineering Services for formatting and compliance with existing recordkeeping.
C. Provide identifying list for all valves. Coordinate with Duke Utilities and Engineering Services for formatting and compliance with existing recordkeeping.

D. Provide identifying list for all steam traps. Coordinate with Duke Utilities and Engineering Services for formatting and compliance with existing recordkeeping.
23 50 00 – Central Heating Equipment

1. Introduction

A. Steam Boilers at two interconnected Central Steam Plants supply steam to both Duke University and Duke Medical Center. Any boiler addition to a central plant requires a significant and thorough effort on the part of the Designer and Duke Utilities and Engineering Services (DUES) and such a project is too complex to be covered under this section.

B. Standalone steam or hot-water boilers for satellite buildings may be selected for heating only if central steam or hot water service is not available or if project conditions otherwise prohibit connection to the steam of hot water utility systems. A full life-cycle cost analysis should be undertaken should this be a project requirement. Designers must coordinate with Duke FMD - DUES on any project requiring a boiler installation, regardless of heat input or output rating.

C. Building heating with direct-fired furnaces or electric heat pumps is generally discouraged. Exemptions from this Standard may be granted if project economics dictate. Designers may also reference Design Standard Section 23 70 00 – Heating, Ventilation, and Air Conditioning Systems for information regarding split-system air conditioner/furnace and heat pumps.

D. Designers should coordinate with and DUES on all phases of projects requiring installation of new boilers or furnaces.

E. All equipment must be supported directly by structural members with adequate load-bearing capacity and material integrity, using appropriate anchoring/connection hardware. Under no circumstances may equipment be supported by connections to finish materials. For example, equipment hung from toggle bolts through plaster-on-lath, gypsum board or ACT ceilings is not acceptable.

2. References

A. ASME Boiler and Pressure Vessel Code, Section I
B. ASME Boiler and Pressure Vessel Code, Section IV
C. ASME Building Services Piping Code, B31.9
D. ASME Pipe and Fittings Codes, B16

3. Design Standards

A. Minimum standards for residential and light commercial packaged-type boilers are listed below:
1. Boilers:
   a. Natural gas should be considered the primary fuel for all direct-fired boilers. In certain situations where a backup fuel is required, No. 2 fuel oil may be considered.
   b. All packaged boilers must have a minimum rated efficiency of 80% AFUE.
   c. Packaged boilers should be equipped with flue-gas economizers if available in the desired size range.

B. Furnaces:

1. Natural gas should be considered the primary fuel for all direct-fired furnaces. In certain situations where a backup fuel is required, No. 2 fuel oil may be considered.

2. All furnaces must have minimum rated efficiency of 95% AFUE.

4. Documentation and Review Requirements
   A. Provide Life-Cycle Cost Analysis for boiler selection and system design.
   B. Provide estimated energy loss calculation for all distribution piping.

5. Installation and Performance Requirements
   A. Confirm installation responsibilities at outset of project. Installation services will be provided in-house or contracted out.
   B. Coordinate all required tie-in points with DUES.
   C. Coordinate all commissioning efforts with DUES.
23 61 00 - Chilled Water Systems

1. Introduction

A. The desired medium for all air conditioning systems is chilled water. Duke University has a campus chilled water system currently served by two central chilled water plants on West Campus and one central chilled water plant on East Campus, as well as several satellite chillers/chiller plants. The campus distribution system is configured in a variable primary flow arrangement, removing the need for decoupler pipes and building (secondary/tertiary) pumps.

B. Campus chilled water is supplied to all buildings at 40°F with pressures up to 125 psi, depending on where the building is located on the distribution loop.

2. Design Standards

A. All chilled water valves shall to be specified for ample close off pressures and capable of handling varying pressure gradients.

B. All cooling coils should be designed for a 16°F-20°F chilled water temperature drop.

C. Campus chilled water will not be used for anything other than HVAC systems or a closed heat exchanger.

   1. Process chilled water systems should be isolated from the campus chilled water system with a water-to-water heat exchanger.

D. Though the central chilled water system is equipped with emergency generators, server rooms and computer rooms that require guaranteed chilled water service should be designed with a secondary cooling source.

E. Chilled water control valves should be pressure independent (PI) valves

   1. Pressure independent control valves shall be able to shut off against a minimum of 200 psi. Valve manufacturer must be approved prior to installation.

   2. All PI valves should be installed on the coil return line.
3. A differential pressure (DP) sensor should be installed across the hydraulically most remove valve and should report back to the Central Plant Control System (Siemens Apogee) to be used in controlling the loop pump speed.

4. Balancing devices are not necessary at chilled water coils. Flow will be measured and limited using the PI valves.

3. **Documentation and Review Requirements**

   A. Provide all calculations used to size PI valves.

4. **Installation and Performance Requirements**

   A. Building connection to campus chilled water system should include appropriate control and metering.

   1. Flow meters shall be installed in accordance with Duke Design Guideline 33 19 00 District Thermal and Water Utility Metering.

   2. Modulating standard butterfly valves should be located as close as possible to the pipe entrance/exit points.

   3. Building supply and return temperature sensors and a building differential pressure sensor are also required devices at the building entrance/exit points.

   4. All chilled water system devices are to be connected to a Siemens Apogee panel. These devices will be managed and monitored by Duke Utilities and Engineering Services Department (DUES).
5. Building Tie-In Schematic

CHILLED & HEATING WATER BUILDING CONNECTION DETAIL
NOT TO SCALE

B. Air separators are required in all new construction installations.

C. Make-up water for the chilled water system is not required; make-up water for the chilled water system is done at the central chilled water plant.

D. Air vents should be installed at the highest system points.
23 70 00 - Central HVAC Equipment (Air Handling Units)

1. Introduction
   A. In general, air handling units should be used for any air conditioning system where more than 2,000 cfm of air is required to maintain the design conditions. These units are manufacturers’ standard products. Custom designed and manufactured units are covered in Section 23 21 23 – Hydronic Pumps. Air handling units may be manufactured in one piece or may be modular units with sections for each function joined together. They typically consist of a casing containing a fan, a filter and cooling, heating and/or humidification coils. Depending on requirements, mixing boxes, return fans, damper sections and other equipment may be included. Units installed inside are typically referred to as air handling units (AHU); those installed exposed are rooftop units (RTU).

   B. Designers should coordinate with Duke Office of Project Management and Duke Utilities & Engineering Services, Department of Planning & Engineering (DUES Engineering) on all phases of projects requiring air handling units. These projects may include but are not limited to:
      1. New buildings
      2. Renovations to the existing building
      3. Replacement of existing equipment

   C. Designers are expected to share and review any project data, load calculations and site condition evaluations with DUES Engineering.

2. References
   A. ASHRAE Standard 52: Dust-spot testing of filters
   B. NFPA 90A: Flame spread, smoke developed characteristics of insulation
   C. ARI Standard 430: Centrifugal fan performance test
   D. AMCA 210: Vane axial fan performance test
   E. ARI Standard 410: Rating of coils containing water or glycol/water
   F. ARI Standard 260: Method of rating sound data for ducted air conditioning equipment

3. Design Standards
   A. Air Handling Units:
1. All air handling unit casings shall be double wall insulated with solid inner skin (minimum 18 gauge) and foamed in place insulation (minimum 2 inch thick). Casing panels shall be removable.

2. Structural integrity of air handling units shall not rely on casing panels.

3. Factory mounted lights shall be provided in each accessible section of the AHU. Lights shall be marine type (of corrosion-resistant materials) with vapor-tight seal. Provide lighted switch outside unit. Either one switch per light fixture or a single switch controlling all light fixtures is acceptable.

4. Hinged access doors shall be provided on each side of unit for access sections, filters, dampers, humidifiers and fans. Access door latches shall not require special tools for opening. Access doors in positively pressurized sections shall open inward or shall have safety catch to prevent sudden opening. Each access door shall have a view window (minimum 12 inch x 12 inch).

5. Access sections shall be provided between filter and coil section (minimum 16 inch) and between any two coil sections (minimum 24 inch).

6. Provide drain pan under each coil (full length of coil section) for coil cleaning. Provide outlet with ball valve on exterior of unit. Provide minimum 3 feet clearance at coil section on drain outlet side.

7. Fans and motors shall be internally isolated.

8. VFD’s shall be mounted on a separate structure, never on or inside the unit itself.

9. VFD motors shaft be provided with an Aegis bearing protection shaft grounding ring.

10. All fans in a Fan Wall arrangement shall be verified at maximum BHP/speed. Provide capacity for failure of one fan.

11. Coils shall be copper with aluminum fins (maximum of 12 fins per inch).

12. Cooling coil casings shall be of stainless steel.

13. Maximum cooling coil face velocity is 550 fpm.

14. Condensate drain pan at cooling coil shall be stainless steel, insulated and sloped to the condensate outlet with outlet in bottom of pan to ensure full drainage. Condensate drain outlet shall be indirectly connected to sanitary waste system with trap designed to always provide water seal between AHU and building drain.

15. Inner skin of humidifier section shall be stainless steel.

16. Outside air and return air inlets shall be arranged to avoid stratification of air as it passes the coil.
17. Pre-filters for air handling units shall be minimum MERV 8, 2 inch throwaway, pleated type. Filters shall be minimum MERV 13, bag type. Filter racks shall be slide in type.

18. Provide plenum section downstream of pre-filter for AFMS where required.

19. Unit shall be selected so that required sound levels can be maintained in surrounding areas and in all areas served. Control of sound levels by proper equipment selection and duct layout and sizing is preferred; however, measures such as sound attenuators may be used if necessary.

20. Include minimum and maximum outside air requirements on equipment schedule.

B. Rooftop Air Handling Units

1. All rooftop unit casings shall be double wall insulated with solid inner skin (minimum 18 gauge) and foamed in place insulation (minimum 2 inch thick). Casing panels shall be removable.

2. Structural integrity of rooftop units shall be maintained when casing panels have been removed.

3. Factory mounted lights shall be provided in each accessible section of the RTU. Lights shall be marine type (of corrosion-resistant materials) with vapor-tight seal. Provide lighted switch outside unit, protected from weather. Either one switch per light fixture or a single switch controlling all light fixtures is acceptable.

4. Hinged access doors shall be provided on each side of unit for access sections, filters, dampers, humidifiers and fans. Access door latches shall not require special tools for opening. Access doors in positively pressurized sections shall open inward or shall have safety catch to prevent sudden opening. Each access door shall have a view window (minimum 12 inch x 12 inch).

5. Access sections shall be provided between filter and coil section (minimum 16 inch) and between any two coil sections (minimum 24 inch).

6. Provide drain pan under each coil (full length of coil section) for coil cleaning. Provide outlet with ball valve on exterior of unit. Provide minimum 3 feet clearance at coil section on drain outlet side.

7. Fans and motors shall be internally isolated.

8. VFD motors shaft be provided with an Aegis bearing protection shaft grounding ring.

9. All fans in a Fan Wall arrangement shall be verified at maximum BHP/speed. Provide capacity for failure of one fan.

10. Coils shall be copper with aluminum fins (maximum of 12 fins per inch).
11. Cooling coil casings shall be of stainless steel.

12. Maximum cooling coil face velocity is 550 fpm.

13. Condensate drain pan at cooling coil shall be stainless steel, insulated and sloped to the condensate outlet with outlet in bottom of pan to ensure full drainage. Condensate drain outlet shall be indirectly connected to sanitary waste system with trap designed to always provide water seal between AHU and building drain.


15. Outside air and return air inlets shall be arranged to avoid stratification of air.

16. Outside air and relief air openings shall be arranged to avoid entrainment of relief air into outside air intake airstream.

17. Pre-filters for air handling units shall be minimum MERV 8, 2 inch throwaway, pleated type. Filters shall be minimum MERV 13, bag type.

18. Provide plenum section downstream of pre-filter for AFMS where required.

19. Duct openings shall not be located in the bottom of the unit. Duct shall be horizontal to avoid collection of water (from coil cleaning) in ductwork.

20. Unit shall be selected so that required sound levels can be maintained in surrounding areas and in all areas served. Control of sound levels by proper equipment selection and duct layout and sizing is preferred; however, measures such as sound attenuators may be used if necessary.

21. Rooftop unit shall include an accessible compartment within the roof curb for valves and controls.

22. Rooftop unit shall include a mounting location for VFD or control panel, accessible from exterior of unit without shutting down unit and ventilated or cooled to maintain manufacturer’s recommended temperature range for the panel.

23. Include minimum and maximum outside air requirements on equipment schedule.

4. Documentation and Review Requirements

A. Documentation of factors used in equipment selection (heating and cooling load, diversity allowed for in air distribution, etc.) must be submitted for review at DD submittal and each subsequent submittal if conditions have changed. Summary of factors shall identify which factors are known and which are assumptions.

B. Detailed equipment selection (including expected sound levels for unit discharge, unit return, radiated sound and sound level in space served). Where multiple spaces are served, expected sound levels are required only for those spaces nearest the unit.
C. Cost of operations and maintenance shall be included in system Life Cycle Cost Analysis. This information shall be reviewed at DD submittal.

5. Installation and Performance Requirements

A. All units shall be installed level.

B. All units shall be installed so that there is sufficient space to perform normal maintenance. This space shall be shown on project drawings.

C. All units shall be installed at a height which allows proper installation of trap at condensate drain.

D. Every effort shall be made to avoid the need for condensate pumps.

E. Unit installation shall include services of a factory authorized service representative for unit start up.

F. Provide auxiliary drain pan under entire unit, fitted with float switch to shut down unit as pan fills. Provide a drain with a ball valve at the bottom of one side wall.

G. Filters shall be in place anytime the unit is running. During construction, filters shall be checked and changed regularly. New filters shall be installed in each unit at turnover. Do not provide spare set of filters for units.

H. Coordinate all commissioning efforts with Duke Utilities and Engineering Services (DUES).

6. As-Built Requirements

A. Designer must provide drawings showing all equipment locations. Drawings must include actual layout, details of all connection points and other pertinent data. Provide electronic copy of all drawings.

B. Provide operations and maintenance manuals for each piece of air handling equipment. Where multiple units are covered by the same manual, duplicate manuals are not required. A list of all equipment (by equipment ID) will be provided in front of each section of the O&M manual with equipment location, title and publication number of appropriate manual shown for each piece of equipment. Provide electronic copy of all components of O&M manuals.

C. O&M manuals shall include fan curves for each fan provided. Each fan shall be represented by a separate fan curve.
23 82 19 - Fan Coil Units and Blower Coil Units

1. Introduction
   A. Fan coils and blower coil units should be used for any air conditioning system where no more than 3,000 cfm of air is required to maintain the design conditions. These units are typically manufacturers’ standard products.

   B. Designers should coordinate with Duke Office of Project Management and Duke Utilities & Engineering Services, Department of Planning & Engineering (DUES Engineering) on all phases of projects requiring air handling units. These projects may include but are not limited to:
      1. New buildings
      2. Renovations to the existing building
      3. Replacement of existing equipment

   C. Designers are expected to share and review any project data, load calculations and site condition evaluations with DUES Engineering.

2. References
   A. ASHRAE Standard 52: Dust-spot testing of filters
   B. NFPA 90A: Flame spread, smoke developed characteristics of insulation
   C. ARI Standard 430: Centrifugal fan performance test
   D. ARI Standard 410: Rating of coils containing water or glycol/water
   E. ARI Standard 260: Method of rating sound data for ducted air conditioning equipment

3. Design Standards
   A. Fan Coil and Blower Coil Units:
      1. Coil units shall have three speed fans with speed adjustment accessible without removing unit panels.
      2. Cooling and heating coils, connecting to campus utilities, shall be sized according to the specified campus utility design entering and leaving water temperature differences.
      3. Coil units shall have control valves factory installed in a location which will be accessible after unit is installed.
4. All horizontal coil units shall have auxiliary drain pans with a valved and capped drain nipple in addition to a float switch to shut down unit.

5. All coil units to be installed exposed shall have a full cabinet with insulation to prevent sweating. Adequate access to piping and fan shall be provided. Insulation exposed to the airstream may not be a fibrous type material.

6. Coil units should not be used where an air handling unit can be used instead of several coil units.

7. Locations of coil units shall take into consideration likely furniture and equipment placement to allow for maintenance access.

8. All coil units must be supported directly by structural members with adequate load-bearing capacity and material integrity using appropriate anchoring/connection hardware. Under no circumstances may equipment be supported by connections to finish materials. For example, equipment hung from toggle bolts through plaster-on-lath, gypsum board or ACT ceilings is not acceptable.

4. Documentation and Review Requirements

   A. Documentation of factors used in equipment selection must be submitted for review at Design Development (DD) review and each subsequent submittal if conditions have changed. Summary of factors shall identify which factors are known and which are assumptions.

   B. Detailed equipment selection including sound levels for unit discharge and radiated sound.

5. Installation and Performance Requirements

   A. All units shall be installed level.

   B. All units shall be installed so that there is sufficient space to perform normal maintenance. This space shall be shown on project drawings.

   C. Access doors shall be provided where units are installed above ceilings which are not easily removable.

   D. Coordinate all commissioning efforts with Duke Utilities and Engineering Services (DUES).

6. As-Built Requirements

   A. Designer must provide drawings showing all equipment locations. Drawings must include final layout, details of all connection points and other pertinent data.
B. Provide electronic operations and maintenance manuals for each piece of air handling equipment. Where multiple units are covered by the same manual, duplicate manuals are not required. A list of all equipment (by equipment ID) will be provided in front of each section of the O&M manual with equipment location, title and publication number of appropriate manual shown for each piece of equipment. Equipment listing shall include a summary of unit design capacities.
25 95 00 – Integrated Automation Control Sequences for HVAC

A. GENERAL

1. The HVAC operational sequences in this guideline are commonly used by Duke University. They are being provided as a preferred design base reference. They are not meant to be used as the only permitted sequences. Exceptions for HVAC systems other than those provided in this guideline may be allowed with Duke FMD approval.

B. INDEX

1. Economizer
2. Economizer with Demand CO2 Ventilation
3. AHU Unoccupied Mode and Morning Warm-up/Cool-down
4. AHU Supply Fan VFD Control
5. AHU Supply Air Temperature Reset

C. OPERATIONAL SEQUENCES

1. Economizer

   a. Initiate economizer mode operation when outdoor air enthalpy reaches 28 Btu/lb. (adjustable) and disable economizer mode when outdoor air enthalpy increases to 29 Btu/lb. Enthalpy information shall be gathered via broadcast outdoor temperature, humidity and enthalpy calculation supplied by Duke FMD.

   When the unit is in economizer mode the return and outside air damper shall modulate to maintain a mixed air setpoint equal to the supply air set point minus 5°F (adjustable). Return, exhaust, and outside air dampers shall each have a separate signal from the BAS. The exhaust damper shall track to outdoor air damper and the return shall modulate opposite the outdoor air damper. If the outdoor air damper is fully open and supply air setpoint is not maintained, the chilled water valve shall modulate to maintain the supply temp setpoint.

   Outdoor air damper shall maintain a minimum outside cfm air setpoint (adjustable) set by the air balance company. A drop in mixed air temp below the mixed air low limit setpoint of 45°F (adjustable) will override economizer, minimum outdoor air, and CO2 to maintain mixed air temp above low limit setpoint.

2. Economizer with Demand CO2 Ventilation

   a. Initiate economizer mode operation when outdoor air enthalpy reaches 28 Btu/lb (adjustable) and disable economizer mode when outdoor air enthalpy increases to 29
**Btu/lb.** Enthalpy information shall be gathered via broadcast outdoor temp, humidity and enthalpy calculation supplied by Duke FMD.

When the unit is in economizer mode the return and outside air damper shall modulate to maintain a mixed air setpoint equal to the supply air setpoint minus 5°F (adjustable). Return, exhaust and outside air dampers shall each have a separate signal from the BAS. The exhaust damper shall track to outdoor air damper and the return shall modulate opposite the outdoor air damper. If the outdoor air damper is fully open and supply air setpoint is not maintained, the chilled water valve shall air setpoint is not maintained, the chilled water valve shall modulate to maintain the supply temp setpoint.

Outdoor air dampers shall maintain a minimum outside cfm air setpoint (adjustable) set by the air balance company. A drop in mixed air temp below the mixed air low limit setpoint of 45°F (adjustable) will override economizer, minimum outdoor air, and CO2 to maintain mixed air temp above low limit setpoint.

b. System will monitor CO2 via air handler return sensor and/or space CO2 sensor located in a high occupancy area. The system should sample the level every 10 min (adjustable) and trigger a “high CO2 mode” when the level reaches greater than 1100 ppm. When in high CO2 mode the outside air damper shall modulate to maintain 1000 ppm. When CO2 level drops to less than 950 ppm the system will turn off the high CO2 mode. Outside air cfm should be limited to 40% of the total supply unless there are special considerations. If any sensor reads greater than 1600 ppm, that sensor should be ignored by the DCV sequence and an alarm should be set. The number of sensors used in the DCV sequence should be minimized to only what is necessary. At no time should be minimized to only what is necessary. At no time should the DCV sequence override the mixed air low temp limit.

c. **Summary of OA Damper Control Modes**

1) System not in Economizer or High CO2 Mode:

OA damper shall control to the minimum OA damper settings and the mixed air low limit loop output.

2) System in Economizer but not in High CO2 Mode:

Damper shall control to the minimum of the economizer mixed air loop output, minimum OA damper setting and the mixed air low limit loop output.

3) System in CO2 Mode but not Economizer Mode:

OA damper shall control to the maximum of the CO2 loop output and minimum and minimum OA damper setting, with mixed air low limit loop output overriding.

4) System in Economizer and High CO2 Mode:
3. **AHU Unoccupied Mode with Morning Warm-up/Cool-down**

   a. **General Guidelines**

      1) Typical applications serving (including but not limited to): Private offices, open office layouts, classrooms, auditorium, dining, support spaces. These sequences do not apply to Dormitories, Laboratories and critical systems/spaces.

      2) AHU's are typically off in Unoccupied Mode unless specified by Duke FMD.

      3) Minimum OA set point should be set to zero during unoccupied heating/cooling modes.

      4) All general exhaust fans shall be turned on during associated air handler occupied heating/cooling mode and shall be turned off during air handler unoccupied heating/cooling modes.

      5) Unoccupied zone heating/cooling set-points shall be 65°F (adj.) for heating mode, and 80°F (adj.) for cooling mode.

      6) Unoccupied zone heating/cooling will be determined by monitoring specific zones as determined by Duke.

      7) AHU supply air reset temperature shall follow Duke FMD guidelines for supply air reset programming temperatures.

   b. **Sequences with Terminal Units**

      1) Sequences will be initiated 30 minutes (adj.) prior to building occupancy schedule.

      2) Mode of operation will be determined by evaluating AHU return air temperature.

      3) The AHU will operate with return air damper fully open, and min/max relief and min/max outside air dampers closed. Heating of the zones will be performed using the zone VAV reheat valve until AHU return air temperature reaches 68°F (adj.). AHU cooling coil control valve will operate to maintain occupied supply air temperature set-point until AHU return air temperature drops below 76°F (adj.).

      4) **Unoccupied Mode Low Temperature Limit:** If low temperature limit is activated, the AHU will operate with return air damper fully open, and min/max relief and min/max outside air dampers closed. The AHU will operate for a min of 30 minutes (adj.) and modulate appropriate terminal unit reheat control valves until applicable zone sensors are 2°F above Low Limit set-point.
5) **Unoccupied Mode High Temperature Limit**: If high temperature limit is activated, the AHU will operate with return air damper fully open, and min/max relief and min/max outside air dampers closed. The AHU will operate for a min of 30 minutes (adj.) and modulate chilled water coil control valve until applicable zone sensors are 2°F below High Limit set-point.

c. **Sequences without Terminal Units**

1) Sequences will be initiated 30 minutes (adj.) prior to building occupancy schedule.

2) Mode of operation will be determined by evaluating AHU return air temperature.

3) The AHU will operate with return air damper fully open, and min/max relief and min/max outside air dampers closed. Heating of the zones will be performed by modulating the AHU preheat coil control valve to maintain normal reset supply air temperature set-point until AHU return air temperature reaches 68°F (adj.). During cool-down mode, AHU cooling coil control valve will modulate to maintain occupied supply air temperature set-point until AHU return air temperature drops below 76°F (adj.).

4) **Unoccupied Mode Low Temperature Limit**: If low temperature limit is activated, the AHU will operate with return air damper fully open, and min/max relief and min/max outside air dampers closed. The AHU will operate for a minimum of 30 minutes (adj.) and will modulate the AHU preheat control valve to maintain normal reset supply air temperature set-point until applicable zone sensor is 2°F above Low Limit set-point.

5) **Unoccupied Mode High Temperature Limit**: If high temperature limit is activated, the AHU will operate with return air damper fully open, and min/max relief and min/max outside air dampers closed. The AHU will operate for a minimum of 30 minutes (adj.) and modulate chilled water coil until applicable zone sensor is 2°F below High Limit set-point.

4. **AHU Supply Fan VFD Control**

   a. On startup, the static pressure set point shall be ramped from 0 to the design set point over a period of 3 minutes to prevent high static trips.

   b. The supply fan(s) VFD shall modulate to maintain supply duct static pressure via sensor located approximately 2/3 downstream in ductwork at the static pressure set point determined during air balance.

5. **AHU Supply Air Temperature Reset**

   a. Air handler supply temperature set point should reset from 55°F-65°F (adj.) and should be based on a maximum of several VAV box cooling loopOut values.
b. The VAV boxes sampled for the reset should be selected to best represent all areas of the building. High occupancy spaces such as classrooms, conference rooms, auditoriums, etc. should be factored into the reset to ensure they are cooled properly. The number of VAV boxes used for the maximum cooling loopOut calculation should be kept to the minimum needed to represent all areas of the building. Using too many VAVs in the calculations increases the chance that one VAV box problem will drive down supply temp on the air handler. Final selection of VAV boxes used for reset should be approved by Duke project team.

c. The supply reset statement should be executed in the program every 5 minutes. If any VAV included in the reset calculation stays at 100% cooling loopOut for greater than 60 minutes (adj.) continuous a virtual alarm should be activated. This alarm point should be on the air handler graphic near the supply temp set point.
26 05 19 – Building Wire and Cable

1. Introduction
   A. In general, wiring methods shall be individual copper conductors in conduit.

2. References
   A. NFPA 70 National Electrical Code
   B. IBC International Building Code

3. Design Standards
   A. Building Wire:
      1. All power wiring rated 600V and below shall be minimum #12 AWG Type THHN/THWN.
      2. All conductors shall be copper. Aluminum is strictly prohibited.
      3. Power and lighting circuits #10 AWG and smaller shall be solid conductors. For connections to vibrating equipment, conductors shall be stranded.
      4. Conductor sizes #8 AWG and larger shall be Class B stranded conductors.
      5. Neutral conductors subject to harmonic loads shall be oversized on Y-grounded systems and considered current carrying conductors when sizing conduits. The neutral conductor shall not be smaller than phase conductors.
      6. Color code system wiring for standard clockwise rotation is shown below:

      | 208/120 Volt Systems | 408/277 Volt System |
      |----------------------|----------------------|
      | Phase A – Black      | Phase A – Brown      |
      | Phase B – Red        | Phase B – Orange     |
      | Phase C – Blue       | Phase C – Yellow     |
      | Neutral – White      | Neutral – Gray       |
      | Ground – Green       | Ground – Green       |

      7. All circuits shall be identified at the connection to the device with source circuit number and panel.
      8. Branch circuit wiring shall be sized for a maximum of 3% voltage drop. The maximum total voltage drop on both feeders and branch circuits to the farthest outlet shall not exceed 5%.
9. All power wiring shall be in conduit. For additional requirements related to conduit, see Section 26 05 33.

10. Do not mix conductors serving two separate power systems (i.e., 208/120 volt and 480/277 volt) in the same raceway, pull box or junction box.

   **Exception:** Where control wiring is a different voltage from power for the same system.

11. Joints in solid conductors shall be spliced using wire nut style connectors in junction boxes, outlet boxes and lighting fixtures. Permanent type crimp connectors shall not be used for branch circuit connections. Plug-in type connectors are prohibited except at end-of-run luminaire connections.

12. Joints in stranded conductors shall be spliced by mechanical connectors and gum rubber tape or friction tape. Solderless mechanical connectors for splices and taps provided with UL-approved insulating covers may be used instead of mechanical connectors plus tape.

**B. Medium Voltage Conductors:**

1. All medium and high voltage phase conductors shall be single-conductor, copper tape shielded, ethylene-propylene rubber insulated power cable rated at 15KV. Circuits shall include a separate 600-volt neutral. Cables shall be approved, terminated and tested by Duke University.

2. Shall be copper and listed for 15 kV service.

3. Type MV-105, insulated to 133% insulation level, EPR.

4. All cable shall be suitable for use in wet or dry locations.

5. Cable shall be identified by phase markings on the outer jacket intervals not to exceed 2 feet.

6. Cable shall be installed in concrete encased underground ductbanks and electrical vaults. Direct burial of conductors is prohibited.

**4. Documentation and Review Requirements**

**A.** The following design calculations shall be submitted with the construction documents:

1. Building short circuit

2. Building load

3. Feeder voltage drop (100A feeders and above)
5. Installation and Performance Requirements
   A. Coordinate all required tie-in points with Duke Utilities and Engineering Services (DUES).
   B. Coordinate all commissioning efforts with DUES.
   C. Provide floorplans with locations of splices in feeders 100A or larger

6. As-Built Requirements
   A. N.A.
26 05 26 – Grounding and Bonding for Electrical Systems

1. Introduction
   A. Grounding is utilized within electrical distribution systems to provide an alternative, low-impedance path around the electrical system for short circuit current to flow during a line to ground fault. In order for the protective devices to function properly and to ensure the safety of the general public and all maintenance personnel, it is critical that the entire electrical distribution system be properly grounded.

2. References
   A. NFPA 70 National Electrical Code
   B. Underwriters Laboratories Inc (UL) 467 – Grounding and Bonding Equipment

3. Design Standards
   A. All grounding and bonding materials shall be copper unless otherwise noted.
   B. Equipment grounding conductors shall be insulated with green colored insulation.
   C. Grounding electrode conductors shall be stranded cable.
   D. Grounding electrodes (i.e. ground rods) shall be 3/4 inch x 10 foot copper-clad steel.
   E. Grounding bus bars mounted exterior to electrical distribution equipment shall be provided with insulated standoffs.
   F. All service entrances shall be solidly grounded using a grounding electrode system connection between ground rods, building steel and metallic cold-water piping.
   G. Additional grounding resistance schemes may be considered but must be approved by the Owner to reduce ground fault current, voltage transients or damage to equipment.
   H. Additional forms of electric generation shall be considered separately derived services.
   I. Provide grounding lugs in all pull boxes and enclosures.
   J. Provide bonding bushings on all metallic raceways inside equipment enclosures that are not equipped with grounding lugs or a mechanical connection. Connect each bonding bushing to the grounding bus inside the equipment with bare conductors.
   K. Isolated grounds shall be derived at the service entrance.
   L. Provide (2” or 4”) x 12” x 1/4” thick grounding bard in each telecommunications room
4. **Documentation and Review Requirements**
   
   A. Provide detail that indicates the grounding connections for all transformers.
   
   B. Provide detail that indicates the grounding connections for all separately derived services.
   
   C. Provide riser diagram and details that indicate the telecommunications grounding system.

5. **Installation and Performance Requirements**

   A. All connections to grounding bus bars either be exothermically welded or utilize a minimum of two (2) mechanical bolts
   
   B. Ground all metal raceways, wiring devices, lighting fixtures, motor frames, switchgear, panels, cable supports, transformer neutrals and non-current carrying metallic parts.
   
   C. Provide insulated equipment grounding conductor for all feeders and branch circuits. Raceways shall not be relied on for equipment grounding continuity.
   
   D. Ground each wiring device by means of a separate conductor that connects the ground terminal of the wiring device to the equipment-grounding conductor.
   
   E. Bare copper conductors installed in metallic raceway shall be bonded at both ends of the metallic raceway.
   
   F. All underground connections and connections to building steel shall be exothermically welded.
   
   G. Provide ground-bonding jumpers across all sections of cable tray and fittings in accordance with manufacturer’s instructions.
   
   H. Ground shielded instrumentation cables in accordance with manufacturer’s instructions.
   
   I. In addition to the branch circuit equipment grounding conductors, provide a separate grounding electrode and grounding conductor for each metal light pole.
   
   J. Provide protection for ground conductors that are subject to physical damage.
   
   K. Prior to equipment shutoff valve, bond gas piping to electrical grounding system.
   
   L. Drive ground rod such that top of ground rod is below frost line or at the height of the ground loop whichever is lower.
   
   M. Perform ground resistance test. If resistance to ground exceeds 5 ohms, provide additional ground rods to reduce ground resistance. Owner to be present during testing.
   
   N. Perform equipment grounding system continuity test.
6. **As-Built Requirements**

   A. Ground resistance test measurements.
26 05 33 - Raceway and Boxes for Electrical Systems

1. Introduction
   A. Section includes conduit, surface raceway, wireways, outlet boxes, pull boxes, junction boxes and handholes.

1. References
   A. NFPA 70 National Electrical Code
   B. IBC International Building Code

2. Design Standards
   A. General:
      1. All equipment must be supported directly by structural members with adequate load-bearing capacity and material integrity using appropriate anchoring/connection hardware. Under no circumstances may equipment be supported by connections to finish materials. For example, equipment hung from toggle bolts through plaster-on-lath, gypsum board or ACT ceilings is not acceptable.

   B. Outlet Boxes:
      1. Outlet and junction boxes shall be a minimum of 4 inches square x 2 1/8 inches deep. Use of round boxes shall be avoided where conduit must enter the box through its side. This would result in a difficult and weak connection with a locknut or bushing on the rounded surface.

      2. Interior outlet boxes shall be galvanized steel constructed with stamped knockouts in back/sides and with threaded holes with screws for securing box coverplates or wiring devices. Multigang outlet boxes shall be of single-piece construction. No box extensions are allowed.

      3. For locations exposed to weather or moisture (interior or exterior), weatherproof boxes and accessories shall be provided. Weatherproof boxes shall be cast-type suited to each application. The boxes shall have threaded conduit ends, cast faceplate with spring hinged waterproof cap suitably configured, a gasket and corrosion proof fasteners.

      4. Pull and junction boxes shall be galvanized sheet steel with screw on covers of the type and size to suit each respective location and installation. Boxes shall have continuously welded seams and shall be equipped with steel nuts, bolts, screws and washers. Provide cast metal, gasketed-type pull boxes for outdoor locations.
5. Floor boxes shall be of brass construction with coverplates. Provide carpet flange for boxes installed in carpeted areas.

6. Where multigang boxes serve normal and emergency power circuits, full length and height barrier plates shall be provided within the box to completely separate normal and emergency circuits. Barrier plates shall also be required where two different 277-volt lighting circuits are present in the same switch box.

C. Conduits:

1. Duct banks for power and telecommunication building services shall be either rigid galvanized conduits or concrete-encased 4 inch Type DB PVC. Each PVC conduit will be supported and completely encased in concrete with a minimum of 3 inches on all sides. The number of bends will be minimized and all bends will be long-radius types. Total bends between pull points shall not exceed 180°. Bell ends shall be installed in the manhole. All duct banks shall be buried no less than 36 inches below finished grade or finished pavement. Conduits shall be left cleaned and with a suitable nylon pull string or pull wire in place. Service conduits shall be slope away from the building to drain back to the manhole.

2. Minimum conduit sizes shall be 3/4 inch (interior) and 1 1/4 inch (exterior). For switch legs, control circuits and signal circuits not exceeding four circuit conductors, 1/2 inch flexible conduit may be used.

3. All conduit shall be GRC unless otherwise permitted.

4. Intermediate metal conduit (IMC) may be used as a substitute for GRC, except for work installed in earth or concrete or where installed exposed less than 6 feet above finished floor and for circuits over 600 volts.

5. Electric metallic tubing (EMT) up to 2 inches for power circuits and up to 4 inches for special system circuits may be used as a substitute for GRC except for work installed in earth, concrete, exterior areas, hazardous areas or where subject to mechanical injury and for circuits over 600 volts. No EMT shall be installed exposed below 6 feet above finished floor unless it enters or exits from the top of a switchboard or panelboard enclosure. EMT fittings shall be steel compression type for sizes 2 inches and less. Steel set-screw type may be used for sizes above 2 inches.

6. Liquid tight flexible metal conduit shall be used for final connection to all motors, transformers, and rotating or vibrating equipment. The maximum length of such conduit shall be 72 inches.

7. Flexible metal conduit shall be used for final connections to lighting fixtures concealed in dry areas only. The maximum length shall be 72 inches.
8. Rigid nonmetallic conduit may be used only for the secondary underground service, the underground telephone service conduit and branch circuits and telephone system conduits located below the concrete floor slab-on-grade or buried on the exterior of the building. All PVC shall be Schedule 40 (unless noted otherwise), UL-listed for use with 75°C conductors.

9. All PVC components of the PVC conduit system shall be furnished from the same manufacturer and used specifically for their intended purpose. All field bends shall be made according to the manufacturer’s instructions and UL requirements. PVC that has been heated with a torch shall be replaced.

10. Rigid nonmetallic conduit shall not penetrate slab-on-grade or be installed anywhere above grade except where used as part of the conduit systems concealed within precast or poured-in-place walls. In all other cases, it shall transition to GRC prior to turning up from underground.

11. Condulet type fittings (LBs, LEBs, etc.) shall not be used on any service conductor conduit or on any conduit containing conductors sized #1/0 AWG or larger.

12. Conduits shall not be installed in concrete floor slabs without prior approval by DUES/FMD.

13. Conduits shall not be installed in the cell of the metal deck above bar joists or other structural member.

14. Conduit penetrations shall be made only at perpendicular angles to the penetrated surfaces unless otherwise specified. Conduit that is run along exterior walls shall not penetrate insulation or vapor barriers.

15. Suitable expansion fittings shall be provided as required on all conduits that are installed on walls subject to expansion or on conduits that penetrate expansion joints. Expansion fittings shall be as recommended by the conduit manufacturer.

16. Two coats of asphaltum or bitumastic paint shall be applied to all underground metallic conduits that are not encased in concrete.

17. 200-pound-test nylon pull cords shall be provided in all empty conduits.

18. All conduits shall be concealed in finished spaces unless non-concealed conduit is specified for aesthetic effect by the Architect and approved by the Owner. Surface mounted devices are generally not permitted. The presence of pre-existing surface-mounted wiring and conduit does not justify the installation of new surface-mounted devices.

D. Wireways / Junction Boxes / Pull Boxes
1. Wireways, pull boxes, and junction boxes shall not be used for routing more than 30 current carrying conductors

3. **Documentation and Review Requirements**
   
   N/A

4. **Installation and Performance Requirements**
   
   A. Coordinate all required tie-in points with Duke Utilities and Engineering Services (DUES).
   
   B. Coordinate all commissioning efforts with DUES.

5. **As-Built Requirements**
   
   A. All underground locations of conduits and boxes.
26 05 53 – Identification

1. Introduction

A. Identification is utilized to accurately identify equipment and other electrical infrastructures throughout facilities for purposes of safety and troubleshooting.

2. References

A. NFPA 70 National Electrical Code

B. 260576– Arc-Flash Studies

3. Design Standards

A. General

1. Signs shall be engraving stock melamine plastic laminate punched for mechanical fastening except where adhesive mounting is necessary because of substrate. Thickness shall be a minimum of 1/16 in. for signs up to 20 sq. in. and 1/8 in. for larger sizes. Fasteners shall be self-tapping screws, except where screws cannot or should not penetrate substrate.

2. Text shall be 1/4 in. in height. Sign shall provide 1/2 in. border around all text.

3. Label / Signs Colors:

a. Blue Surface / White Core: 120/208V

b. Black Surface / White Core: 277/480V

c. Red Surface / White Core: Generator Fed / Fire Alarm

4. Accessible Conduit Colors:

a. Red: Fire Alarm

5. Junction Box Colors:

a. Red: Fire Alarm

b. Blue & White: Controls

B. Equipment/System
1. Provide engraved plastic laminate sign on each major unit of electrical equipment within the facility. Sign shall include the Equipment Name, Amperage Rating, MCB or MLO, Voltage, Phase/Wire Quantity, Source Name, Source Location, Alternate Source (if applicable), and Alternate Source Location (if applicable). Provide sign that indicates each sub-feed load and location for all switchboards and panelboards 800A and greater. For voltages $>$ 600V, provide “DANGER – HIGH VOLTAGE” sign.

a. Switchboards

b. Panelboards

c. Transfer Switches

d. Disconnect Switches

e. Multi-Throw Switches

f. Enclosed Circuit Breakers

g. Transformers

h. Motor Control Centers

i. Motor Starters

j. Contactors

k. Variable Frequency Drives

l. Uninterruptible Power Supplies

m. Battery Racks

n. Power Generators

o. Dimming Control / Switching Panels

p. Inverters

q. Fire Alarm Control Panel / Annunciators

r. Bus Duct

C. Panel Schedules

1. Provide typed panelboard directory. Hand written directories are not permitted. Each directory line item shall include the “Load Name” and “Load Location”. When circuiting within an existing panelboard is changed, a new typed circuit directory shall be provided.
D. Wiring Devices
   1. Provide self-adhesive label on device faceplate that indicates the source panel and circuit serving the device.

E. Access Panels / Wireways / Troughs / Gutters / Junction Boxes
   1. For voltages > 50V & < 600V, mark with indelible marker or self-adhesive label that indicates the circuit(s) located within.
   2. For voltages > 600V, provide “DANGER – HIGH VOLTAGE” sign and self-adhesive label that indicates the circuit(s) located within.

F. Conduit / Armored Cable
   1. Provide snap-around label or band, with diameter to suit, to each conduit or cable served from switchboard or panelboard to indicate circuit(s) located within.

G. Conductors
   1. Provide self-adhesive label with circuit number on each phase and neutral conductor in all electrical equipment, wireways, troughs, gutters, and junction boxes.

H. Operational Instructions / Warnings
   1. Provide underground warning tape, buried six inches (6”) below finished grade, directly above all underground power, lighting, communications lines.
   2. Where detailed instructions or explanations are needed, provide plasticized sheet with clearly typed instructions.

4. Documentation and Review Requirements
   A. Provide schedule / list of all signs and labels to be applied to all equipment and systems for review by Engineer of Record and Duke University.
   B. Provide sample of labels to be applied to all access panels, wireways, troughs, gutters, junction boxes, devices, conduits, cables, and conductors for review by Engineer of Record and Duke University.

5. Installation and Performance Requirements
   A. Verify identity of each item prior to the installation of the identification product.
   B. Provide and apply labels. Prior to the application of the labels, clean the area to which the labels will be applied.
26 05 76 - Arc-Flash Studies

1. Introduction

   A. Arc-Flash Studies are utilized to assist qualified personnel in identifying the hazards associated with electrical equipment. Duke University requires Arc-Flash Studies for equipment rated 208 VAC and higher likely to require service or inspection while energized. This guideline is for existing systems, the expansion and modification to existing systems, and new construction.

2. Objective

   A. Perform an Arc-Flash Study of the electrical distribution system using the IEEE 1584 methodology. Use Power*Tools for Windows (PTW) software from SKM Systems Analysis, Inc. to conduct this study.

   B. Scope shall include at a minimum:
      i. field verify accuracy of electrical system information
      ii. collect additional electrical system information as needed
      iii. produce a detailed report of findings/recommendations
         a. draft pre-mitigation report
         b. final pre-mitigation report
      iv. complete a detailed short circuit fault current analysis
      v. complete a detailed coordination analysis
      vi. complete a detailed arc-flash risk assessment
      vii. produce floorplans showing location of major electrical equipment
      viii. produce up-to-date single-line diagrams (SLDs)
      ix. produce/apply arc-flash hazard labels
      x. provide electronic copy of all deliverables

   C. Scope may also include:
      i. produce an asbuilt post-mitigation report (typically under separate contract after recommended remediation items have been completed)

3. References

   A. NFPA 70E: Standard for Electrical Safety in the Workplace


   C. IEEE 1584.1-2013: Guide for the specification of Scope and Deliverable Requirements for an Arc-Flash Hazard Calculation Study in Accordance with IEEE Std 1584

   D. IEEE C37.20.7: Guide for Testing Metal-Enclosed Switchgear rated up to 38 kV for internal arcing faults
4. **Acronyms**

   AFB – Arc-Flash Boundary  
   AFIE – Arc-Flash Incident Energy  
   ATS – Automatic Transfer Switch  
   DUES – Duke Utilities and Engineering Services  
   FMD – Facilities Management Department  
   MCC – Motor Control Center  
   OCPD – Over Current Protection Device  
   SLD – Single-Line Diagram  
   UPS – Uninterruptible Power Supply  
   VFD – Variable Frequency Drive  

5. **Information/Resources Supplied by Duke**

   A. Available 3-Phase and Single-Line-Ground fault currents and associated X/R ratios at the service entrance location (utility source)  
   B. Single-line diagrams (as available)  
   C. Floorplans (as available)  
   D. Assistance during field verifications / Personnel knowledgeable of electrical system  
   E. Direction on mitigations to be included in final (pre-mitigation) and as-built (post-mitigation) reports  
   F. Direction as to how/where labels are to be applied  
   G. CustomLabel.dat file with Duke SKM Label Templates
6. Performance and Installation Requirements

A. Field verify all equipment in the electrical system (starting at the service disconnect), equipment types, cable types, protective device types and settings. The level and accuracy of detail regarding the existing infrastructure shall be investigated prior to submission of proposal. For safety purposes, a preliminary study shall be performed to estimate the hazards of all equipment prior to exposure of any energized components. Once the preliminary study is complete, all equipment shall be accessed and any unlabeled circuits traced, as needed, by Duke University personnel only.

B. During the course of field investigations, un-named equipment to be included with the study shall be given a logical identifying name for creation of the single-line diagram. The equipment shall be legibly marked with its identifying name during field investigations for later reference prior to final labeling. See Figure C for SKM nomenclature guideline.

C. Provide a 1-hr. training session to present the findings of the associated study.

D. Provide and apply final pre-mitigation labels to all equipment associated with the arc-flash study within 30 days of acceptance of report. Labels shall be suitable for the environment for which they are installed. For example, labels installed on outdoor equipment shall be weather and UV resistant.

E. Provide and apply asbuilt post-mitigation labels to all equipment affected by remediation measures completed within 30 days of acceptance of report. Obsolete labels previously applied shall be completely removed.

F. Photographic Records

i. During the course of field investigations, capture and provide suitable photographs of each piece of equipment included within the SKM model to represent:

   a. Overall view of equipment (only to the extent possible avoiding exposure to energized parts)

   b. Equipment designation/nameplate

   c. Breaker position and trip rating (where applicable)

   d. Adjustable breaker settings (where applicable)

   e. Arc Flash & Hazard labeling (where applicable)
7. Detailed Report Requirements

A. Format

i. Cover (to include both building number and building name)
ii. Modification Log Sheet
iii. Executive Summary
   a. Background / Calculation Means and Methods
   b. Brief Summary of Existing Conditions / Missing Information / Assumptions
   c. Brief Summary of Recommendations
   d. Table of Recommended Remediation (Duke template)
iv. Input Data Report  *(in PDF format only, do not include in Hard Copy)*
v. Short Circuit Fault Current Analysis/Recommendations
vi. Coordination Analysis/Recommendations
   a. Existing Time-Current Curves
   b. Recommended Time-Current Curves
vii. Arc-Flash Risk Assessment/Recommendations
viii. Floorplans (Ledger Sized, 11 inch x 17 inch)
ix. Input and Output Single-Line Diagrams (Ledger Sized, 11 inch x 17 inch)
x. Arc-Flash Labels

B. Short Circuit Fault Current Analysis

i. Complete a detailed analysis of each piece of equipment in the system and report any deficiencies and/or recommended corrections/improvements.

ii. The system shall be modeled in all operating modes [i.e. normal, emergency (if applicable), bypass (if applicable)]. Report shall also indicate the maximum available fault current from all operating modes.

iii. Emphasis shall be placed on equipment exceeding its interrupting rating by more than 110%.
C. Coordination Analysis

i. Complete a detailed device coordination analysis of the electrical system and report any deficiencies, concerns and/or recommended corrections/improvements.

ii. The first building protective device shall coordinate with closest upstream High Voltage protective device.

iii. Provide both existing and recommended time-current curves. A partial one-line diagram of the associated devices shall be attached to each time-current curve. Curves shall be in color and contain the following protective device information: Component Name, Manufacturer, Type, Frame/Model, Sensor/Trip, Plug and Settings. Adequate equipment protection should also be evaluated.

iv. Recommendations for coordination improvement shall also indicate the affect to downstream AFIE.

D. Arc-Flash Risk Assessment

i. Complete a detailed arc-flash risk assessment of each piece of equipment in the system and report any deficiencies and/or recommended improvements.

ii. Emphasis shall be placed on equipment that has an Incident Energy greater than 8 cal/cm².

iii. The system shall be modeled in all operating modes [i.e. normal, emergency (if applicable), bypass (if applicable)]. Report shall also indicate the maximum available arc-flash rating from all operating modes.

E. Floorplans

i. Produce scaled floorplans in AutoCAD format that indicate the location of all major equipment. Floor plans shall be printed on ledger sized (11 inch x 17 inch) pages with matchlines and page numbers to other pages as required. Provide keyed plan to indicate plan location within the associated floor (as needed).

ii. Floorplans shall have a title block designating building number, building name, and drawing number at a minimum.

iii. For Arc-Flash studies of new construction and renovation projects, the Architect is responsible for providing floor plans to the consultant team conducting the Arc-Flash study.

iv. Minor updates to floorplans shall be included in this scope to correct any discrepancies observed in the mechanical and electrical rooms.
F. Single Line Diagrams (SLDs)

i. SKM single-line diagrams shall be exported to AutoCAD format and printed on ledger sized (11 inch x 17 inch) pages with references to other pages as required. Provide keyed plan to indicate page location within the diagram.

ii. SLDs to include building number, building name, and drawing number.

iii. Separate diagrams shall be provided for input and output data.
   a. Refer to Figure B for Duke FMD SKM one-line datablock formats.
   b. Refer to Figure C for Duke FMD SKM nomenclature guideline
   c. Refer to Figure D for sample Input and Output one-lines.

G. Equipment Labels

i. Arc-flash labels shall be provided for and applied to the following equipment rated 208 VAC and higher likely to require service or inspection while energized (both front and rear entry – if applicable):
   a. Metal-Clad Switchgear:
      (1) Incoming section—line-side of main
      (2) Branch feeder sections—load-side (ONLY IF the worst case incident energy at line-side is greater than 8 cal/cm² AND the equipment meets ANY of the following criteria):
         (a) Equipped has an “arc-resistant” barrier built in compliance with ANSI/IEEE C37.20.7 standard that can insure that the dangerous power of the higher line-side incident energy from the incoming section will not migrate to the adjacent feeder section.
         (b) A qualified person with the skills and knowledge of electrical equipment construction confirms the presence of a complete barrier between the line-side connections and the possible location of an arc-flash in the adjacent feeder section. [C]

   b. All other Switchgear, Switchboards, Panelboards, Industrial control panels, Meter socket enclosures, VFD’s, ATS’s, Machine control panels, MCC’s, Contactors, UPS’s, Busway(s), and Bus plugs
      (1) Incoming section—line-side of main (if equipped)

   c. Three-Phase Mechanical and Equipment Disconnect– Fused and Non-Fused
      (1) Incoming section—line-side of fuse (if equipped)
ii. Labels shall indicate at a minimum:
   a. Nominal Voltage (Shock Hazard)
   b. Arc-Flash Boundary
   c. Available Incident Energy (cal/cm²) & Working Distance
   d. Site Specific PPE Level
   e. Available Fault Current (Isc)
   f. Glove Class
   g. Limited Approach Distance
   h. Restricted Approach Distance
   i. Building ID Number (Bldg #)
   j. Company Identification (prepared by)
   k. Date Label Prepared

iii. See Figure A for label examples and Avery Template Numbers. Prior to the application of the labels, clean the area to which the labels will be applied. Source feed labels will be provided by Duke University personnel at the time of label application (as needed).
8. SKM Analysis

A. Equipment below 240 volts need not be considered unless it involves at least one 125 kVA or larger transformer as its immediate power supply [B]. This direction refers to incident energy calculations only. All equipment operating at 50 volts and higher in the facility shall be assessed for other possible electrical dangers such as shock and overload conditions. Within SKM, utilize options under menu Arc Flash – Study Options ->Standard and Unit; select “<240 V” and “Report as Category 0 if Transformer Size < 125kVA” to provide labels compliant with the Duke University SKM labeling nomenclature guideline.

B. Utilize a maximum arcing time of 2 seconds for incident energy calculations as is acceptable to NFPA 70E, IEEE 1584 and Duke FMD. Sound engineering judgment should be used in applying the 2-second maximum clearing time because there could be circumstances where an employee’s egress is inhibited. Sound engineering judgment shall include the use of code and standards, lessons learned, past experience, industry experts and peers to develop a compliant definable basis for minimizing exposure to electrical hazards.

C. Within SKM, utilize options under menu Arc Flash – Study Options >Standard and Unit; select check box “Check Upstream devices for mis-coordination” under [Upstream Mis-Coordination Options]. Apply a minimum value of 3 within field “Levels to Search”.

D. All major equipment likely to contribute energy to the system (transformers, generators, motors 25HP or greater, chillers, boilers, AHU’s, etc.) shall be verified and incorporated into the SKM one-line/model.

E. Provide an additional bus (representative only) inside the SKM model at:

   i. the line-side (“source side”) lugs of the service disconnecting means (i.e. Main OCPD)

   ii. the line side lugs of Switchboard/Panelboard Main OCPD (if equipment), Disconnects, ATS’s, VFD’s and UPS’s

   iii. the secondary terminals of large (125kVA or larger) distribution transformers
9. **Draft Pre-Mitigation Report – Deliverables**

   A. Provide one (1) hard copy of the arc-flash report for review.

   B. Provide one (1) CD-ROM or flash-drive containing the following:

      i. Electronic copy of the “Project>Backup” of SKM model with all associated files.

      ii. Electronic copy of the exported SKM one-line diagram(s) in AutoCAD and PDF formats.

      iii. Electronic copy of the scaled floorplan(s) in AutoCAD and PDF formats.

      iv. Electronic copy of report (with all scanned or printed into PDF format). The structure of electronic file submission shall match the order and file format as described in Part 7.A of this guideline.

      v. Electronic copies of photographs. Photographs shall be provided pre-sorted and in a folder-file structure grouped by building and then by panel/equipment designation.

10. **Final Pre-Mitigation Report – Deliverables**

    A. Provide one (1) hard copy of the arc-flash report for review that incorporates comments/corrections/direction from Duke FMD review of draft report.

    B. One (1) CD-ROM or flash-drive containing the following:

        i. Electronic copy of the “Project>Backup” of SKM model with all associated files.

        ii. Electronic copy of the exported SKM one-line diagram(s) in AutoCAD and PDF formats.

        iii. Electronic copy of the scaled floorplan(s) in AutoCAD and PDF formats.

        iv. Electronic copy of report (with all scanned or printed into PDF format). The structure of electronic file submission shall match the order and file format as described in Part 7.A of this guideline.
11. As-Built Post-Mitigation – Deliverables

Once FMD/DUES has provided final comment and direction regarding Recommended Remediation and all Remediation has been completed, the report & model shall be updated and the following items shall be provided:

A. Provide one (1) hard copy of the arc-flash report.

B. Provide one (1) CD-ROM or flash-drive containing the following:
   
   i. Electronic copy of the “Project>Backup” of the SKM model with all associated files.
   
   ii. Electronic copy of the exported SKM one-line diagram(s) in AutoCAD and PDF formats.
   
   iii. Electronic copy of the scaled floorplan(s) in AutoCAD and PDF formats.
   
   iv. Electronic copy of report (with all scanned or printed into PDF format). The structure of electronic file submission shall match the order and file format as described in Part 7.A of this guideline.
Figure A: Label Examples

![Warning Table]

**WARNING**

**Arc Flash and Shock Risk**

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 in</td>
<td>Flash Hazard Boundary</td>
</tr>
<tr>
<td>0.21 cal/cm^2</td>
<td>Flash Hazard at 18 in</td>
</tr>
<tr>
<td>0.55 kA</td>
<td>Available Fault Current (Isc)</td>
</tr>
<tr>
<td>480 VAC</td>
<td>Shock Hazard when cover is removed</td>
</tr>
<tr>
<td>00</td>
<td>Glove Class</td>
</tr>
<tr>
<td>42 in</td>
<td>Limited Approach</td>
</tr>
<tr>
<td>12 in</td>
<td>Restricted Approach</td>
</tr>
</tbody>
</table>

**Panel:** PNL-E401

---

**DANGER**

**NO SAFE PPE EXISTS**

**ENERGIZED WORK PROHIBITED**

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>156 in</td>
<td>Flash Hazard Boundary</td>
</tr>
<tr>
<td>41 cal/cm^2</td>
<td>Flash Hazard at 18 in</td>
</tr>
<tr>
<td>Dangerous!</td>
<td>Available Fault Current (Isc)</td>
</tr>
<tr>
<td>10.44 kA</td>
<td>Shock Hazard when cover is removed</td>
</tr>
<tr>
<td>480 VAC</td>
<td>Glove Class</td>
</tr>
<tr>
<td>00</td>
<td>Limited Approach</td>
</tr>
<tr>
<td>42 in</td>
<td>Restricted Approach</td>
</tr>
<tr>
<td>12 in</td>
<td></td>
</tr>
</tbody>
</table>

**Panel:** SWBD-MAIN-LINE (Electri Bldg#: 7731

---

Figure 1. Example label for PPE Levels 0 through 4; **Avery 6878**

Figure 2. Example label for PPE Level DANGEROUS!; **Avery 5265**
## Figure B: Typical SKM One-line Datablock Formats

All component types shall include their Component Name on both input and output one lines.

Create and name the Datablock Formats as listed below.

<table>
<thead>
<tr>
<th>Component Type</th>
<th>Input Data - Displayed Attributes (Attribute Template)</th>
<th>Output Data - Displayed Attributes (Attribute Template)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Datablock Format Name</strong></td>
<td><strong>“Duke University – Input”</strong></td>
<td><strong>“Duke University – Output”</strong></td>
</tr>
<tr>
<td><strong>Bus</strong></td>
<td>SystemNominalVoltage (%1 %2) ContinuousRating (%1 %2) ShortCircuitRating (%1 %2) Description (Loc./Room: %1 %2)</td>
<td>AF_IncidentEnergy (%1 %2 %a) AF_WorkingDistance (@ %1 %2) AF_PPE Category (PPE Level %1 %2) AF_Boundary (AF_Boundary %1 %2) InitSymRMS 3P (Isc 3P %1 %2) Description (Loc./Room: %1 %2)</td>
</tr>
<tr>
<td><strong>Cable</strong></td>
<td>CableSize (%1 %2) QtyPerPhase (%1 %2 /Ph) Length (Length %1 %2)</td>
<td></td>
</tr>
<tr>
<td><strong>2-Winding Transformer</strong></td>
<td>Nominal kVA (%1 %2) Z% (Z% %1 %2) SystemNominalVoltage (Pri. %1 %2) SystemNominalVoltageSecondary (Sec. %1 %2) X/R (X/R %1 %2)</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Utility</strong></td>
<td>SC Contribution 3P (SC Contribution 3P %1 %2) X/R 3P (X/R 3P %1 %2) SC Contribution SLG (SC Contribution SLG %1 %2) X/R SLG (X/R SLG %1 %2)</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Generator</strong></td>
<td>SystemNominalVoltage (%1 %2) RatedSize (%1.1 %2) InitSymRMS 3P (Isc 3P %1 %2) InitSymRMS SLG (Isc SLG %1 %2)</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Induction Motor (&gt;25 HP)</strong></td>
<td>Rated HP (%1 %2) Description (Loc./Room: %1 %2)</td>
<td>Description (Loc./Room: %1 %2)</td>
</tr>
<tr>
<td><strong>Synchronous Motor (&gt;25 HP)</strong></td>
<td>Rated HP (%1 %2) Description (Loc./Room: %1 %2)</td>
<td>Description (Loc./Room: %1 %2)</td>
</tr>
<tr>
<td><strong>Protective Device / Switch</strong></td>
<td>Frame/Model (%1 %2) Sensor/Trip (%1 %2) InterruptingRating (%1 %2)</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Auto-Transfer Switch</strong></td>
<td>Amps Rating (%1 %2) Withstand Sym kA (%1.1 %2) Description (Loc./Room: %1 %2)</td>
<td>InitSymRMS 3P (Isc 3P %1 %2) Description (Loc./Room: %1 %2)</td>
</tr>
<tr>
<td><strong>UPS</strong></td>
<td>SystemNominalVoltage (Pri. %1 %2) SystemNominalVoltageLoad (Sec. %1 %2) UPS Rating (UPS Rating %1 %2kVA) Description (Loc./Room: %1 %2)</td>
<td>Description (Loc./Room: %1 %2)</td>
</tr>
<tr>
<td><strong>Motor Controller (VFD)</strong></td>
<td>Rated Size (Rated Size %1 %2) Rated Voltage (Rated Voltage %1 %2) Ampacity (Ampacity %1 %2) Description (Loc./Room: %1 %2)</td>
<td>Description (Loc./Room: %1 %2)</td>
</tr>
</tbody>
</table>
Figure C: Duke University SKM nomenclature guideline

Below represents typical nomenclature to be used in all SKM models.
Utility transformer to be omitted from Building model in the presence of a High Voltage Study giving the exact utility input at the secondary lugs (provided by Duke FMD)
Figure D-2: Typical Output One-line

Utility transformer to be omitted from Building model in the presence of a High Voltage Study giving the exact utility input at the secondary lugs (provided by Duke FMD)
26 08 00 – Commissioning of Electrical Systems

1. GENERAL

A. GENERAL PROVISIONS

1. Drawings and general provisions of the Contract, including General Conditions and Division - 1 Specifications Sections, apply to Work of this section.

2. Provisions of Divisions 23 and 26 of the project specifications which are applicable to Commissioning of the Electrical Systems are an integral part of this Section.

3. Commissioning is an important and integral part of the Contractor's Quality Control program.

B. WORK INCLUDED

1. “Active participation” in the Commissioning program as generally outlined in this section.

C. COMMISSIONING PROGRAM

1. Description

   a. The purpose of this section is to specify the Division 26 Contractor's responsibilities and participation in the commissioning process.

   b. Commissioning is primarily the responsibility of the Commissioning Authority and Owner, with support for start-up, testing and commissioning the responsibility of the Division 26 Contractors. The commissioning process does not relieve this Contractor from participation in the process, or diminish the role and obligations to complete all portions of work in a satisfactory and fully operational manner.

2. Work of Division 26 includes:

   a. Testing and start-up of the electrical equipment.

   b. Assistance in functional testing to verify equipment/system performance.

   c. Providing qualified personnel to assist in commissioning tests, including seasonal testing.

   d. Completion and endorsement of pre-functional test checklists provided by the Commissioning Authority to assure that Division 26 equipment and systems are fully operational and ready for functional testing.
e. Providing equipment, materials, and labor necessary to correct deficiencies found during the commissioning process which fulfill contract and warranty requirements.

f. Providing operation and maintenance information and as-built drawings to the Commissioning Authority for their use in developing the Systems Manual.

g. Providing assistance to the Commissioning Authority to develop, edit, and document system operation descriptions.

h. Providing training for the systems specified in this Division with coordination by the Commissioning Authority. Prior to training, submit a training plan complete with syllabus and sample training material. The Commissioning Authority will review and approve the training plan.

3. Commissioning Coordinators for Lighting Controls

a. The Contractors shall assign qualified individuals from each discipline with at least ten (10) years of relevant experience in the installation, testing and start up of Lighting Control systems.

D. RELATED WORK

1. All testing and start-up procedures and documentation requirements specified within Division 1, Division 26, and related portions of this project.

2. Commissioning procedures that require participation of Division 26 Contractors.

3. Cooperate with the Commissioning Authority in the following manner:

   a. Allow sufficient time before final completion dates so that test and balance and functional testing can be accomplished.

   b. Provide labor and material to make corrections when required without undue delay.

   c. For specified electrical systems and component testing by a third-party testing Contractor, coordinate with the Commissioner, the scope and schedule of that testing for observation by the Commissioner during the actual testing

4. Scope: For coordination purposes, the Commissioning scope is generally outlined below:

   a. Review contractor submittals for the systems included in the scope of commissioning.

   b. Review training materials and agendas provided by the contractor and determine the adequacy of training. Verify training has been completed.
c. Document compliance with design intent of the lighting system

d. Verify that equipment and systems have been properly installed in accordance with the contract documents and manufacturer’s written installation instructions.

e. Verify that equipment has been placed into operation with the appropriate manufacturer’s oversight and approval.

f. Verify that adjusting of occupancy sensors has been properly done.

g. Develop a Systems Manual

h. Document and review warranty start and end dates.

i. Perform an assessment of the first 10 months of building operations and include a plan for resolution and correction of outstanding commissioning items.

2. PRODUCTS

A. TEST EQUIPMENT

1. Standard test equipment for commissioning will be provided by the installing contractor.

2. Division 26 shall provide standard and specialized test equipment as necessary to test and start up the electrical equipment.

3. Proprietary test equipment required by the manufacturer, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist the Commissioning Authority or Owner in the commissioning process. The test equipment will become the property of the Owner.

3. EXECUTION

A. PREPARATION OF COMMISSIONING PROGRAM

1. The Commissioning program shall be prepared by the Commissioning Authority and submitted to the Engineer for approval.

B. COMMISSIONING TEAM

1. The Commissioning Coordinator shall assemble the Commissioning Team which shall consist of the following persons:

   a. Commissioning Authority

   b. Plumbing Contractor and Trade Representative(s)

   c. HVAC Contractor and Trade Representative(s)
d. Control System Trade Representative(s) (from Owner)
e. Test, Adjust and Balance Trade Representative (from Owner)
f. Electrical Contractor’s Representative
g. Fire Alarm Contractor
h. Owner’s Project Manager
i. Owner’s Maintenance staff
j. Engineer of Record
k. The Commissioning Team shall develop and generally follow a schedule of Commissioning events for the project.

C. RESPONSIBILITIES

1. Owner

   a. Assign appropriate staff and schedule them to participate in the various meetings, training sessions and inspections as follows:

   b. Pre-commissioning coordination and schedule of events meeting.

   c. Initial training session at initial placement of major equipment.

   d. Maintenance orientation and inspection at initial placement of major equipment.

   e. Maintenance orientation and inspection at connection of distribution systems.

   f. Conduct Functional Testing of systems.

   g. Owners training and demonstration session(s).

   h. Review of operation and maintenance manuals and submittals for key components of the electrical systems.

   i. Participate in final review and acceptance meeting.

2. Commissioning Authority

   a. Review all Commissioning requirements and intent of the Contract Documents. Assure all specialty Trade Subcontractors include their active participation in the Commissioning of the electrical systems.

   b. Prepare the Commissioning program. Include input from Trade Representatives.

   c. Coordinate the implementation of the Commissioning program, through organization of all Commissioning meetings, tests, demonstrations, training
events and performance verifications described in the Contract Documents and the Commissioning program.

d. Review the plans and specifications with respect to their completeness in all areas as they relate to the Commissioning program.

e. The plan and specification review by the Commissioning Authority does not include any responsibility for the system evaluation, adequacy of the system to meet design intent, capacity of the system or any of the other elements of the system design which are the strict responsibility of the Engineer of record.

f. Schedule a pre-commissioning coordination meeting with the Commissioning Team within 45 days of the award of the contract, at a convenient location. This pre-commissioning meeting will be for the purpose of reviewing the complete Commissioning program and establishing tentative schedules for maintenance orientation and inspections, O&M submittals, training sessions, system flushing and testing, job completion, system start-up and test, adjust and balance work.

g. Verify accessibility of equipment for maintenance and component replacement/repair.

h. Conduct site installation verification visits to observe that equipment and systems are installed per the contract documents and applicable standards.

i. Upon notification from the Electrical Contractor that the electrical systems have been started, that all lighting control systems have been started, tested, and adjusted and that the systems and equipment is functioning as designed and specified, schedule the functional testing. Functional testing will be conducted by the Owner. Any Commissioning Team member may witness testing.

j. Provide a final Commissioning Report and LEED letters.

3. Engineer of Record

a. Provide clarification of any design intent questions raised by the Commissioning Team.

b. Attend and actively participate in initial pre-commissioning coordination meeting to be scheduled by the Commissioning Authority within 45 days of the award of the contract.

c. Review and approve Commissioning program.

d. Participate in sessions scheduled in the Commissioning program.

e. Receive and review operation and maintenance manuals as submitted by the Electrical Contractor.
f. Attend Owner training sessions as appropriate.

g. Prepare record drawings for the project after receipt from the Electrical Contractor.

D. WORK PRIOR TO COMMISSIONING

1. Complete all phases of work so the systems can be energized, started, tested, and otherwise commissioned. Division 26 has primary start-up responsibilities with obligations to complete systems, including all sub-systems so they are functional. This includes the complete installation of all equipment, materials, raceways, wire, terminations, controls, etc., per the Contract Documents and related directives, clarifications, change orders, etc.

2. A commissioning plan will be developed by the Commissioning Authority. Upon request of the Commissioning Authority, this Contractor shall provide assistance and consultation. The commissioning plan will be developed prior to completion of the installation. This Contractor is obligated to assist the Commissioning Authority in preparing the commissioning plan by providing all necessary information pertaining to the actual equipment and installation. If system modifications/clarifications are incorporated to this and related sections of work, commissioning of this work will be made at no additional cost to the Owner. If Contractor-initiated system changes have been made that alter the commissioning process, the Commissioning Authority will notify the Architect, and the Contractor may be obligated to compensate the Commissioner to test the revised product, or confirm the suitability/unsuitability of the substitution or revision.

3. Specific pre-commissioning responsibilities of Division 26 are as follows:

   a. Normal start-up services required to bring each system into a fully operational state. This includes motor rotational check, cleaning, lug tightening, control sequences of operation, etc. The Commissioning Authority will not begin the commissioning process until each system is complete, including normal contractor start-up.

   b. The Contractor shall perform pre-functional tests on the following equipment and systems. Contractor start-up forms may be substituted for the pre-functional test forms with prior approval by the Commissioning Authority.

      Emergency Generator
      Occupancy Sensors
      Daylighting Systems
      Automatic Transfer Switches
      Photovoltaic Systems
c. Acceptance phase should begin upon completion of all building systems. However, testing of individual systems can begin as long as it has been completely tested by the sub-contractor and it is in the best interests of the Owner. Commissioning activities and schedule will be coordinated with the Contractor. Start of commissioning before system completion will not relieve the Contractor from completing those systems as per the schedule.

E. PARTICIPATION IN COMMISSIONING

1. Provide skilled technicians to start-up and debug all systems within the division of work. These same technicians shall be made available to assist the Commissioning Authority/Owner in completing the commissioning program as it relates to each system and their technical specialty. Work schedules, time required for testing, etc., will be requested by the Commissioning Authority/Owner and coordinated by the Contractor. Contractor will ensure the qualified technician(s) are available and present during the agreed-upon schedules and of sufficient duration to complete the necessary tests, adjustments, and/or problem resolutions.

2. System problems and discrepancies may require additional technician time, Commissioning Authority/Owner time, redesign and/or reconstruction of systems, and system components. The additional technician time shall be made available for the subsequent commissioning periods until the required system performance is obtained.

3. The Commissioning Authority/Owner reserves the right to judge the appropriateness and qualifications of the technicians relative to each item of equipment, system, and/or sub-system. Qualifications of technicians include expert knowledge relative to the specific equipment involved, adequate documentation and tools to service/commission the equipment, and an attitude/willingness to work with the Commissioning Authority/Owner to get the job done. A liaison or intermediary between the Commissioning Authority/Owner and qualified factory representatives does not constitute the availability of a qualified technician for purposes of this work.

F. WORK TO RESOLVE DEFICIENCIES

1. In some systems, misadjustments, misapplied equipment, and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work will be completed under the direction of the Architect/Engineer of Record, with input from the Contractor, equipment supplier, Owner and Commissioning Authority. Whereas all members will have input and the opportunity to discuss, debate, and work out problems, the Architect/Engineer of Record will have final jurisdiction on the necessary work to be done to achieve performance.
2. Corrective work shall be completed in a timely fashion to permit the timely completion of the commissioning process. Experimentation to render system performance will be permitted. If the Commissioning Authority/Owner deems the experimentation work to be ineffective or untimely as it relates to the commissioning process, the Commissioning Authority/Owner will notify the Architect/Engineer of Record indicating the nature of the problem, expected steps to be taken, and the deadline for completion of activities. If the deadline(s) passes without resolution of the problem, the Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner will be the Contractor's responsibility.

G. ADDITIONAL COMMISSIONING

1. Additional commissioning activities may be required after system adjustments, replacements, etc., are completed. The Contractor, suppliers, and Commissioning Authority shall include a reasonable reserve to complete this work as part of their standard contractual obligations.

H. SEASONAL COMMISSIONING AND OCCUPANCY VARIATIONS

1. Subsequent commissioning may be required under conditions of minimum and/or maximum occupancy or use. All equipment and systems affected by occupancy variations will be tested and commissioned at the minimum and peak loads to observe system performance. Each Contractor and supplier will be responsible to participate in the occupancy sensitive testing of systems to provide verification of adequate performance.

2. At 10 months into the warranty period, the Commissioning Authority and Owner will review the operation to date. The Contractors will be expected to be available to address any warranty related items that come out of this review.

I. TRAINING OF OWNER’S PERSONNEL

1. The Owner’s staff shall be given comprehensive training in the operation and maintenance of each major piece of equipment.

2. The Construction Manager in cooperation with the Commissioning Team, will be responsible for scheduling and actively participating in the training. A training plan is to be submitted to the Commissioning Authority for review prior to training being scheduled.

3. Hands on training shall include start-up, operation in all modes possible, shut-down and any emergency procedures.

4. The manufacturer’s representative shall provide the instructions on each major piece of equipment. These sessions shall use the printed installation, operation and maintenance instruction material included in the operation and maintenance manuals.
and shall include a review of the written operation and maintenance manuals. Training will be included for all major pieces of equipment. Equipment training shall be done by qualified service representatives employed by the manufacturers.

5. Contractor will be required to participate in the training of the Owner's engineering and maintenance staff for each mechanical system and the related components. Training may be conducted in a classroom setting, with system and component documentation, and suitable classroom training aids, or in the field with the specific equipment. The type of training will be per the Owner's option.

J. SYSTEMS DOCUMENTATION

1. In addition to the requirements of Division 1, update Contract Documents to incorporate field changes and revisions to system designs to account for actual constructed configurations. All drawings shall be red-lined on two sets. Division 26 as-built drawings shall include updated architectural floor plans, and the individual electrical systems in relation to actual building layout.

2. Maintain as-built red-lines on the job site as required in Division 1. Given the size and complexity of this project, red-lining of the drawings at completion of construction, based on memory of key personnel, is not satisfactory. Continuous and regular red-lining and/or posting of drawings is considered essential and mandatory.

K. NOTIFICATION OF SYSTEM COMPLETION AND REQUEST FOR FINAL ACCEPTANCE OF THE LIGHTING CONTROL SYSTEMS

1. When systems are ready for final acceptance, the Contractor shall certify to the Commissioning Team, in writing, that all systems are complete and fully functional.

2. Should the commissioning tests determine that the equipment is still not performing as specified or control operation is not acceptable on the second inspection, the time and expenses of the Commissioning Authority, Engineer of Record and Owner to make further verification shall be considered as additional cost of the Owner. The total sum of such costs shall be deducted from the final payment to the Electrical Contractor.

L. REPORT REQUIREMENTS

1. The Commissioning Authority shall document each Commissioning event with meeting minutes or a report. The documents shall separately list deficiencies observed or discovered during the event. The document shall be distributed to Commissioning Team members.

2. The Commissioning Authority shall prepare a final report to the Commissioning Team which will include a narrative in the form of an Executive Summary of the results of program, executed construction checklists/startup documentation,
executed functional test procedures, project reports, issues log and other pertinent documents.
26 20 00 - Low-Voltage Electrical Distribution

1. Introduction
   A. This section pertains to electrical systems under 600 volts, which are defined by the NEC as Low Voltage.
   B. This Construction and Design standard covers electrical systems and is to be used in conjunction with other related sections listed below:

      26 08 01  Electrical Equipment Acceptance Testing

2. References
   A. NFPA 70 National Electrical Code
   B. General Electrical Requirements

3. Design Standards
   A. Primary Electrical Distribution
      1. The primary electric distribution system serving the campus is a private system, owned, operated and maintained by Duke University. The majority of the primary system is rated at 12,470/7,200V. Several portions remain at 4,160/2,400V and are currently being phased out.

      2. All items associated with the design, demolition/installation and testing of all primary distribution components (i.e. switchgear, sectionalizing switches, transformers, manholes, ductbanks, cable pulls, cable terminations, cable splices, etc.) shall be performed by the Duke Utility & Engineering Services (DUES) High Voltage Department.

      3. The Engineer of Record shall coordinate the project requirements with the High Voltage Engineer via the Project Manager for specific information concerning the detailed scope of work to be provided under the contract documents. The selection of the transformer shall be approved by the Project Manager prior to the material purchase by the DUES High Voltage department.

      4. The placement of equipment and the routing of all ductbanks associated with the project shall be coordinated with the DUES Master Plan, the High Voltage Engineer and the Project Manager.

      5. Schedule all utility interruptions via the Project Manager. At minimum, the High Voltage Engineer shall be notified in writing seven (7) days prior to the requested timeframe so that the utility interruptions can be scheduled and all concerned parties
can be notified. Overtime, if required by the schedule, shall be at the expense of the Contractor.

B. Service Entrance(s)

1. Service entrance(s), less than 600V, serving the campus facilities are owned, operated and maintained by Duke University; but, are typically designed by an Engineer of Record and installed by a Contractor.

2. The type of service is determined by the load type and the need for reliability (e.g. dual feed arrangements are required for all research facilities, animal facilities, central utility plants, data centers and specified large departmental facilities).

3. The dual feed arrangement is determined by site and facility conditions. Typically, when a dual feed arrangement is required, the services terminate in load break switches in combination with a unit substation switchgear assembly inside the facility. Both the switches and the switchgear shall have a main-tie-tie-main configuration.

4. Service(s) shall be 480/277V or 208/120V three-phase, four-wire with ground, unless otherwise approved by DUES. Consideration shall be given to a 480V service with interior step-down dry-type transformers for loads greater than 500kVA.

5. Provide all service entrance conductors and ductbank assemblies.

6. The routing and entrance location of all ductbank assemblies associated with the facility shall be coordinated all other utility service entrances.

7. Provide secondary lugs for the termination of the service entrance conductors to transformer secondary spades. Lugs shall be rated and sized appropriately for the service entrance. DUES High Voltage Department shall terminate conductors.

8. Generator service entrance conductors and all ductbank and distribution assemblies shall be separated based on their load type (as defined by NEC).

9. Kirk key interlocks shall be provided between the tie switches/breakers and their corresponding main switches/breakers.

10. The Engineer of Record shall specify that the Contractor provide and maintain a temporary electrical distribution system for all needs during construction. Temporary service(s) shall be separately metered. The Contractor shall be responsible for payment for energy used.

C. Electrical Distribution(s)

1. Electrical distribution systems shall be 480/277V or 208/120V three-phase, four-wire with ground, unless otherwise approved by DUES.
2. Switchboards and panelboards shall be located in protected areas dedicated for the use of electrical distribution. Switchboards and panelboards shall not be located in janitorial closets, storage rooms, in any unprotected area or area where devices may impede access to the panel.

3. Sprinkler Systems in rooms containing electrical service equipment, switchboards, and/or medium voltage equipment: In lieu of a sprinkler system, electrical equipment shall be installed in a 2-hour fire-rated room with smoke detection as allowed in NFPA13. This enclosure shall: be dedicated to electrical equipment only, use only dry-type electrical equipment, and provide only non-combustible storage in the space.

4. Electrical distribution and panel arrangement shall separate lighting loads from receptacle loads. Partial renovations/additions to existing facilities shall make attempt to separate lighting loads from receptacle loads as much as possible. Electrical distribution from generator systems shall be separated based on their load type (as defined by NEC).

5. Lay out and arrange distribution components to minimize the distances of branch circuit homeruns.

6. Lay out and arrange distribution components to provide access and enable future renovations or additions. Components shall be capable of replacement without damage to equipment or building.

7. Lay out and arrange distribution components to limit single points of failure for entire mechanical systems during outages or during maintenance.

8. All breakers, fuses and distribution equipment shall have interrupting ratings at least 1.25 times the available fault current as determined by the fault current analysis. Coordinate all relays, breakers, fuses and other over-current protective devices in order to protect the electrical equipment from damage and to isolate the fault to the smallest possible portion of the distribution system.

9. Coordinate locations of all recessed panels to enable future access. Stub-up a number of empty 3/4 inch conduit equal to the sum of spare breakers and spaces (but no fewer than 10) into accessible ceiling space or space designated to be ceiling space in the future.

4. Documentation and Review Requirements

A. Provide detailed site plan that clearly indicates the routing of all ductbank(s). Provide an elevation that clearly indicates the service entrance penetrations into the facility.

B. Provide detailed one-line and riser diagrams (as applicable) for all electrical equipment.
C. Provide scaled floorplans that clearly indicate the location of all equipment and the required clearances.

D. Provide mounting details for an elevated low voltage distribution transformer

E. The Engineer of Record shall provide an arc-flash study for all electrical equipment within new facilities. For existing facilities where an arc-flash study has been performed, the Engineer of Record shall update the existing system model to encompass the project scope of work. For existing facilities where an arc-flash study has not been performed, the Engineer of Record shall perform a fault and coordination study to the depth needed to assure that the specified devices will properly and safely interrupt faults, overloads and that the system is properly coordinated. The available fault current values for service(s) shall be derived from the primary electrical distribution system study. Contact DUES High Voltage Department for this information. See Section 26 05 76 – Arc-Flash Study for full study requirements.

5. Installation and Performance Requirements

A. Provide lugs for Duke DUES High Voltage to terminate secondary cables.

B. Do not mix 277/480V and 120/208V conductors in the same raceway, pullbox or junction box except where control wiring is different voltage than power.

6. As-Built Requirements

A. Provide arc-flash study that reflects the as-built field conditions within the input data and includes a short circuit analysis, a time-current curve coordination and calculations of the incident energy available at each piece of electrical equipment. See Section 26 05 76 – Arc-Flash Study for full study requirements.

B. Provide evidence of proper coordination for all over-current current protective devices. Include plots of coordination curves and a one-line diagram to identify each element.
28 31 00 – Fire Detection and Alarm System

1. **Audible Alarms**
   
   A. Audible emergency alarms shall produce a sound that exceeds the prevailing equivalent sound level in the room or space by at least 15 dBA or exceeds any maximum sound level with a duration of 60 seconds by 5 dBA (whichever is louder). Sound levels for alarm signals shall not exceed 120 dBA.

2. **Visual Alarms**
   
   A. At a minimum, visual signal appliances shall be provided in buildings and facilities in each of the following areas: toilets, hallways, lobbies, meeting rooms, breakrooms, areas designated for public use, common use and general usage areas. Visual alarm signal appliances shall be integrated into the building or facility alarm system. Visual alarm signals shall have the following minimum photometric and location features:

   1. The lamp shall be a xenon strobe type or equivalent.
   2. The lens color shall be clear or nominal white (i.e. unfiltered or clear filtered white light).
   3. The maximum pulse duration shall be 0.2 sec with a maximum duty cycle of 40 per cent. The pulse duration is defined as the time interval between initial and final points of 10 per cent of maximum signal.
   4. The intensity shall be a minimum of 75 candela.
   5. The flash rate shall be a minimum of 1 Hz and a maximum of 3 Hz.
   6. The appliance shall be placed 80 inches above the highest floor level or within the space of 6 inches below the ceiling (whichever is lower).
   7. In general, no place in any room or space required to have a visual signal appliance shall be more than 50 feet from the signal in the horizontal plane. In large rooms and spaces exceeding 100 feet across without obstructions 6 feet above the finished floor (such as auditoriums), devices may be placed around the perimeter and spaced a maximum of 100 feet apart (in lieu of suspending appliances from the ceiling).
   8. No place in common corridors or hallways in which visual alarm signaling appliances are required, shall be more than 50 feet from the signal.

   B. When visual alarms are in place, the signal shall be visible from all areas of the unit or room. Instructions for use of the auxiliary alarm or receptacle shall be provided.
3. **Auxiliary Alarms**

   A. All residential rooms shall be equipped with either:

   1. A visual alarm connected (hard-wired) to the building emergency alarm system or
   2. A standard 120V electrical receptacle dedicated for connection of an auxiliary alarm. Provision of an auxiliary alarm must include any signaling/triggering system required so that the building emergency alarm will activate all auxiliary alarms.

4. **Manual Pull Stations**

   A. Manual pull stations shall be mounted at locations as specified in NFPA 72, but at a height such that the actuation device is not more than 48 inches above the finished floor.
33 11 00 – Water Utility Distribution Piping

1. Introduction

A. Duke University owns and operates the water distribution system throughout the campus boundaries; however, water is supplied by the City of Durham. Durham has two main water supply sources to the distribution system, Lake Michie and the Little River.

B. Campus water distribution systems will be designed in accordance with master plans developed by the Duke Utilities and Engineering Services (DUES) department.

C. Planning for utility requirements to support projects must start in the programming stages to insure the work is coordinated with ongoing projects and there is adequate capacity to support the project.

D. All proposed water system modifications and extensions shall be coordinated with the Duke Utilities and Engineering Services (DUES) department.

2. References

A. Materials and operations shall comply with the latest revision of the Codes and Standards listed:

1. AASHTO - American Association of State Highway Transportation Officials
2. ANSI - American National Standards Institute
3. AREA - American Railway Engineers Association
4. ASTM - American Society for Testing and Materials
5. AWWA - American Water Works Association
6. CISPI - Cast Iron Soil Pipe Institute
7. FS - Federal Specifications
8. SDS - Material Safety Data Sheets
9. NFPA - National Fire Protection Association
10. UL - Underwriter's Laboratories
11. City of Durham: Water and Sewer Construction Specifications

3. Water Distribution Piping Design
A. Project team’s civil engineer shall schedule an initial meeting with Duke Utilities and Engineering Services to review project utility requirements and design guidelines during the early stages of design.

B. Refer to Section 5.0 of the City of Durham’s "Reference guide for Development" for City requirements for pipe material and pressure requirements.

C. Pressure

1. Water mains shall be sized to provide a minimum system pressure of 20-pounds per square inch (psi) during peak system demands plus fire demand.

2. A booster pump may be needed to assure adequate pressure.

3. Peak system demands are described as follows:
   a. The peak domestic demand plus
   b. The Fire Protection System (sprinkler) demand plus
   c. The fire flow demand (campus fire flow demand is 2000-gpm) is the demand for any hydrant on the project. Minimum residual pressure of 20-psi shall be available at all points in the distribution system during peak system demands.

4. A Fire Flow Report is required by the City of Durham for all projects containing a proposed hydrant. Submit request to DUES for hydrant flow testing. Only qualified Duke Personnel are allowed to conduct hydrant flow testing.

5. All water main, services and appurtenances shall be shown on the drawings and coordinated with all other proposed utilities, improvements (e.g., walls, handicap ramps) and proposed landscaping. All water main piping and components and services shall be accessible for operation and maintenance and eventual replacement.

6. Encasements are required for bored crossings and railroad right of way. See City of Durham sizing table for carrier pipes and casing pipes for bored crossings.

7. Water mains shall be flushed, pressure tested and disinfected prior to connection to the University’s system, conforming to the City of Durham’s specification. Pressure tests will be performed at 200 psi for duration of 2 hours.

D. Alignment

1. Water mains shall be designed with a minimum of 3 feet of cover to finished grade or 2 feet below subgrade, whichever is greater.

2. Parallel Installations: 10-ft lateral separation (pipe edge to pipe edge) or minimum 3-ft lateral separation, and water line at least 18-inches above sanitary sewer line measured vertically from top of sewer pipeline to bottom edge of water main. In
some cases where the sanitary sewer and the water main are installed with at least 3-feet of lateral separation but less than 10-feet of horizontal separation, and less than 18-inches of vertical separation, both the water main and sanitary sewer shall be constructed of ductile iron pipe with joints in full compliance of these standards. Water mains shall have a minimum clearance of 18-inches feet horizontal from any other underground pipe.

3. Crossings (Water Main Over Sewer): At a minimum, 18-inches of clearance shall be maintained between the bottom edge of the water main and the top edge of the sewer main. If 18-inches of clearance are not maintained, the water main and sanitary sewer main shall both be constructed of ductile iron pipe with joints in conformance with water main construction standards. The sanitary sewer shall be ductile iron the entire run from manhole to manhole. When the separation between pipelines is 18-inches or less, the void space between the pipes shall be filled with minimum 500-psi, quick setting, non-excavatable, flowable fill extending 3-feet on both sides of the crossing. Regardless of pipe material, at least 12-inches of vertical separation is required for both sanitary and/or storm sewer crossings of potable water mains.

4. Valves shall be installed on all branches from feeder mains and hydrants. Provide 4 valves at all crosses. Provide 3 way valve arrangement at all tees on mains and service connections.

4. Materials

A. All water piping size 4” and above shall be ductile iron pipe. All services less than 4” and less shall be copper tubing.

B. Distribution Mains shall be ductile iron pipe complying with requirements of ANSI / AWWA C-151. Thickness class shall be 51 for 4 inch to 6-inch diameter and Class 50 for 6 inch up to 24-inch diameter.

C. Ductile Iron Pipe:

1. Ductile Iron pipe shall be designed and manufactured in accordance with AWWA C150 and C151 and provided in nominal 18-feet or 20-feet lengths. The manufacturer shall be AMERICAN Ductile Iron Flex-Ring® Joint Pipe or pre-approved equivalent. Pipe mortar lining shall comply with AWWA C104, double thickness.

2. Pipe joints shall be mechanical joint or push-on type as per AWWA C111. Pipe lining shall be cement mortar with a seal coat of bituminous material in accordance with AWWA C104. All buried ductile iron pipe shall have a bituminous exterior coating in accordance with AWWA C151.

3. Pipe Class shall be 350 and comply with AWWA C151. Bituminous coating shall comply with AWWA C110. Cement Mortar Lining shall comply with AWWA C104, double thickness.
D. Ductile Iron Fittings:

1. All ductile iron fittings shall be mechanical joint with MEGALUG style restraints and provided in conformance with AWWA C110 for standard ductile iron fittings and AWWA C153 for compact ductile iron fittings.

2. All fittings shall be pressure rated for a minimum 350-psi through 24-inches in diameter and 250-psi for fittings greater than 24-inches in diameter.

3. All fittings for potable water service shall be provided with cement mortar linings and asphaltic seal coats in accordance with AWWA C104.

4. All ductile iron fittings shall have an asphaltic exterior coating in accordance with AWWA C151.

5. All DI fittings shall be provided with mechanical joint end connections and restrained with standard blocking and rodding or wedge action retainer glands.

E. Restrained Joint Ductile Iron Pipe:

1. Restrained joint ductile iron pipe unless otherwise specified shall be of the boltless restrained joint type as assembled with a steel flexible ring that locks into position inside the bell of the connecting pipe. The locking rings shall be one-piece construction. For installations requiring welded locking rings, the rings shall be factory welded. The restrained joints shall provide a minimum of 4-degrees of deflection for pipe sizes, 4-inches through 12-inches in diameter.

2. All proprietary pipe restraint systems shall be approved by DUES and provided in compliance with all standards for coatings, linings, pressure classes, etc. as required for ductile iron pipe. All restrained joint pipe shall be installed based on laying conditions, pressure class, etc. as required for typical ductile iron pipe. Approved manufactures are SIGMA Corporation ONE-LOK Series SLDE for Ductile Iron Pipe and EBAA Iron Series 1100 MEGALUG Mechanical Joint Restraint for Ductile Iron Pipe or pre-approved equivalent.

F. Copper Tubing:

1. Copper tubing shall be Type K, hard drawn temper and comply with ASTM B88.

2. Press fitting shall comply with ASME B16.18, cast copper or ASME B16.22, wrought copper. Viega ProPress fitting or approved equivalent.

3. Joints shall be compression connection.

4. Sealing Element shall be Ethylene-propylene-diene-monomer (EPDM)

5. Installation
A. Ductile iron pipe shall be installed in accordance with the requirements of AWWA C600 and the Ductile Iron Pipe Handbook published by the Ductile Iron Pipe Research Association. Materials at all times shall be handled with mechanical equipment or in such a manner to protect them from damage. At no time shall pipe and fittings be dropped or pushed into ditches.

B. Pipe and fitting interiors shall be protected from foreign matter and shall be inspected for damage and defects prior to installation. In the event foreign matter is present in pipe and fittings, it shall be removed before installation. Open ends of pipe shall be plugged or capped when pipe laying is not in progress.

C. All water pipe shall be constructed with at least 36 inches of cover below the finished surface grade. Pipe shall be laid on true lines as directed by the Engineer. Trenches shall be sufficiently wide to adjust the alignment. Bell holes shall be dug at each joint to permit proper joint assembly. The pipe shall be laid and adjusted so that the alignment with the next succeeding joint will be centered in the joint and the entire pipeline will be in continuous alignment both horizontally and vertically. Pipe joints shall be fitted so that a thoroughly watertight joint will result. All joints will be made in conformance with the manufacturer’s recommendations for the type of joint selected. DUES shall approve all transition joints between different pipe materials. All transition joints between different types of pipe shall be made with transition couplings approved on shop drawings showing the complete assembly to scale.

D. Pipe shall be installed at laying conditions as specified by the plans. Laying conditions for ductile iron pipe shall be as described in AWWA C151 and the Ductile Iron Pipe Research Association. Laying conditions shall be defined as follows:

1. Type 1: Flat Bottom Trench with Pipe Resting on Stable Undisturbed Earth. Unstable conditions such as wet trench bottoms, intermediate rock layering, partially weathered rock, and other unsuitable soil conditions shall require utilizing more stringent laying conditions. At a minimum, Type 4 laying condition shall be utilized with a minimum of 4-inches of bedding to overcome unstable conditions. For severe unstable soil conditions, undercut excavation and an engineer designed foundation plan shall be provided prior to pipeline installation.

2. Type 4: Pipe bedded in Class 1 material, No. 67 or No. 78 crushed stone to a depth of 1/8 pipe diameter or a minimum of 4-inches. Embedment material, consisting of Class 1, Class 2 or Class 3 materials, shall be compacted greater than 95% Proctor to the top of the pipe. Careful attention must be allocated to compacting embedment material under the bottom edges of the pipe.

3. Type 5: Pipe bedded in Class 1 material, No. 67 or No. 78 crushed stone to the center of the pipe and extending a minimum of 4-inches under the pipe. Granular or select embedment, consisting of Class 1 or Class 2 materials, compacted to greater than 95% Proctor installed to the top of the pipe.

E. Prior to beginning construction, the Contractor shall comply with all provisions set by the Duke University Excavation Program. Please refer to the following link for additional information: http://fmd.duke.edu/construction/excavation_files/index.php
F. Please contact Duke FMD prior to operating any waterline valves. All valves within campus proper shall be operated only by Duke Personnel. Contractor’s personnel shall only be responsible for operating valves within new construction areas that are not directly connected with the existing distribution system.

6. Fire Protection

A. Fire Hydrants

1. Location


   b. Fire Hydrants shall be located so that they shall be installed on a 6-inch branch line and shall be equipped with a gate valve for isolation purposes. The hydrant isolation valve shall be located directly adjacent to the water main and shall be inside the pavement when possible.

   c. Hydrants shall be oriented so that large diameter connection faces fire apparatus access.

   d. Hydrants shall be no closer than 10-feet from the PC or PT of any intersection, including driveways.

   e. Hydrants are to be placed 18-inches to back of curb

   f. Fire hydrants shall be located at each street intersection

   g. Maximum spacing between hydrants shall not exceed 500-feet. The hydrant spacing distance shall be the horizontal distance as measured along the centerline of the street.

   h. Phased projects shall be designed such that there guidelines are met during each phase and after completion of the project.

   i. Hydrants shall be situated at locations which enable fire apparatus to pass other fire apparatus which have stopped to connect to the hydrant (driveway width 20-feet minimum).

   j. A hydrant shall be installed no less than 6-feet nor more than 50-feet (lineal) from any and all Fire Department Connections (FDC).

   k. Landscape plantings (when fully grown) or other vertical projections greater than 6-inches in height shall not encroach upon any fire hydrant within a 3-foot radius and not obscure view of hydrant upon approach.

   l. Hydrants shall be located a minimum of 40-feet from any building walls.
m. Hydrants shall be situated to enable fire equipment to first pass a fire hydrant before reaching any structure or hazard associated with a site.

2. Materials

a. All hydrants shall be of the City of Durham established standards.

b. Fire Hydrants shall be of the safety flange, breakaway top type and shall meet requirements of AWWA C-502, "AWWA Standard for Dry - Barrel Fire Hydrants."

c. Hydrants shall have a barrel diameter no smaller than 7 inches, a hydrant valve diameter no smaller than 5 inches, and shall be equipped with two 2 ½ inch hose nozzles and one 4 ½ inch pumper connection. All hydrants shall be equipped with a Storz connection. All hydrants shall be Mueller or American Darling or approved equal by DUES.

d. Hose and pumper outlet threads shall match local fire department equipment.

B. Fire Department Connections (FDC)

1. The fittings, typically associated with a sprinkler/standpipe system within a building, shall be located no closer than 6-feet or greater than 50-lineal feet of a fire hydrant. In all instances, these fittings shall be located on the same side of the travel lane. Both hydrant and connection shall be accessible along the roadway fronting the building or along the roadway approaching the building.

2. All FDC’s shall be installed to such that the low point in the line is located at the FDC. This will eliminate additional ball drip valves for draining the pipe system.

3. Contact Fire Department for requirements for buildings with standpipe systems.

7. Valves

A. Type

1. DUES requires valve box for all valves.

2. Gate valves

a. Shall be used up to and including 16-inch diameter water lines.

b. Gate valves sizes 3" through 12" shall have non-rising stem and shall meet requirements of AWWA C-500 or C-509.

c. Gate Valves shall be at least 200-psi working.

d. Valve ends shall be compatible with piping systems in which they are installed.

e. All valves shall have cast iron bodies and bronze stems.
f. Gate valves shall have O-ring seals and shall open counterclockwise.

3. Valves shall be in accordance with the North Carolina Fire Prevention Code. Post indicator valves (PIV), located 40-feet from building walls when possible, shall be installed unless other valve arrangements are approved by the Fire Official.

4. Valve Boxes:
   a. The valve box frames and covers shall conform to the City of Durham Standard.
   b. Valve boxes shall be adjustable cast iron of the three - piece type, consisting of lid, two piece sliding extension, and base.
   c. Base shall be proper type and size for the valve with which it is used.
   d. The word “WATER” shall be cast or embossed on the valve box lid in letters not less than 1 inch high.

B. Locations
   1. Each intersection of water mains shall have a main line valve installed.

C. Tapping Sleeves
   1. Wet Taps/Saddle Taps are not permitted unless given written permission from Duke Utility and Engineering Services (DUES).
   2. A City of Durham Engineering Division Inspector is to be present at all taps to water mains prior to the tap being made unless other arrangements have been made with the City Inspector.
   3. Same size taps are only allowed on an 8-inch line and smaller. Any larger same size connection requires installing a tee and valve(s).
   4. If a tapping valve is 12-inch or larger, the valve and the tapping sleeve are to be located within one manhole. Cut in tees with sleeves are required for 12-inch by 12-inch same size taps or larger.

D. Blow-offs
   1. Blow-offs shall be installed on all dead end mains and at elevated points along the water main. A 1-inch blow off assembly shall be installed on all dead end mains 8-inch or less in diameter and a 2-inch blow-off assembly shall be installed on all dead end mains greater than 8-inches in diameter. Fire hydrants are not considered as blow-offs.

E. Services and Meters
   1. Services:
a. Service pipe less than 4” shall be type K wall hard drawn copper.

b. Joints shall be made with flared type brass fittings.

c. Service pipe larger than 2” shall be 4” ductile iron water main.

d. Main line tap for service connection is not permitted by DUES. All service connections shall be cut in.

2. Meters:

a. Water meters shall be manufactured by Neptune with E-coder type technology with Tricon S pulsing transmitter.

b. Water meters shall be sized accordingly to flow variations. Positive Displacement Meters shall be installed at low flow levels. Compound Meters are preferred at high flow levels.

8. General Requirements

A. Concrete for Reaction Anchors shall have 3,000-psi strength at twenty-eight days and shall meet requirements of ASTM C-94.

B. Sleeves through concrete or masonry walls or slabs shall be either cast iron or galvanized, schedule 40 steel.

C. Pipe to Sleeve Sealant shall be either grouting compound or mechanical type seal.

D. Grouting Compound shall have 80 psi tensile strength and 700 percent elongation in accordance with ASTM D-3574 Test E, and linear dimension change shall not exceed 18 percent when subject to wet and dry cycles in accordance with ASTM D756, G, and D-1042.

9. Building Entry Requirements

A. DIP piping shall enter the building below slab with a mega-lug restrained gland at the elbow below slab and pre-manufactured flanged end entering the building mechanical space. DUES does not allow Uni-flanged type installation into the mechanical space.

B. Copper pipe entering building shall be rodded with a minimum of 2 threaded rods.
33 19 00 – District Thermal Energy and Water Utility Metering

A. GENERAL

1. Duke FMD Utilities & Engineering Services operates district energy and water systems to provide power, heating, and cooling utilities to University & Health System campus facilities. The metering applications listed below and the resultant data are critical to the successful operation, maintenance, and sustainability goals of the campus, and as such, are critical to building design.

2. The district energy and water utility metering equipment listed in this guideline are the only devices currently approved by Duke University FMD for use in existing and new construction. Any variance in design, hardware, or equipment, other than those provided in this guideline must be approved by Duke University FMD.

3. For all applications, designers should take care not to oversize hardware based on extreme operating conditions or unnecessarily conservative load calculations; rather, selecting metering hardware that meets the normal minimum and maximum loads anticipated by the facility through a normal operating year. Under no circumstances will Duke FMD accept “line-sizing” as a justification for meter hardware selection.

4. Refer to the following Design & Construction Standard sections for reference, as needed:
   a. 22 05 09 - Meters and Gauges for Plumbing
   b. 23 61 00 – Chilled Water Systems
   c. A33 63 00 – Steam Energy Distribution

B. METER APPLICATIONS

1. District Chilled Water
   a. Design & Installation
      a. Main supply and return main chilled water piping connections should be provided with flow, pressure, and temperature transmitters for accurate utility metering.
      b. In certain applications, to be discussed with Duke FMD staff, district chilled water supplied to process equipment should be provided with flow, pressure, and temperature transmitters for submetering of loads.
      c. All energy calculations and conversion should be done in the building automation system software, derived from the below specified hardware for flow, pressure, and temperature measurement. No standalone “flow computer” hardware should be specified.
d. All flow meters and temperature sensors must be installed in locations that can be regularly accessed from floor level, without the aid of a ladder or lift.

b. Hardware

a. Flow: Siemens Sitrans Ultrasonic flow meter model # FST020 (supply & return), provided with transducer set appropriate to pipe size. Provide switch to isolate 120V power locally for meter replacement.

b. Temperature: Reotemp 100ohm RTD assembly, 30-90F range (supply & return)

c. Automated Isolation Valving: Bray Model S70, 4-20mA modulating w/analog position feedback (supply & return). Provide switch to isolate 120V power locally for actuator replacement.

d. Pressure: Setra C206, pressure sensor, 0-200psi range (supply & return)

e. All utility metering hardware should be installed in locations and orientations that allow personnel simple access to calibrate, maintain, and replace these devices.

c. Data Acquisition and BAS Integration

a. District Chilled Water meters and associated transmitter hardware are to be connected to the Siemens building automation system. Designers, contractors, and integrators should discuss data capture intervals, specific BAS programming coding requirements, and long-term data storage requirements with Duke FMD staff.

2. District Hot Water

a. Design & Installation

a. Main supply and return main chilled water piping connections should be provided with flow, pressure, and temperature transmitters for accurate utility metering.

b. In certain applications, to be discussed with Duke FMD staff, district hot water supplied to process equipment should be provided with flow, pressure, and temperature transmitters for submetering of loads.

c. All energy calculations and conversion should be done in the building automation system, derived from the below specified hardware for flow, pressure, and temperature measurement. No standalone “flow computer” hardware should be specified.

d. All flow meters and temperature sensors must be installed in locations that can be regularly accessed from floor level, without the aid of a ladder or lift.
b. Hardware

a. Flow: Siemens Sitrans Ultrasonic flow meter model # FST020 (supply & return), provided with transducer set appropriate to pipe size. Provide switch to isolate 120V power locally for meter replacement.

b. Temperature: Reotemp 100ohm RTD assembly, 30-90F range (supply & return)

c. Automated Isolation Valving: Bray Model S70, 4-20mA modulating w/analog position feedback (supply & return). Provide switch to isolate 120V power locally for actuator replacement.

d. Pressure: Setra C206, pressure sensor, 0-200psi range (supply & return)

e. All utility metering hardware should be installed in locations and orientations that allow personnel simple access to calibrate, maintain, and replace these devices.

c. Data Acquisition and BAS Integration

d. Data Acquisition and BAS Integration

a. District Hot Water meters and associated transmitter hardware are to be connected to the Siemens building automation system. Designers, contractors, and integrators should discuss data capture intervals, specific BAS programming coding requirements, and long-term data storage requirements with Duke FMD staff.

3. Domestic Water

a. Design & Installation

a. For water utility connections falling within the Duke University FMD-owned utility system, all domestic water metering equipment should be installed within building mechanical rooms, as close as possible to piping entrance, backflow preventers, and isolation valves.

b. For facilities connected to the Durham water utility, domestic water metering equipment should be installed per direction from the City of Durham Water Management Department. Typically, this will be an in-ground vault external to the building footprint.

c. Designers should provide metering equipment for the main water service entering the building, and design any irrigation systems such that irrigation water can be submetered from a single take-off point.

d. Domestic water connected to fire protection services is not typically metered.
e. All metering devices must be installed in locations that can be regularly accessed from floor level, without the aid of a ladder or lift.

b. Hardware

a. Duke University owned metering, installed inside building mechanical rooms

(1) For water connections carried with less than 2” nominal pipe size, use Neptune T-10 positive-displacement nutating disc type meter equipped with TRICON/S pulse-output transmitter register. Provide with analog dial face, measuring in units of cubic feet.

(2) For water connections carried with 2” and greater nominal pipe size, use Neptune Tru/Flo compound/dual-register meter equipped with TRICON/S pulse output transmitters. Provide each register with analog dial face, measuring in units of cubic feet.

b. Duke University owned metering, installed outside connected to City of Durham water utility

(1) For water connections carried in 2” and less nominal pipe size, use Neptune T-10 positive-displacement nutating disc type meter, “pit-set” version equipped with R900 “ecoder” option for remote data collection. Provide with analog dial face, measuring in units of cubic feet, and remote antenna kit for mounting in the meter vault lid.

(2) For water connections carried in greater than 2” nominal pipe size, use Neptune Tru/Flo compound/dual-register meter equipped with R900 “eCoder” option for remote data collection. Provide each register with analog dial face, measuring in units of cubic feet, and remove antenna kit for mounting in the meter vault lid.

c. Data Acquisition & BAS Integration

a. Meters equipped with Neptune TRICON/S pulse-output transmitter(s) should be connected to the Siemens building automation system prior to energizing water services. Designers, contractors, and integrators should discuss data capture intervals, specific BAS programming coding requirements, and long-term data storage requirements with Duke FMD staff.

b. Meters equipped with Neptune R900 “eCoder” AMR transmitters should be integrated with FMD maintained Neptune software prior to energizing water services.
4. District Steam and Condensate
   a. Design & Installation
      a. Main district steam supply piping connections to campus buildings should be
         metered.
      b. In certain but atypical applications, to be discussed with Duke FMD staff, district
         steam utility should be metered.
      c. In certain applications, to be discussed with Duke FMD staff, district steam
         supplied to process equipment should be provided with flow, pressure, and
         temperature transmitters for submetering of loads.
      d. All energy calculations and conversion should be done in the building automation
         system, derived from the below specified hardware for flow, pressure, and
         temperature measurement. No standalone “flow computer” hardware should be
         specified.
      e. All metering devices must be installed in locations that can be regularly accessed
         from floor level, without the aid of a ladder or lift.

   b. Hardware
      a. Piping 2” NPS and larger: Veris Accelabar differential pressure flow meter, single
         transmitter option
      b. For horizontal installation arrangements, provide with integral transmitter port
         valves and direct mount transmitter
      c. For vertical (upward flow) installation arrangements, provide with integral port
         valves and remote mount transmitter kit
      d. For all material and installation requirements for steam systems, refer to sections
         33 61 00 Steam Energy Distribution Metering, and 40 10 00 Building Steam
         and Condensate Systems

   c. Data Acquisition and BAS Integration
      a. District steam meters and associated transmitter hardware are to be connected
         to the Siemens building automation system. Designers, contractors, and
         integrators should discuss data capture intervals, specific BAS programming
         coding requirements, and long-term data storage requirements with Duke FMD
         staff.
5. Energy meters – see section 23 09 23 13 Energy Meters

C. METER INSTALLATION

1. Campus Hot and Cold Water

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CHILLED & HEATING WATER BUILDING CONNECTION DETAIL
NOT TO SCALE
2. Domestic & Irrigation Water - interior

3. District Steam – Refer to A336300 Steam Energy Distribution for additional details.
33 30 00 – SANITARY SEWER DISTRIBUTION

1. INTRODUCTION

A. Duke University owns and operates the sewer distribution throughout campus boundary. Duke does not own City of Durham mains that provide service to non-Duke facilities.

B. Campus sewer distribution systems will be designed in accordance with master plans developed by the Duke Utilities and Engineering Services (DUES) department.

C. Planning for utility requirements to support projects must start in the programming stages to insure the work is coordinated with ongoing projects and there is adequate capacity to support the project.

D. All proposed sewer system modifications and extensions shall be coordinated with the Duke Utilities and Engineering Services (DUES) department.

2. REFERENCES

A. Materials and operations shall comply with the latest revision of the Codes and Standards listed:

- AASHTO: American Association of State Highway and Transportation Officials
- ACI: American Concrete Institute
- ACPA: American Concrete Pipe Association
- ASTM: American Society for Testing and Materials
- AWWA: American Water Works Association
- BIA: Brick Institute of America
- CRSI: Concrete Reinforcing Steel Institute
- FS: Federal Specifications
- NCMA: National Concrete Masonry Association
- NCPI: National Clay Pipe Institute
- ANSI: American National Standards Institute
- SDS: Material Safety Data Sheets
- UL: Underwriter’s Laboratories
- COD: Reference Guide for Development

3. PRODUCT DELIVERY, STORAGE AND HANDLING

A. Inspect materials thoroughly upon arrival. Examine materials for damage. Remove damaged or rejected materials from site.

B. Observe manufacturer’s directions for delivery and storage of materials and accessories.

C. Protect pipe coating during handling using methods recommended by the manufacturer. Use of bare cables, chains, hooks, metal bars or narrow skids in contact with coated pipe is not permitted.
D. Prevent damages to pipe during transit. Repair abrasions, scars and blemishes. If repair of satisfactory quality cannot be achieved, replace damaged material immediately.

E. Construct piping to accurate lines and grades and support as required on drawings or described in specifications. When temporary supports are used, ensure that sufficient rigidity is provided to prevent shifting or distortion of pipe. Install expansion devices as necessary to allow expansions and contraction movements.

F. Check bells and spigots closely for smoothness, roundness, and honeycombing (concrete pipe), which may be a source of infiltration. Check for cracks, chips, etc. on both ends. Reject any pipe that will not provide watertight seal or otherwise is structurally deficient.

4. DUCTILE IRON SANITARY SEWER PIPE AND FITTINGS
   A. Ductile iron pipe shall be Grade 60-42-10 and manufactured in accordance with all applicable requirements of AWWA C151/ANSI A21.51 and ASTM A746, Standard Specification for Ductile Iron Gravity Sewer Pipe for 8-inch and larger diameter pipe, pressure class rated, 350 psi minimum. The thickness of Ductile Iron Pipe shall be determined by considering trench load in accordance with ANSI C150 and AWWA A21.50. (Public Sewers shall be no less than 8-inch diameter).
   1. Interior Lining
      a. The ductile iron pipe shall be cement mortar lined with a seal coat in accordance with ANSI/AWWA C-104/21.4. Outside coat shall be a minimum of 1 mil bituminous paint according to ANSI/AWWA C151/A21.21 Section 51-8.1. Duke University does not require ceramic epoxy lining on private sewer distribution; however if the sanitary line is owned by the City of Durham, then piping specification should be consistent with Section 33.31.13 of the City of Durham specification.

   B. Each joint of ductile iron pipe shall be hydrostatically tested, before the outside coating and inside lining are applied, at the point of manufacturer to 500 psi. Testing may be performed prior to machining bell and spigot. Failure of ductile iron pipe shall be defined as any rupture or leakage of the pipe wall.

   C. All materials used in production of the pipe are to be tested in accordance with AWWA C151 for their adequacy within the design of the pipe, and certified test results are to be provided to the City upon request. All certified tests, hydrostatic and material, are to be performed by an independent testing laboratory at the expense of the pipe manufacturer.

   D. Joints:
      1. Pipe joints may be either push-on or mechanical joint pipe sizes 8 inches through 48 inches in diameter. Rubber Gasket Joints and Mechanical Joints shall comply with AWWA C111/ANSI A21.11. Acceptable pipe joints are as follows:
         a. Push-On Joints: Push-On Joint, Ductile Iron Pipe shall conform to AWWA C151/ANSI A21.51 Ductile-Iron Pipe, Centrifugally Cast, for Water("Fastite," or "Tyton,"). The dimensions of the bell, socket, and plain end shall be in accordance with the manufacturer’s standard design dimensions and tolerances. The gasket shall be of such size and shape to provide an adequate compressive force against the plain end and
socket after assembly to affect a positive seal. Gaskets to be American Amarillo Fast-Grip Gaskets (yellow) with high-strength stainless steel (for use with Fastite or Flex-Ring sockets); pipe sizes 6 inches through 30 inches and shall comply with AWWAC111/ANSI A21.11 Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings. The yellow color is to be inherent within the rubber; not attained by a surface coating.

b. Mechanical Joints: Mechanical joint pipe Ductile Iron Pipe shall be used only at specific location identified on the drawings or as approved by the City and shall meet AWWA C111/ANSI A21/11. The mechanical joint shall consist of:
   1) A bell cast integrally with the pipe or fitting and provided with an exterior flange having cored or drilled bolt holes and interior annular recesses for the sealing gasket and the spigot of the pipe or fitting;
   2) A pipe or fitting spigot;
   3) Mechanical Joint Gaskets to be plain rubber (Styrene Butadiene [SBR]) per AWWA C111/ANSI A21.11;
   4) Separate ductile iron follower gland having cored or drilled bolt holes; and
   6) The joint shall be designed to permit normal expansion, contraction, and deflection of the pipe or fitting while maintaining a leak proof joint connection.
   7) Bolts are to be torqued in accordance with the requirements of AWWA C600.

E. Fittings:
   1. AWWA C153 (compact) or AWWA C110, ductile iron full body fittings, Class 350 for 6” through 24” and Class 250 psi for pipe greater than 24” and less than 48” in diameter.

5. PVC SOLID WALL PIPE AND FITTINGS

A. ASTM D3034, Type PSM, Poly (Vinyl Chloride) (PVC) material, SDR 35 minimum; bell and spigot style rubber ring sealed gasket joint.

B. PVC Solid Wall Sewer Pipe (8 inches through 15 inches): PVC Solid Wall Sewer Gravity Pipe and Fittings, Bell and Spigot Joints shall comply with ASTM D3034, Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings, SDR 35 minimum (8 inches -15 inches). Pipe shall be made of PVC plastic having a cell classification of 12454 B or 12454 C or 12364 C or 13364 B, with a minimum tensile modulus of 500,000 psi as defined in ASTM D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds, and shall be appropriately marked. Laying lengths shall be a minimum of 12.5 feet for pipes 15 inches or less and 11 feet for the pipes greater than 15 inches.

PVC pipe strength shall be capable of withstanding stiffness, flattening, and impact test as scheduled or referenced in ASTM D3034 or ASTM F949. Smooth wall pipe shall have a Standard Dimension Ratio (SDR) of 35 or less. All PVC pipe shall have a minimum pipe stiffness of 46 psi when measured at 5 percent vertical ring deflection and tested in accordance with ASTM F477, Standard Specification for Elastomeric Seals (Gaskets) for
Joining Plastic Pipe. With the exception of services, PVC Fittings shall not be used with pipes 8 inches and larger in diameter.

C. PVC Gravity Pipe Joints: Joints for solid wall PVC sewer gravity pipe and fittings and elastomeric flexible seals (Gaskets) shall be compatible with pipe and shall meet the requirements of ASTM D3212 Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals. Rubber Gaskets shall be used which conform to the requirements of ASTM F477, Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

D. PVC Solid Wall Service Pipe (4-inch to 6-inch diameter): ASTM D1785, Minimum Schedule 40, Poly (Vinyl Chloride) (PVC) material; bell and spigot style solvent sealed joint ends.
   1. Fittings: ASTM D2466, PVC.

6. C900 PVC PIPE FOR GRAVITY SEWER AND FORCE MAINS (4-INCH THROUGH 12INCH):

A. C900 PVC gravity and pressure pipe, 4-inch through 12-inch, with bell end with gasket and spigot end shall comply with AWWA C900, Pressure Class 150, DR 18. Pipe shall also meet ASTM D2122, Standard Method of Determining Dimensions of Thermoplastic Pipe and Fittings, and ASTM D3139, Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals. Pipe shall have a bell with an integral wall section with a factory installed, solid cross section elastomeric ring in accordance with ASTM F477, Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

B. The pipe shall be extruded from Class 12454-A or 12454-B PVC compound as defined in ASTM D1784. Stress due to working pressure cannot exceed the HDBa (4000 psi) ÷ 2.5 safety factor (HDS = 1,600 psi). The pipe outside diameters shall conform to dimensions of Ductile Iron Pipe. All pipe furnished shall be in conformance with AWWA C900, latest revision.

C. The minimum pipe stiffness shall be 364 psi.

D. In accordance with ASTM D1599, Standard Test Method for Resistance to Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings, a minimum pipe burst of 755 psi shall be withstood without failure.

E. The pipe must be able to withstand an impact of 100 foot-pounds without visible evidence of shattering or splitting as specified in ASTM D2444, Standard Test Method for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight).

F. Pipe shall be homogenous throughout. It shall be free from voids, cracks, inclusion, and other defects. It shall be as uniform as commercially practical in color, density, and other physical properties. Pipe surfaces shall be free from nicks and scratches. Joining surfaces of spigots and joints shall be free from gouges and imperfections that could cause leakage.
G. Each length of pipe furnished shall bear identification marking that will remain legible after normal handling, storage, and installation. Markings shall be applied in a manner that will not weaken or damage the pipe. Markings shall be applied at intervals of not more than 5 feet on the pipe. The minimum required markings are given in the list below. Marking requirements shall be in conformance with AWWA C900.

1. Nominal Size and OD Base (e.g. 12CI)  
2. PVC  
3. Dimension Ratio (e.g., DR 18)  
4. AWWA pressure rating (e.g. PR 150)  
5. AWWA designation number (AWWA C900)  
6. Manufacturer’s name or trademark  
7. Manufacturer’s production code, including day, month, year, shift, plant, and extruder of manufacture.

H. C900 pressure pipe for force mains shall be used with ductile iron fittings (restrained joint).

7. PVC SOLID WALL PIPE AND FITTINGS


Joints for solid wall PVC sewer gravity pipe and fittings and elastomeric flexible seals (gaskets) shall be compatible with pipe and shall meet the requirements of ASTM D3212 Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals. Rubber gaskets shall be used which conform to the requirements of ASTM F477, Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

8. STEEL PIPE FOR ENCASEMENT, AERIAL CREEK CROSSINGS, BORING APPLICATIONS, AND VENT PIPES:

A. Pipe shall be unwrapped high strength steel, spiral welded or smooth-wall seamless manufactured in accordance with ASTM A139 Standard Specification for Electric-Fusion (Arc)-Welded Steel Pipe (NPS 4 and Over) and ASTM A283/283M Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates, Grade “B” steel with a minimum yield strength of 35,000 psi or ASTM A252 Standard Specification for Welded and Seamless Steel Pipe Piles, Grade 2 steel with a minimum yield strength of 35,000 psi. All encasement pipes shall meet the applicable NCDOT, Municipal, or AREA specifications but shall be no less than 6 inches larger than the outside diameter of the carrier pipe bell. The steel pipe shall be capable of withstanding the design load. Unless otherwise shown on the approved drawings, no interior lining and exterior coating shall be required except that all exposed metal is to be coated with epoxy or asphaltic material. The pipe shall have welded joints and be in at least 18-foot lengths.
1. Steel Encasement Pipe for Boring Applications: Encasement pipe shall meet applicable NCDOT and AREA specifications. Casing pipe shall include pipe carriers (spiders) to support carrier pipe (interior of pipe to be uncoated).
   a. Casing Wall Thickness: Refer to City of Durham Standard Detail C07.01 for standard wall thickness based on diameter and location (i.e. highway, rail).
   b. Steel Casing End Seals: Casing end seals shall be 8-inch thick brick masonry with a 1-inch diameter weep hole constructed as shown on City of Durham Standard Detail C07.01.
      1) Band and Risers:
      2) Band: 14 gauge T-304 Stainless Steel; 8 or 12 inches. Interior surface of circular stainless steel band.
      3) Riser: 10-gauge T-304 Stainless Steel. All risers shall be welded to band by MIG welding. All welds shall be passivated.
      4) Band width requirements to be determined by weight, pipe and fluid and spacing.
      5) Band Spacing, unless otherwise noted on plans: 1 to 2 feet from each end of bell joint and one placed every 7 to 9 feet thereafter; 3 per pipe 18-foot pipe joint.
      6) Liner – Elastomeric PVC per ASTM D149 or extruded EPDM
      7) Skids/Runners: Abrasion resistant runners attached to band. Glass reinforced nylon or Ultra High Molecular weight (UHMW) polyethylene per ASTM D638. Ends of Skids/runners to be beveled to facilitate installation over rough weld beads or welded ends of misaligned or deformed casing pipe.
      8) Fasteners: Type 304 stainless steel per ASTM A193.
      9) See City of Durham Standard Detail C07.01 for spacing/location of spiders.

2. Steel Pipe for Aerial Creek Crossings (without encasement and carrier pipe): The outside of the pipe shall have one coat of zinc chromate primer conforming to Federal Specification TT-P-1757 and afterwards painted with coal-tar enamel.

3. Rail Applications: Encasement for rail applications, encasement pipe to be coal tar coated, lined, and wrapped except, if permitted by Rail agency, the interior shall be left unlined to permit ease of carrier pipe/spider installation.


B. Carrier pipe shall be mechanical joint or restrained joint ductile iron pipe of the class indicated on the drawings but no less than pressure class 250 psi.

9. SEWER MAIN WYES, SADDLES AND COUPLING CONNECTION

A. In-line wye with Schedule 40 connection (gasketed main or glued service) with GPK Repair Coupling PVC SDR 35, GXG; as manufactured by GPK Products, Inc. or an approved equal.

B. Saddle: 45 degree SDR 35 Type PSM PVC Saddle wye meeting ASTM D3034 and ASTM F1336, as manufactured by GPK Products, Inc. or an approved equal.

C. Poured concrete collars are not permitted.

D. Flexible couplings are not permitted.
33 40 00 – Storm Drainage

1. Introduction

   A. Duke University is divided into the main areas of the Medical Center, West Campus, Central Campus, and East Campus. The University also includes the Washington Duke Inn and Golf Course, the Sarah P. Duke Gardens, Duke Forest, and the Lemur Center.

   B. The University campus is in both the Cape Fear and Neuse River Basins. In the Cape Fear, the main branches flow to Sandy Creek and Mud Creek generally to the southwest. In the Neuse River Basin, the campus area drains to unnamed tributaries to Ellerbe Creek. No areas of the Duke Campus are within a watershed protection district for either Jordan Lake Reservoir or the Falls Lake Reservoir.

   C. Duke University is located within the City of Durham limits. A “UC Zoning” district has been established for the University. One requirement of this zoning district is that an overall campus Stormwater Impact Analysis (SIA) be developed and maintained for the University. The current SIA was submitted and approved by the City of Durham in 2004 and is currently updated for all development projects on campus.

   D. Three separate HEC-HMS models were run for the Duke University Campus SIA based on City of Durham requirements. All three HEC-HMS models use SCS unit hydrograph routing and the SCS curve number loss method. SCS model based on hydrologic soils and cover conditions and is modeled with HEC-HMS (Hydraulic Modeling System). Separate models are set up for water quantity and quality.

2. General Requirements and Process

   A. Project team’s civil engineer shall schedule an initial meeting with DUES to review project utility requirements and applicable design guidelines prior to preparing and submitting plans for budgeting or outside regulatory review.


   C. All existing and proposed storm drain pipes, system elements and drainage barriers shall be shown on the drawings and coordinated with all other proposed utilities and improvements and proposed landscaping. All components shall be accessible for operation and maintenance and eventual replacement.

   D. Calculations or computer modeling are required for new buildings or other projects that increase impervious surface area, for sizing storm drain systems and for evaluating the impact of site development on existing drainage patterns and facilities. Profiles of storm drainage piping including HGL calculations are required for all storm piping.

   E. Storm piping shall have a minimum vertical separation of 18-inches between all utilities crossings. Vertical separation between storm and sanitary shall be 24-inches when horizontal separation is 3 feet or less.
F. Stone for rip–rap shall be clean and essentially free of rock dust and fines, and shall consist of spalls passing a 5 inch sieve, Class I. The largest pieces shall have a volume of not more than 2 cu.ft.; no more than 10 percent of the total weight of rip–rap shall exceed maximum size. All rip rap materials have to be reviewed and approved by DUES.

G. Soil separator shall be Celanese Mirafi, 104N.

3. Quality Standards

A. Materials and operations to comply with the latest edition of Codes and Standards listed:

1. AASHTO - American Association of State Highway Transportation Officials
2. ACI - American Concrete Institute
3. ACPA - American Concrete Pipe Association
4. AISI - American Iron and Steel Institute
5. ASTM - American Society for Testing and Materials
6. BIA - Brick Institute of America
7. CRSI - Concrete Reinforcing Institute
8. FEMA - Federal Emergency Management Agency
9. FS - Federal Specifications
10. HEC - Hydraulic Engineering Center
11. NCMA - National Concrete Masonry Association
12. NCSPA - National Corrugated Steel Pipe Association

4. References

A. Current SIA document: Contact Duke Utility and Engineering Services (DUES) regarding questions related to the SIA document.

B. The following City of Durham links:

1. Most current City of Durham Reference Guide for Development
2. Most current City of Durham Stormwater Performance Standard
3. Most current City of Durham Stormwater Ordinance

C. Section 31 23 00 Trenching, Backfilling and Compaction of Utilities

5. Materials

A. Reinforced Concrete Pipe shall conform to ASTM C76, Latest Class III, IV & V, AASHTO M-170-Latest. Joints shall conform to ASTM C-443-Latest. Joints shall be sealed with a plastic cement putty meeting Federal Specification SS-S-00210, such as Ram-Nek or a butyl rubber sealant.

B. High Density Polyethylene (HDPE) Corrugated Pipe: Installation of HDPE pipe shall adhere to design criteria standards. Pipe material shall meet the product specifications of ASTM F667 and shall have a smooth interior. Pipe joints shall consist of an integral bell and spigot type joint with "O" ring rubber gasket meeting ASTM F477 placed on the spigot end. At least two (2) corrugations of the spigot end must insert in the bell end. Installation shall adhere to the specification of ASTM D2321 and certified by an engineer. HDPE pipe shall only be used in non-traffic loading areas.

C. Ductile Iron pipe shall be used in areas that do not meet minimum cover requirements with other utilities. The use of DIP will be determined on a project specific basis. Pipe joints, push on type utilizing rubber ring gasket, AWWA C111 (polyvinyl wrap).

D. PVC sewer pipe: ASTM D3033, Type PSP, SDR 35; or ASTM D3034, Type PSM, SDR 35 with PVC, ASTM D3033 or D3034, solvent cement joints complying with ASTM D2855 using solvent cement complying with ASTM D2564; or elastomeric joints complying with ASTM D3212 using elastomeric seals complying with ASTM F477. PVC pipe shall only be used in non-traffic loading areas. PVC is allowed provided the pipe meets the loading criteria of the application.

6. Structure Materials

A. Clay Brick shall be solid, rough, sound clay brick conforming to ASTM C32, Grade MS. The brick shall be laid with full shove joints, filling up the joints with mortar. The thickness of the joints shall not exceed 3/8 of an inch.

B. Concrete Block or brick shall be solid and conform to ASTM C139 as to design and manufacture. The block or brick shall be embedded in a mortar bed to form a 1/2 inch mortar joint.

C. Precast Concrete Manholes shall meet ASTM C478 as to design and manufacture. All manhole cones shall be the eccentric type. Joints shall be sealed with a plastic cement putty meeting Federal Specification SS-S-00210, such as Ram-Nek or a butyl rubber sealant.

D. Headwalls and Endwalls shall be constructed in accordance with NCDOT details, or precast concrete with wing walls and apron by an approved manufacturer. Installation of
precast headwalls and endwalls shall be in accordance with the manufacturer's recommendations.

E. Retention/Detention outlet structures shall be cast in-place or precast concrete.

F. Frame, Grate & Hood shall be cast iron and meet the ASTM requirements set forth in the latest edition of the NCDOT “Standard Specifications for Roads and Structures” and the dimensional requirements set forth in the latest edition of the NCDOT “Roadway Standard Drawings #840.03”. Grate shall be stamped with the NCDOT specification number as evidence of satisfying the above requirements. Frame shall be anchored to structure.

7. Installation

A. Minimum and Maximum: Minimum allowable slope shall provide flow velocities of at least 2.0 feet per second and maximum allowable slope shall provide flow velocities no greater than 10.0 feet per second during peak flow conditions.

B. Straight Alignment: All storm sewer mains shall be laid in a straight alignment between manholes.

C. Curvilinear Mains Prohibited: Curvilinear storm sewer mains shall not be allowed.

D. Pipe may enter through the corner of all structure material types except precast concrete "waffle" boxes.

E. The minimum cover for storm sewer pipe shall be 2 feet to finished subgrade under roads and 1 foot to finished grade in non-load-bearing areas.

F. Pipe shall not project into a drainage structure but shall be finished flush with the inside of the structure.

G. Catch basins between 5 and 20 feet in depth shall have minimum interior dimensions of 4 feet by 4 feet, and those over 20 feet in depth shall have minimum interior dimensions of 5 feet by 5 feet.

H. Each drainage structure shall have an invert constructed from concrete and shaped to conform with the pipe ID, and a bench with a maximum 5:1 slope. The bench shall begin at a height of one-half the pipe diameter for 12 to 24 inch pipe, one-third the pipe diameter for 30 to 48 inch pipe, and one-fourth the diameter for pipe greater than 48 inches in diameter. Precast headwalls and endwalls shall only be installed at single pipe culverts.

I. Each curb’s inlet must be installed such that the front wall is straight and aligned with the curb and gutter.

J. See section 31 23 00 Trenching, Backfilling and Compaction of Utilities for additional information.
8. **Inspection**

   A. Materials must be in good condition when delivered to site. Rejected materials shall be immediately removed from the job.

   B. Storm drain lines shall be clean and free from obstruction and shall be visually inspected from every structure or opening. Lines which do not exhibit a true line and grade or which have structural defects shall be corrected.

   C. All piping shall be video inspected and approved by FMD representative.

9. **Summary of Water Quality Requirements**

   A. Duke University is required to comply with the City of Durham Ordinance for water quality control.

   B. The analysis points for the water quality model were defined where stormwater enters the stream buffer.

   C. Water Quality is based on the proposed project boundary. Coordinate with FMD for site boundary requirements. See table 1 below for performance criteria.

   D. Effective Date for Nitrogen Control means March 9, 2001 for that portion of campus in the Neuse River Basin, and March 17, 2009 for Cape Fear Basin.

   E. Effective Date for Phosphorous Control means June 15, 2010 for that portion of campus in the Neuse River Basin and the Cape Fear Basin.

   F. Duke has a water quality “credit” bank and is seeking potential water quality credits for regional treatment facilities. Consultants should coordinate with DUES Stormwater Engineer during the early phases of the project to determine potential credit availability.

10. **Summary of Water Quantity Requirements**

    A. Volume and peak discharge control requirements are based from the campus SIA. The SIA detention model is an SCS curve number model.

    B. The cover conditions for each sub-basin were calculated based on soil type and overlying condition. This cover condition establishes the CN number for each sub-basin. The baseline for the campus “Land Use Cover Conditions” is 1997 conditions and will not change in relation to the SIA.

    C. Each project on campus is analyzed for changes in the CN calculation. If no change to the CN is calculated, then no further analysis is required. If the CN value “flips”, then
further analysis is needed at the analysis point. Coordinate with DUES representative regarding CN analysis.

D. Analysis points are identified across campus at points where stormwater leaves campus.

E. Peak Flow Rate Detention Requirements are as follows: (Only if CN value “flips”)

1. Two and Ten Year Storms. Land disturbance that increases the peak runoff rate from either the 2-year or the 10-year storm may be required to install BMPs to address the impact. The Two and Ten year storms to be controlled to predevelopment (1997 cover conditions) flow rates. Analysis points where stormwater leave’s Duke’s property.

2. One Year Storm. Development may not increase the post-development peak runoff rate from the one-year storm over the pre-development (2009 in Cape Fear Basin and 2001 in Neuse River Basin) peak runoff rate. If the post-development peak runoff rate does increase, stormwater management facilities shall be provided such that there is no net increase. Analysis points where stormwater enters a stream section (streams defined by quad and/or soils map). Existing sub-basins may require further sub-dividing.

3. Other Design Storms. In certain circumstances (i.e. when there are existing flooding concerns, potential to flood existing structures, etc.), Development that increases the peak runoff from other design storms such as the 100-year storm may be required to install BMPs to address the impact, as determined in accordance with standards of the City’s Engineering and Stormwater Division.
33 61 00 – Chilled Water Distribution

1. Introduction

   A. Campus chilled water leaves the central chilled water plants at 40°F with pressures up to 125 psi and is returned to the chilled water plants at 56°F.

   B. Campus chilled water distribution systems will be designed in accordance with master plans developed by the Duke Utilities and Engineering Services (DUES) Department.

   C. Planning for utility requirements to support projects must start in the programming stages to ensure the work is coordinated with ongoing projects and there is adequate capacity to support the project.

   D. All proposed system modifications and extensions shall be coordinated with the DUES Department. Final approval of any system modifications and extensions require the final review and approval of the Chilled Water Systems Manager.

2. References

   A. AWWA Standards

3. Design Standards

   A. Buried piping systems shall withstand HS-20 highway loading with 3 feet of compacted backfill over top of conduit. Mark each section of buried conduit with fabricator’s name, product identification and publications to which the items conform. Provide each section of carrier pipe including factory-applied insulation and conduit, with waterproof conduit ends at both ends of each section of carrier pipe, except for piping systems which have the field joints insulated and covered with waterproof shrink sleeves.

   B. End Seals: Each length of pre-insulated pipe shall be fitted with a watertight mastic end seal at jacket and pipe surfaces. All field cuts to be sealed with a field applied end seal. For non-insulated joints, the end seal shall have certification from an independent testing laboratory that all have been tested and certified to be watertight. Testing shall be by means of 20 feet of head pressure over the entire surface for a minimum of 48 hours.

   C. Considerations in developing pipe routing:

      1. Hydraulic analysis will be performed by DUES appointed engineering firm.

      2. Proper locations of drain and fill assemblies shall be identified to allow for the complete drainage of the campus chilled water distribution system in its entirety.

      3. Determine if there is a need for redundant points of service.
D. Provide factory pre-insulated piping system with HDPE (high density polyethylene) outer jacket for all underground chilled water distribution supply piping (return piping is not insulated or jacketed).

   a. Pipe, fittings, flanges and couplings shall be marked with manufacturer's name, product identification and publication to which items conform.

2. Insulation: Provide polyurethane foam with a minimum K factor of 0.13 and a density of 2 pcf. Closed cell content to be 90-95% in conformance with MIL-I-24172 completely filling the annular space between the carrier pipe and jacketing.

3. Jacket Pipe: Outer casing shall be polyethylene of 80-mil minimum thickness. Fiberglass jacketing is not allowed and is not considered to be an equal. All jackets shall be polyethylene NO EXCEPTIONS.

4. Fittings: Provide uninsulated fittings conforming to AWWA C110 or AWWA CL II that are furnished by the contractor and approved by the pre-insulated pipe manufacturer.

5. Restraints: All fittings shall be provided with “Megalug” torque type restraints. Pressure test and approve piping joints.
   a. Mechanical joint restraint shall be incorporated into the design of the follower gland. The restraining mechanism shall consist of individually actuated wedges that increase their resistance to pull-out pressure as pressure or external forces increase. The device shall be capable of full mechanical joint deflection during assembly and the flexibility of the joint shall be maintained after burial.
   b. The joint restraint ring and its wedging components shall be made of grade 60-42-10 ductile iron conforming to ASTM A536-84.
   c. The wedges shall be heat-treated to a minimum hardness of 370 BHN.
   d. Dimensions of the gland shall be such that it can be used with the standardized mechanical joint bell fitting conforming to ANSI/AWWA C111 /A21.11 and ANSI/AWWA C153/A21.53 of the latest revision.
   e. Torque limiting twist-off nuts shall be used to insure proper actuation of the restraining wedges.
   f. The mechanical joint restraint shall be available in the three through forty-eight inch sizes.
g. They shall have a rated working pressure of 350 psi in sizes sixteen inch and smaller and 250 psi in sizes eighteen inch through forty-eight inch.

h. The devices shall be listed by UL up through twenty-four inch and approved by Factory Mutual up through twelve-inch size.

i. Restrained joint: Restrained type joint gasket assembly rated up to 250 psi conforming to ANSI/AWWAC111/A21.11 standard. All gaskets shall be similar to U.S. Pipe FIELD LOK Gasket. Stainless steel locking segment vulcanized into the gasket.

6. Chilled Water Valves: System isolation valves shall be buried service valves. All valves shall be high pressure rated and capable of bubble tight shutoff capacity of 150-psig differential pressure in either direction.

4. Documentation and Review Requirements
   A. Provide manufacturer’s pre-insulated piping catalog data showing thermal properties for pipe, fittings and end connections.

5. Installation and Performance Requirements
   A. Duke University is registered with the State of North Carolina’s “One-Call System.” All contractors, prior to excavation on any University project, shall contact North Carolina One-Call System at 800-632-4949.

   B. Buried piping systems shall withstand HS-20 highway loading with no less than 3 feet of compacted backfill over top of conduit.

   C. Utility contractor shall extend chilled water piping inside building envelope to a blind-flanged connection. This shall be a factory made flanged pipe, not field installed “uni-flange.”

   D. Upon completion of the project, Chilled water piping requires spiral washing and witnessed hydro-testing to a minimum of 200 psig for 2 hours.

6. Manufacturers and Basis of Design
   A. To establish a level of quality for performance comparisons, the following are considered the basis of design and approved equals for conduit systems:

      a. Basis of design: ROVANCO ductile iron system insulated by Thermacor Process Ltd.

   B. To establish a level of quality for performance comparisons, the following are considered the basis of design and approved equals for torque type restraints:
a. Basis of design: Megalug Series 1100 as manufactured by EBBA Iron Sales, Inc.

b. Field LOK gasket as manufactured by U.S. Pipe.

C. Ductile Iron Pipe:
   a. U.S. Pipe
   b. Tyler Pipe
   c. HARCO, Inc.
   d. American Ductile
   e. Grinnell

7. **Buried Warning and Identification Tape Requirements**

   A. Provide detectable aluminum foil plastic backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried piping. Tape shall be detectable by an electronic detection instrument. Provide tape in rolls, 3 inches minimum width, color coded for the utility involved with warning and identification imprinted in bold black letters continuously and repeatedly over entire tape length. Warning and identification shall read “CAUTION BURIED PREINSULATED WATER PIPING BELOW” or similar wording. Use permanent code and letter coloring unaffected by moisture and other substances contained in trench backfill material.
33 63 00 - Underground Steam and Condensate Distribution System

1. Introduction

A. Steam is distributed to University and Medical Center buildings through an underground piping system year-round at a nominal 125 psig. Both West and East Campus (Buildings 7754 & 7254) plants will supply the same piping system to west, central, and east campuses. The majority of campus high-pressure steam (HPS) distribution and condensate return piping is direct-buried, with manhole access. The remainder of the piping is accessible via full-height tunnel.

B. Designers should coordinate with and Duke Utilities & Engineering Services (DUES) on all phases of projects requiring steam and condensate utility service. These projects may include, but are not limited to: a) efforts requiring new underground steam and condensate utility distribution piping, b) changes to the existing piping, or c) removal of existing piping. Designers are expected to share and review any project data, load calculations, and site condition evaluations.

2. References

A. ASME Power Piping Code, B31.1
B. ASME Building Services Piping Code, B31.9
C. ASME Pipe and Fittings Codes, B16
D. Duke Standard Details
   1. Duke Steam Vault
   2. Duke Steam Pit Entry
   3. Duke Standard Steam Connections

3. Design Standards

A. All steam and condensate system designs must take into account energy efficiency, reliability, serviceability, operational functionality, and life-safety issues, such that the University may fully and accurately evaluate the project.

B. Detailed documentation regarding as-built conditions of the site is required. This may include underground utility elevation profiles, analysis of systems to which connections will be made, and locations of existing utilities that may be disturbed. Additionally, existing conditions of surface expressions, landscaping features, and trees should also be recorded.
C. Distribution Piping

1. Steam and condensate piping should be routed in the most efficient manner allowable, such that maximum loading per linear-foot of pipe may be achieved.

2. Steam and condensate system should include valving appropriate for required isolation of branch and main lines.

3. Piping should be routed to avoid trees, foundation walls/footings, roads, pedestrian access ways, railroad tracks, and paths of ingress and egress around buildings where possible.

4. Steam and condensate distribution must be designed as “three-pipe” system: steam delivery, pressurized condensate return, and pumped condensate return piping must be utilized. High-pressure condensate from main drip trap stations must not be returned to any pumped condensate piping. If installation of a high-pressure condensate line is not feasible, discharge from steam trap stations should be piped to the nearest building flash tank/condensate receiver.

5. Where steam and condensate piping are run in accessible tunnels, pipe insulation to be flexible aerogel type 3, grade 1 blanketing with aluminum jacketing. Non-ferrous wire or straps should be used to secure jacketing.

6. Where steam and condensate piping are direct-buried, piping must be of pre-insulated, three-layer piping system. System must include a carrier pipe, steel conduit, and impermeable outer membrane. Designer should select insulation layers appropriate to the project. Thermacor Duo-Therm “505” or equivalent is acceptable.

7. Steam piping to be Schedule 40 carbon (black) steel, ASTM A106, all welded construction. 300-pound rated fittings to be used throughout.

8. Condensate piping to be Schedule 80 carbon (black) steel, ASTM A106, all welded construction. Schedule 80 fittings to be used throughout.

9. Where possible, all steam and condensate piping should be installed in a manner that allows gravity return of condensate.

10. Acceptable methods of pipe thermal expansion compensation are U-bend “expansion loops” and metal bellows-type mechanical expansion joints. No other methods should be used.

11. Condensate collection pockets (“drip legs”) should be placed in steam piping at intervals no greater than 300 feet, AND at steam pipe elevation changes. Drip leg piping should be full line-size in distribution piping up to 6-inch NPS, and at least one-half the nominal diameter for all piping over 6-inches in diameter, but not less than 6 inches in diameter. Drip legs should be 12-18 inches long (unless space...
conditions prohibit), and should include steam trap stations. Drip legs and steam trap stations must be accessible via manhole.

12. All take-offs intended as a future connection(s) shall be equipped with isolation valves and terminated with caps. A spool piece equipped with a 3/4” blowdown valve shall be installed between the isolation valve and cap in the spool piece.

D. Valves

1. Isolation valves shall be gate valves constructed from cast or wrought steel. Internal trim must be stainless steel. Triple offset high performance butterfly valves may be used where space is limited however will be approved on a case by case basis by system owner. In cases where triple offset high performance butterfly valves are used. Triple offset high performance butterfly valves must be capable of bi-directional flow and zero bubble per minute shut off.

2. All steam and condensate distribution isolation valves shall be butt welded or socket welded construction. First valve take-off from a main shall be located as close to the main as possible and be located preferably in the horizontal orientation. Drain valves shall be installed where piping slopes to the valve to aid in removal of collected condensate during shut downs.

3. Drain valves shall be ANSI Class 800, carbon steel, socket weld connection. Drains shall terminate with caps on end. Drain piping shall be positioned to discharge directly on the floor (should not drain on any piping, valves, equipment, etc.).

E. Steam Traps

1. All steam traps must be installed with upstream isolation valve and strainer with blowdown valve, downstream spring assisted in-line check and isolation valves, and unions on either side of the trap. Refer to Duke Standard Connections Detail for more details.

2. Steam trap preferences for high pressure distribution lines are as follows:
   a. First choice – Inverted-bucket traps
   b. Second choice – Thermodynamic (TD) traps.
   c. Third choice – should Duke ever require any high-pressure process equipment where steam/condensate is automatically controlled, float and thermostatic type traps should be used.

F. Manholes

1. Manholes must be at least 8 feet long, by 8 feet wide, by 8 feet tall in dimensions. Size must increase as required to allow adequate clearance around pipes, valves,
Manholes must be pour-in-place concrete, with waterproofed base slab and water seal at the key joint. Precast manholes are acceptable where necessary and require approval by DUES. Each manhole must have at least two openings, diagonally opposed. Where possible, manholes should be located to provide easy access from roads and sidewalks. Placement of manholes in delicate landscapes and extensive hardscapes should be avoided where possible.

2. Manholes must have a minimum 30-inch by 30-inch x 30-inch sump. Sump should drain by gravity to storm sewer system and be equipped with a back water valve to prevent backflow into manhole. Flood rim of storm structure outfall shall be evaluated prior to designing for gravity system. Sump placement shall be offset from MH ladders not directly under MH opening (refer to Duke Steam Vault Detail found in A33 63 00 for additional details). Ductile iron drainage pipe should be used for gravity drains. Where gravity drainage is not feasible, a high temperature sump pump shall be installed (refer Pumps and Pumping Systems in the Duke Design Guidelines for materials of construction and ratings). Sump pump discharge shall be 2” type K copper pipe inside vault and 4” ductile iron outside vault to storm sewer system.

3. Manholes must be provided with a welded steel ladder for entry and exit, anchored to the top, bottom, and side faces of the interior space. Ladders shall be located at each access point. Ladder steps shall not be welded to the side flat bar, but shall continue through the side flat bar and be welded on each side of the flat bar.

4. Two access points are required for each manhole. Access points shall be 36 inch and 24 inch in diameter and shall be preferably located diagonally across from each other. The 36 & 24 inch manhole cover shall be carbon fiber lockable covers with a minimum HS20 load rating. Fiber lids shall be reviewed and approved by DUES prior to construction. The lid shall include permanent engraving of the MH number and shall have STEAM identified on the lid. Manhole numbering shall be provided by DUES personnel.

G. Flushing & Testing

1. All field and shop welded piping for both steam and condensate shall be 100% radiograph tested by an approved third party testing agency. Welds shall be inspected in accordance with ASME B31.1 Power Piping code requirements.

2. If any welds are found to be defective, the weld must be cut out and re-welded. Repair of defective welds by adding weld material over the defect, or by peening shall not be permitted. Welders responsible for the defective welds shall be re-qualified before performing more welding on the job. Any failed weld shall be retested by radiograph at the contractor’s expense.

3. Hydrostatic testing is not required on steam or condensate piping but may be performed at the contractor’s discretion and expense. Condensate piping shall be
flushed with water prior to energizing. All direct buried steam piping shall be blown down with steam for final flushing. Contractors shall make provisions for blowing down steam system and shall include installing temporary piping to blowdown to atmosphere, vent silencers, etc. Temporary piping shall be steel and can be threaded. All blowdown procedures must be approved at least 2 weeks prior to performing blowdown with DUES. A blowdown will not be scheduled until project including a final inspection is performed.

4. Documentation and Review Requirements

A. Analysis of the steam distribution system should be considered in the Life Cycle Cost analysis required for project approval.

B. Provide finite-element analysis of pipe system prior to release for bid. Analysis may be performed by designer or by manufacturer of pipe system, but must identify locations of high stress in system. Designers should show calculations for pipe fluid velocities, thermal stress and expansion, heat energy losses and insulation selection.

5. Installation and Performance Requirements

A. Confirm installation responsibilities at outset of project. Installation services will be provided in-house or contracted out.

B. Coordinate all required tie-in points with DUES.

C. Coordinate all commissioning efforts with DUES.
33 63 00 - Underground Steam and Condensate Distribution System

1. Introduction

A. Steam is distributed to University and Medical Center buildings through an underground piping system year-round at a nominal 125 psig. Both West and East Campus (Buildings 7754 & 7254) plants will supply the same piping system to west, central, and east campuses. The majority of campus high-pressure steam distribution and condensate return piping is direct-buried, with manhole access. The remainder of the piping is accessible via full-height tunnel.

B. Designers should coordinate with and Duke Utilities & Engineering Services (DUES) on all phases of projects requiring steam and condensate utility service. These projects may include, but are not limited to: a) efforts requiring new underground steam and condensate utility distribution piping, b) changes to the existing piping, or c) removal of existing piping. Designers are expected to share and review any project data, load calculations, and site condition evaluations.

2. References

A. ASME Power Piping Code, B31.1
B. ASME Building Services Piping Code, B31.9
C. ASME Pipe and Fittings Codes, B16
D. Duke Standard Details
   1. Duke Steam Vault
   2. Duke Steam Pit Entry
   3. Duke Standard Steam Connections

3. Design Standards

A. All steam and condensate system designs must take into account energy efficiency, reliability, serviceability, operational functionality, and life-safety issues, such that the University may fully and accurately evaluate the project.

B. Detailed documentation regarding as-built conditions of site is required. This may include underground utility elevation profiles, analysis of systems to which connections will be made, and locations of existing utilities that may be disturbed. Additionally, existing conditions of surface expressions, landscaping features, and trees should also be recorded.
C. Distribution Piping

1. Steam and condensate piping should be routed in the most efficient manner allowable, such that maximum loading per linear-foot of pipe may be achieved.

2. Steam and condensate system should include valving appropriate for required isolation of branch and main lines.

3. Piping should be routed to avoid roads, pedestrian access ways, railroad tracks, and paths of ingress and egress around buildings where possible.

4. Steam and condensate distribution must be designed as “three-pipe” system: steam delivery, pressurized condensate return, and pumped condensate return piping must be utilized. High-pressure condensate from main drip trap stations must not be returned to any pumped condensate piping. If installation of a high-pressure condensate line is not feasible, discharge from steam trap stations should be piped to the nearest building flash tank/condensate receiver.

5. Where steam and condensate piping are run in accessible tunnels, pipe insulation to be calcium silicate with aluminum jacketing. Non-ferrous wire or straps should be used to secure jacketing.

6. Where steam and condensate piping are direct-buried, piping must be of pre-insulated, three-layer piping system. System must include a carrier pipe, steel conduit, and impermeable outer membrane. Designer should select insulation layers appropriate to the project. Thermacor Duo-Therm “505” or equivalent is acceptable.

7. Steam piping to be Schedule 40 carbon (black) steel, ASTM A106, all welded construction. 300-pound rated fittings to be used throughout.

8. Condensate piping to be Schedule 80 carbon (black) steel, ASTM A106, all welded construction. Schedule 80 fittings to be used throughout.

9. Where possible, all steam and condensate piping should be installed in a manner that allows gravity return of condensate.

10. Acceptable methods of pipe thermal expansion compensation are U-bend “expansion loops” and metal bellows-type mechanical expansion joints. No other methods should be used.

11. Condensate collection pockets (“drip legs”) should be placed in steam piping at intervals no greater than 300 feet, AND at steam pipe elevation changes. Drip leg piping should be full line-size in distribution piping up to 6-inch NPS, and at least one-half the nominal diameter for all piping over 6-inches in diameter, but not less than 6 inches in diameter. Drip legs should be 12-18 inches long (unless space conditions prohibit), and should include steam trap stations. Drip legs and steam trap stations must be accessible via manhole.
12. All take-offs intended as a future connection(s) shall be equipped with isolation valves and terminated with caps. A spool piece equipped with a 3/4” blow down valve shall be installed between the isolation valve and cap in the spool piece.

D. Valves

1. Isolation valves shall be gate valves constructed from cast or wrought steel. Internal trim must be stainless steel. Triple offset high performance butterfly valves may be used where space is limited however will be approved on a case by case basis. In cases where triple offset high performance butterfly valves are used, provide a warm up bypass line around the valve. Triple offset high performance butterfly valves must be capable of bi-directional flow and zero bubble per minute shut off.

2. All steam and condensate distribution isolation valves shall be butt welded or socket welded construction. First valve take-off from a main shall be located as close to the main as possible and be located preferably in the horizontal orientation. Drain valves shall be installed upstream of steam isolation valves where piping slopes to the valve permitting condensate to collect during shut downs.

3. Drain valves shall be ANSI Class 800, carbon steel, socket weld connection. Drains shall terminate with caps on end. Drain piping shall be positioned to discharge directly on the floor (should not drain on any piping, valves, equipment, etc.).

E. Steam Traps

1. All steam traps must be installed with upstream isolation valve and strainer with blowdown valve, downstream spring assisted in-line check and isolation valves, and unions on either side of the trap. Universal-type traps and connectors with integral strainer are preferred.

2. Steam trap preferences for high pressure distribution lines are as follows:
   a. First choice – Inverted-bucket traps
   b. Second choice – Thermodynamic (TD) traps.
   c. Third choice – should Duke ever require any high-pressure process equipment where steam/condensate is automatically controlled, float and thermostatic type traps should be used.

F. Manholes

1. Manholes must be at least 8 feet long, by 8 feet wide, by 8 feet tall in dimensions. Size must increase as required to allow adequate clearance around pipes, valves, equipment, etc. Manholes must be pour-in-place concrete, with waterproofed base slab and water seal at the key joint. Precast manholes are acceptable where necessary and require approval by Duke FMD. Each manhole must have at least
two openings, diagonally opposed. Where possible, manholes should be located to provide easy access from roads and sidewalks. Placement of manholes in delicate landscapes and extensive hardscapes should be avoided where possible.

2. Manholes must have a minimum 24-inch by 24-inch x 24-inch sump. Sump should drain by gravity to storm sewer system and be equipped with a back water valve to prevent backflow into manhole. Ductile iron drainage pipe should be used for gravity drains. Where gravity drainage is not feasible, a high temperature sump pump shall be installed (refer Pumps and Pumping Systems in the Duke Design Guidelines for materials of construction and ratings). Sump pump discharge shall be type K copper pipe to storm sewer system.

3. Manholes must be provided with a welded steel ladder for entry and exit, anchored to the top, bottom, and side faces of the interior space. Ladders shall be located at each access point. Ladder steps shall not be welded to the side flat bar, but shall continue through the side flat bar and be welded on each side of the flat bar.

4. Two access points are required for each manhole. Access points shall be 36” and 24” in diameter and shall be preferably located diagonally across from each other. Both manhole covers shall be ductile or cast iron. The lid shall have STEAM identified on the lid. Manhole numbering shall be provided by Duke FMD personnel.

G. Flushing & Testing

1. All field and shop welded piping for both steam and condensate shall be 100% radiograph tested by an approved third party testing agency. Welds shall be inspected in accordance with ASME B31.1 Power Piping code requirements.

2. If any welds are found to be defective, the weld must be cut out and re-welded. Repair of defective welds by adding weld material over the defect, or by peening shall not be permitted. Welders responsible for the defective welds shall be re-qualified before performing more welding on the job. Any failed weld shall be retested by radiograph at the contractor’s expense.

3. Hydrostatic testing is not required on steam or condensate piping but may be performed at the contractor’s discretion and expense. Condensate piping shall be flushed with water prior to energizing. All direct buried steam piping shall be blown down with steam for final flushing. Contractors shall make provisions for blowing down steam system and shall include installing temporary piping to blow down to atmosphere, vent silencers, etc. Temporary piping shall be steel and can be threaded. All blow down procedures must be approved at least 2 weeks prior to performing blowdown with FMD DUES. A blow down will not be scheduled until project including a final inspection is performed.

4. Documentation and Review Requirements
H. Analysis of the steam distribution system should be considered in the Life Cycle Cost analysis required for project approval.

Provide finite-element analysis of pipe system prior to release for bid. Analysis may be performed by designer or by manufacturer of pipe system, but must identify locations of high stress in system. Designers should show calculations for pipe fluid velocities, thermal stress and expansion, heat energy losses and insulation selection.

5. Installation and Performance Requirements

A. Confirm installation responsibilities at out-set of project. Installation services will be provided in-house or contracted out.

B. Coordinate all required tie-in points with DUES.

C. Coordinate all commissioning efforts with DUES.

6. As-Built Requirements

A. Designer must provide drawings showing all as-built piping, equipment, and manhole locations. Drawings must include final site plan layout and elevation profile, details of pertinent equipment (such as typical steam trap stations, manhole layouts, etc.), details of all building connection points, as well as anchorage points, cross-over/under of other utilities, obstructions, and other pertinent data. USGS coordinates for all major pipe intersections, elevation changes, and manhole locations are required.

B. Provide identifying list for all manholes. Coordinate with DUES for formatting and compliance with existing recordkeeping.

C. Provide identifying list for all valves. Coordinate with DUES for formatting and compliance with existing recordkeeping.

D. Provide identifying list for all steam traps. Coordinate with DUES for formatting and compliance with existing recordkeeping.
40 10 00 Building Steam & Condensate Systems

1. Introduction
   A. Medium Pressure and Low Pressure Steam are utilized exclusively inside building envelopes on the Duke University and Duke Medical Center campuses. Each building receives high-pressure steam from the campus distribution system, where it is automatically regulated down to a pressure suitable for building equipment. Typically, medium pressure service is utilized for process loading (washers, autoclaves, pressure-powered condensate pumps, etc.) and low-pressure service is utilized for HVAC purposes. For the purposes of this Standard, Medium Pressure Steam (MPS) refers to any systems operating between 75 psig – 16 psig, and Low Pressure Steam refers to systems operating at or below 15 psig. Medium Pressure Condensate (MPC) and Low Pressure Condensate (LPC) correspond to the same respective pressure ranges.
   B. Designers should coordinate with Duke Utilities & Engineering Services (DUES) on all phases of projects requiring steam and condensate utility service. These projects may include, but are not limited to: a) efforts requiring new steam piping and equipment b) changes to the existing piping, or c) removal of existing piping. Designers are expected to share and review any project data, load calculations, and site condition evaluations.

2. References
   A. ASME Building Services Piping Code, B31.9
   B. ASME Pipe and Fittings Codes, B16
   C. ASHRAE Standard 90.1 – 2007
   D. Duke Standard Details
      1. Duke Standard Steam Connections
      2. Duke Standard 2-Stage Pressure Reducing Valve (PRV) Station

3. Design Standards
   A. All steam and condensate system designs must take into account energy efficiency, reliability, serviceability, operational functionality, and life-safety issues, such that Duke may fully and accurately evaluate the project.
   B. Detailed documentation is required with regard to existing conditions. This may include, but is not limited to, documentation of existing steam-fired equipment, analysis of building steam loads, and evaluation of building distribution piping.
   C. Building Service Pressure Reduction
1. Where MPS is required or if the building requires less than 10 psig, high-pressure steam (HPS) must be reduced in pressure in two stages such that the first stage pressure-reducing valve provides MPS service, and the second stage provides LPS service.

2. If load diversity is 70% or less of designed peak load, utilize parallel valves sized at a 1/3 - 2/3 ratio of the peak load.

3. PRVs should be pilot-operated, cast iron body, class 250-rated body and connections.

4. Designers should NOT include bypass lines around PRV stations.

5. PRV stations must be designed with steam trapping at HPS, MPS, and LPS header piping.

6. PRV stations must utilize safety relief valves for each stage of pressure reduction. Relief vent piping must be piped to exterior. An intermediate (medium pressure) safety relief valve is not required if MPS does not serve equipment and is only used for intermediate reduction to LPS.

7. Safety Relief Valve piping must have no other equipment vent tie-ins.

D. Building Piping

<table>
<thead>
<tr>
<th>Service</th>
<th>Size</th>
<th>Fitting Connection</th>
<th>Pipe Connection</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Pressure Steam</td>
<td>2” and smaller</td>
<td>Socket Weld</td>
<td>Socket Weld</td>
<td>SCH 80, A106 Carbon Steel, Seamless</td>
</tr>
<tr>
<td></td>
<td>2-1/2” and larger</td>
<td>Butt Weld</td>
<td>Butt Weld</td>
<td>SCH 40, A106 Carbon Steel, Seamless</td>
</tr>
<tr>
<td>Medium Pressure Steam</td>
<td>2” and smaller</td>
<td>Threaded (NPT)</td>
<td>Socket Weld or Threaded (1” and smaller)</td>
<td>SCH 80, A106 Carbon Steel, Seamless</td>
</tr>
<tr>
<td></td>
<td>2-1/2” and larger</td>
<td>Class 150 Flange</td>
<td>Butt Weld</td>
<td>SCH 40, A106 Carbon Steel, Seamless</td>
</tr>
<tr>
<td>Low Pressure Steam</td>
<td>2” and smaller</td>
<td>Threaded (NPT)</td>
<td>Socket Weld or Threaded (1” and smaller)</td>
<td>SCH 80, A106 Carbon Steel, Seamless</td>
</tr>
<tr>
<td></td>
<td>2-1/2” and larger</td>
<td>Class 150 Flange</td>
<td>Butt Weld</td>
<td>SCH 40, A106 Carbon Steel, Seamless</td>
</tr>
<tr>
<td>High Pressure Condensate</td>
<td>2” and smaller</td>
<td>Socket Weld</td>
<td>Socket Weld</td>
<td>SCH 80, A106 Carbon Steel, Seamless</td>
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## Table: Condensate, Steam, and Continuous Vent Table

<table>
<thead>
<tr>
<th>Service</th>
<th>Size</th>
<th>Fitting Connection</th>
<th>Pipe Connection</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condensate</td>
<td>2-1/2&quot; and larger</td>
<td>Butt Weld</td>
<td>Butt Weld</td>
<td>SCH 80, A106 Carbon Steel, Seamless</td>
</tr>
<tr>
<td>Medium Pressure</td>
<td>2&quot; and smaller</td>
<td>Threaded (NPT)</td>
<td>Socket Weld or Threaded (1&quot; and smaller)</td>
<td>SCH 80, A106 Carbon Steel, Seamless</td>
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<td>Condensate</td>
<td>2-1/2&quot; and larger</td>
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<td>Condensate</td>
<td>2-1/2&quot; and larger</td>
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<td>SCH 80, A106 Carbon Steel, Seamless</td>
</tr>
<tr>
<td>Continuous Vent</td>
<td>2&quot; and smaller</td>
<td>Threaded (NPT)</td>
<td>Threaded</td>
<td>SCH 40, A 53 Gr. B Carbon Steel, Seamless</td>
</tr>
<tr>
<td>Continuous Vent</td>
<td>2-1/2&quot; and larger</td>
<td>Class 150 Flange</td>
<td>Butt Weld</td>
<td>SCH 40, A53Gr. B Carbon Steel, Seamless</td>
</tr>
<tr>
<td>Steam Relief Vent</td>
<td>2&quot; and smaller</td>
<td>Threaded (NPT)</td>
<td>Socket Weld or Threaded (1&quot; and smaller)</td>
<td>SCH 80, A106 Carbon Steel, Seamless</td>
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<td>Steam Relief Vent</td>
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<td>Class 150 Flange</td>
<td>Butt Weld</td>
<td>SCH 40, A106 Carbon Steel, Seamless</td>
</tr>
</tbody>
</table>

1. Steam and condensate piping should be routed in the most efficient manner allowable, such that maximum loading per linear-foot of pipe may be achieved.

2. Steam and condensate system should include valving appropriate for required isolation of branch and main lines. Isolation valves shall be located as close to main as possible and still provide accessibility.

3. Where possible, all steam and condensate piping should be installed in a manner that allows gravity return of condensate.

4. Building LPC and MPC piping should be routed to allow gravity drainage to appropriate flash vessels and/or condensate pumping equipment. Condensate return and pumped condensate flow paths must not intersect.

5. MPS, LPS, MPC, and LPC piping and fittings should be insulated. Insulation losses must meet current ASHRAE 90.1 standards for energy usage.
6. MPS and LPS piping to be Schedule 40 carbon (black) steel, ASTM A53B or A106. All welded construction. Class 150-rated fittings to be used. Notable exceptions include but are not limited to small bore piping with threaded connections. Welding requirements can be reviewed where necessary on a case by case basis.

7. Condensate piping to be Schedule 80 carbon (black) steel, all welded construction. Schedule 80 fittings to be used throughout. Threaded piping may be used under certain circumstances and must be approved by DUES prior to utilizing.

8. Acceptable methods of pipe thermal expansion compensation are U-bend “expansion loops” and externally pressurized metal bellows-type mechanical expansion joints. No other methods should be used.

9. Condensate collection pockets (“drip legs”) should be placed in steam piping at intervals no greater than 200 feet, AND at steam pipe elevation changes. Drip leg piping should be full line-size in distribution piping up to 6-inch NPS, and at least one-half the nominal diameter for all piping over 6-inch diameter, but not less than 6 inches in diameter. Drip legs should be 12-18 inches long (unless space conditions prohibit), and should include fully isolatable steam trap stations and blowdown valves.

E. Valves

1. Isolation valve bodies may be cast or wrought steel. Internal trim must be stainless steel. Valve must be rated for steam service.

2. Valves 2" diameter and below should use socket-weld connections. Piping greater than 2" diameter. Should be use butt-welded connections.

3. Automatic control valve bodies may be of steel, iron, or bronze construction. Valve must be rated for steam service.

F. Steam Traps

1. All steam trap assemblies shall be installed per Duke Standard Steam Trap Details found in A336300 Steam Energy Distribution appendix.

2. Steam trap preferences for medium-pressure lines are as follows:

   a. First choice – Thermodynamic (TD) traps

   b. Second Choice – Float and Thermostatic (F&T) traps – should be used primarily on medium pressure process equipment, HVAC equipment, or any other applications where steam/condensate flow is automatically controlled.

3. Low-pressure systems must use F&T type steam traps for all applications.

G. Flushing & Testing
1. Field and shop welded piping for both all steam and condensate shall be tested 10% or a minimum of 5, whichever is more by means of radiograph by an approved third party testing agency. Welds shall be inspected in accordance with ASME B31.1 Power Piping code requirements. All welds shall be selected by a DUES representative.

   a. If any welds are found to be defective, the weld must be cut out and re-welded. Repair of defective welds by adding weld material over the defect, or by peening shall not be permitted. Welders responsible for the defective welds shall be re-qualified before performing additional welding on the job. Any failed weld shall be retested by radiograph at the contractor’s expense.

      (1) For any welding failures, radiograph testing shall continue until 100% of 10% of remaining welds pass. Additional testing will be at the contractor’s expense.

      Example: Steam system has 50 welds, which 5 welds would be tested. One weld fails testing. The failed weld would be reworked and retested. The remaining 45 welds would be tested at 10%. An additional 5 welds would need to be tested and pass before the testing procedure would be complete. If another weld failed, the process repeats until 100% of the 10% of tested welds pass.

   b. Hydrostatic testing is required on steam or condensate piping inside the building. Hydrostatic test pressures shall be a 1-1/2 times operating pressure for 2 hours. Pressure test should be witnessed by engineer of record or a DUES representative.

      (1) All steam piping shall be blown down with steam from the distribution piping as a means for final flushing. Contractors shall make provisions for blowing down steam system and shall include installing temporary piping to blow down to atmosphere, vent silencers, etc. as required by FMD DUES. Temporary piping shall be carbon steel. Threaded connections are acceptable on all piping smaller than 2” for blowdown. All blow own procedures must be approved at least 2 weeks prior to performing blowdown with FMD DUES. A blow down will not be scheduled until project including a final inspection is performed.

      (2) Condensate piping shall be hydrostatically tested at pressure steam piping is tested and flushed prior to energizing.

4. **Documentation and Review Requirements**

   A. Analysis of the building MPS and LPS systems should be considered in the Life Cycle Cost analysis required for project approval.
B. Provide finite-element analysis of pipe system prior to release for bid. Analysis may be performed by designer or by manufacturer of pipe system, but must identify locations of high stress in system.

C. Provide estimated energy loss calculation for all distribution piping.
27 00 00 - Communication  
Facilities Construction Design Standards

1. Introduction

   A. Duke University has a multitude of voice, data, audio visual and security requirements that rely on a wiring infrastructure that is of quality design, reliable, and flexible, to meet the ever-changing demands of its educators, medical staff, and researchers.

   This document is designed to inform planners, architects, engineers, and contractors of the minimum infrastructure requirements of Duke University. These requirements must be met for all on-campus Duke University Facilities.

2. References

   A. ADA standards

   B. Appendix A270000 Communication contains plans or diagrams for

      1. Typical MDF Design
      2. TR Rack Elevations
      3. TR Rack Power Receptacle Options
      4. TR Voice Riser
      5. TR Outlet Labeling

3. Design Standards

   During the planning and implementation stages of any new facility or renovation, engineers and architects will come into contact with one or several representatives from Duke's communications service provider, Office of Information Technology (OIT). OIT is interested in providing a high quality, consistent infrastructure, and bring expertise to the complex world of communications at Duke.

   Renovation projects are quite different in nature from new construction and require very early consultation with an OIT representative. This early consultation will ensure all existing and future communications distribution system requirements are addressed.

   For ease of coordination, please contact an OIT analyst below. In turn, they will coordinate a team of communications engineers, technicians, and support personnel to meet the scope of the project. It is extremely important that a representative from OIT be contacted during the early planning stages to ensure all aspects of communications requirements are met.
The diversified communications options vary from building to building and require a great deal of planning. The team will work with the occupants, contractors, and project managers during the planning stages, and provide them with the space requirements for communications room(s), distribution design assistance/approval, and cost estimates.

For all University buildings, contact either of the following:

**Chet Sikes**, RCDD  
Communications Infrastructure Design and Engineering, OIT  
334 Blackwell St., Suite 2111  
Box 104111  
Durham, NC 27708-4111  
(919) 684-2045  
chet.sikes@duke.edu

**Dickson Clifford**  
Field Operations Manager, OIT  
334 Blackwell St., Suite 2111  
Box 104111  
Durham, NC 27708-4111  
(919) 613-6697  
dickson.clifford@duke.edu

A. Responsibilities

These standards apply to all Duke buildings irrespective of the funding source. OIT is responsible for supplying all voice, data and video backbone and horizontal cable. OIT will hire a telecommunication contractor to pull, terminate, label and test all cable. OIT will provide voice and data equipment and materials to up fit the telecommunications rooms.

The electrical contractor is responsible for the purchase and installation of the approved raceway system.

4. Building Communications Service Entrance

Every new University building must be tied into the existing underground conduit duct system for voice, data, and video communications.

A. Routing of Underground Conduit

All inter-building communications cabling on the Duke campus is installed in underground ducts encased in concrete. This duct system follows a master plan developed several years ago with the University Architect, and is placed in designated utility corridors. OIT is responsible for the design, installation, and budget of the underground duct system up to the manhole outside of a new building. During the design process, OIT will specify the route and building entrance location.

B. Number of Conduits Required

OIT will assist in developing the best size and number of conduits, to anticipate ultimate requirements for service and emergency needs. Construction drawings shall provide a minimum of four 4" conduits extending from a manhole (typically located 5'-0" outside the building) and terminating in the building's Telecommunications Entrance Room as described later in this document.
C. Conduit

Where the entrance conduits penetrate the foundation, footings, or outside walls of a building, rigid metallic conduit shall be used. Plaster fiber ducts or aluminum conduit are not acceptable. These conduits shall have a minimum of 2'-0" ground cover at the point of exit. A downward slope must be maintained to the manhole to prevent water from draining into the building.

D. Sealing Conduits

Seal all conduits inside the building to prevent rodents, water, or gases from entering the building.

E. Bends

Bends in conduit runs must not exceed 180° between manholes or other access points. The total number of bends in a conduit section run must not exceed two 90° bends or equivalent of sweeps and radius bends. All bends must be long, sweeping bends, with a radius not less than ten times the conduit's diameter. For example, a 4" conduit would have a minimum sweep of 40".

F. Pull Strings

Equip every conduit with a nylon line that has a minimum test rating of 200 pounds.

G. Building Feed Cables

Each building must have inter-building copper, and fiber to provide voice, data, and video services. Contact OIT for a cost estimate of the cable. OIT will also serve as contractor for the cable installation.

3. Main Distribution Frame (MDF) Room

The Main Distribution Frame (MDF) room serves as the demarcation point location for the building. It is the transitional point from the voice, data, and video building feed cables to intra-building backbone cable, which runs to each Intermediate Distribution Frame (IDF) room. The MDF contains electronic equipment and can double as the IDF room for the area of the building around it. Connecting conduit or raceway systems are required to ensure that the greatest distance from any telecommunications outlet to the nearest IDF does not exceed 295 linear feet or 90 linear meters.

See Appendix A270000 for more details on a Typical MDF design.

OIT will design and budget for the cable support system in each MDF and IDF according to minimum standards. These specifications will be included in the bid documents to the telecommunications contractor.
A. Location

1. General

The MDF room for each building is typically in the basement and must be located on a bearing wall, which reduces the possibility of relocating the room if the building is expanded or altered. Do not locate the MDF room in any place that may be subject to water infiltration due to flooding, steam infiltration, humidity from nearby water or steam, heat, or any other corrosive atmospheric or environmental conditions. Do not allow utilities except those serving the room to run above or in this room (for example, HVAC ducts, electrical service planes, plumbing lines [water, soil, or steam]).

2. Relation to IDF

Locate the MDF room in such a place as to provide a riser for all other IDF rooms in the building.

3. Electromagnetic Interference

Do not locate the MDF room near equipment that can cause electromagnetic interference (EMI). Keep electrical feeders and branch circuits of noisy equipment away from sensitive equipment and its associated circuits. Likely sources of EMI are heavy-duty electromechanical equipment (for example, copiers, door openers, and elevator systems).

B. Size

The MDF room must be a minimum of 150 sq. ft. (minimum width 10'), which provides a 32" clearance on each side of a loaded 19" equipment rack, on which power outlets are normally mounted. This room size will provide service to approximately 20,000 square feet of building.

C. Risers

Vertical cable risers make for ease of design, construction, and maintenance. Provide a riser with a minimum of four 4" conduits or sleeves to each communications room. The total number of conduits or sleeves depends on the number of floors in the building and on the number of tenants/outlets required in the building.

Architects and engineers shall include a single line riser diagram of all conduits as part of the construction documents and drawings. An OIT representative shall review the conduit sizes and details of this drawing.

1. Entrance to the MDF Room

Locate the riser entrance in a corner of the MDF room. Conduit or sleeves must extend far enough below the ceiling to permit installation of a bushing and cap. In the IDF room above, the conduit should extend a minimum of 3" above the finished floor.

Conduits entering the MDF room shall penetrate the room walls at no less than 8'-0" above the finished floor and extend one to two inches into the room with bushings.
The telecommunications contractor will provide and install overhead ladder racks to support the horizontal wire.

2. Riser Cable

The telecommunication contractor is responsible for determining the length of and pulling, all voice, data, and video communications cabling. This shall include:

- All intra-building backbone cable for voice, data, and video communications between the MDF room and each IDF room.

- All horizontal cable for voice, data, and video communications between the IDF room and each communications outlet.

The telecommunications contractor shall label all cable pulls in the IDF room with the end-termination room number (for example, for room 101, label pulls 101-1, 101-2 etc.).

An OIT representative will determine placement and route of cable drops in each IDF room. Each cable run shall include a minimum of 25'-0" of slack in the communications room and 12" of slack at the communications outlet.

*See Appendix A270000 for more details on a TR Voice Riser.*

5. Firestopping

Firestopping is to be placed on the outside of all conduits and sleeves installed into cored holes. The telecommunications contractor is responsible for firestopping the inside of all risers when penetrating floor slabs or fire-rated walls. Unused conduits and sleeves shall be capped.

D. Electrical Requirements

Communications systems have strict requirements for electric power. To ensure reliable service, adhere to the following guidelines.

1. Lighting

Fluorescent light fixture(s) are required. Fixture(s) shall be located to provide adequate lighting with an illumination of no less than 50 foot candles at 3'-0" above the finished floor. A wall switch should be located near the door.

2. Power requirements

*When emergency power is available:*

Provide one dedicated simplex receptacle NEMA 5-15R 20A/120V to normal power and one dedicated simplex NEMA 5-15R 20A/120V emergency standby power terminated in each vertical wire manager.

*When only standard power is available:*

Provide one dedicated quad receptacle NEMA5-20R 20A/120V to normal power terminated in each vertical wire manager.

*See Appendix A270000 for details on TR Rack Power Options.*
3. Grounding

Supply a power ground or building ground connection utilizing a minimum #6 green copper conductor as close as possible to the service entry conduits. Leave a wire coil the length of the floor to the ceiling, plus 6'-0", in the room.

E. Structure Requirements

1. Door

Provide double 6'-0" wide, 7'-6" high solid doors (no center post and no seal) with 180° hinges, mounted to swing outside the room, if possible, according to code.

2. Floor Coverings

To keep dust and static electricity to a minimum in the MDF room, use floor finishes of VCT or cement sealers. Carpeting is not permitted.

3. Walls

The walls of the MDF room must extend from the finished floor to the regular ceiling and be rated fire resistant. They must support loading of 200 pounds; this load can occur every two feet at 5'-6" above the finished floor.

4. Wall Covering

All interior wall surfaces shall be lined with pressure-treated, fire-retardant 3/4" plywood. These 4’ x 8’ plywood panels shall be installed vertical 6" above a finished floor and painted white for light reflection. Anchors for plywood panels shall be sufficient to support all background equipment apparatus.

5. Ceiling

Ceilings must be at least 12'-0" high to provide adequate space over the equipment frames for cables and suspended racks. False ceilings are not permitted in the MDF room.

6. Environment

The temperature of the MDF room must be maintained between 64 ° and 75 ° F. The relative humidity range must be between 30% and 55%.

A minimum of 20,000 BTUs of cooling is required. A thermostat located within the room and 5'-0" above the finished floor shall control the cooling system. The room shall be positive with respect to corridor or area adjoining these rooms. Auxiliary air conditioning units may be required in rooms with high volumes of voice, data, and video electronics.

7. Fire Protection

Fire alarm equipment and circuit terminations are often co-located with communications equipment. Fire alarm infrastructure and operation requirements are separate and in addition to OIT standards. For specific information on fire alarm requirements, contact the Fire Safety Division at (919) 684-5609.
8. Card Readers

Provide a card reader for entry into the MDF.

Card and electronic access equipment and circuit terminations are often co-located with communications equipment. Card and electronic entry reading infrastructure and operation requirements are separate and in addition to OIT standards.

For all University buildings, contact the Duke Card office at (919) 684-5800.

4. Intermediate Distribution Frame (IDF) Room

IDF rooms house intra-building backbone cables and serve as a distribution point for horizontal cabling. The physical size of a building determines the need for communications rooms. The length of the horizontal standard cabling for voice, data and video is limited to 295 linear feet or 90 linear meters from the room to the communications outlet.

See Appendix A270000 diagram T101 for more details on typical IDF design.

A. Location

IDF rooms shall be vertically stacked with relation to one another. They shall be interconnected with a riser system using sleeves or conduits. The room shall be located off a corridor or an area not associated with business offices or high activity areas. Restrooms and all other water, soil, and steam sources shall not be designed on any side of or above the IDF rooms.

B. Size

IDF rooms are sized to provide the linear wall footage necessary for routing cable, mounting termination blocks, mounting electronics and other equipment. Size should be a minimum of 100 sq. ft. (10’ by 10’) to provide a 32” clearance on each side of the loaded 19” equipment racks.

C. Other Specifications

All other specifications for IDF rooms are identical to those listed in sections 3.D Electrical requirements and 3.E Structure requirements except the following.

1. Door

A single, solid door 3'-0" in width with a 180° hinge shall be provided and mounted to swing outside the room. The door shall be installed either on the right or left side of the room, and not in the middle of a wall.

2. Environment

A minimum of 10,000 BTUs of cooling is required.

5. Intra-Building Distribution System

In all buildings, horizontal and vertical communications distribution systems are an absolute necessity in meeting and in keeping pace with the building occupants’ voice, data, and video communications needs. The distribution systems are designated to
house the cables and wiring necessary to connect communications equipment with the control and cross-connecting switching equipment located in the MDF room and in each IDF room.

As the needs of the University grow, the communications service requirements increase accordingly. Although the initial communications outlets are identified based on furniture layouts, changes occur each year. The design and capacity of a communications distribution system should have built-in flexibility to anticipate this movement and should be planned for in the initial building design. Therefore, it is prudent to design a building in such a way as to ensure that an adequate and functional intra-building distribution system is provided for communications. The capacity and flexibility of the communications system is determined in consultation with OIT and the project manager.

A. Horizontal Cabling System

1. Cable Tray

Minimum standards require that the cable tray be 12" wide and 4" deep basket tray. The tray shall be suspended from the ceiling by supporting rods as recommended by the manufacturer. No rod threads should be exposed in the cable tray, to avoid damaging the cable during installation. The cable tray shall have a minimum clearance of 12” on top and 6” on the sides and bottom from all obstructions (for example, sprinkler pipe, HVAC ducts, lights).

A minimum of one 1” conduit shall be used from the cable tray to the user's communications outlet to house communications cabling. Stub conduits one to two inches from the cable tray. See section 5.A.3 Conduit systems for standard installation requirements.

2. J-hooks

J-hooks are not recommended and the designer must receive approval for use in Duke University Buildings. If approved, the minimum standards require that J-hooks are not more than 5’ apart and are installed on the walls above the finished ceiling. J-hooks shall be accessible with a minimum clearance of 6” above, below, and on all sides.

3. Conduit System

Conduit systems are designed to protect the communications cabling. The following are installation standards for each type of conduit. The Duke project manager must approve the type of conduit through consultation with Duke Facilities Management. The conduit system shall be designed to allow no more than 25 pounds of pulling pressure on cable when installed.

a. Rigid Metallic Conduit

- Conduit shall be industry-standard, heavy wall steel conduit, and shall have a galvanized finish throughout.
- Conduit shall not be less than 1” trade size.
• Make all cuts square.
• Ream out all burrs from end after threading and before mounting in place.
• Utilize factory-manufactured elbows where change in direction is required. No more than two long radius 90° bends or the equivalent are permitted between junction boxes, pull boxes, cabinets, or cable access points. Pull boxes may not be substituted for 90° bends.
• Utilize threaded couplings and make all joints tight. Running threads, split couplings, and thread-less couplings are not acceptable.
• Install metallic bushings at all terminations, both free standing and within boxes, enclosures, and cabinets.
• During installation, cap all runs left unfinished or unattended. Cap all terminations of finished runs until wire and cable are pulled in. Manufactured fittings shall be used for this purpose.
• All conduit runs between communications outlets and new IDF rooms shall be on the same floor. When existing IDF rooms are not on the same level, conduit shall be installed as individual home runs, unless an OIT representative has granted prior approval of some other method.

b. Electrical Metallic Tubing (EMT)
• Conduit shall be cold rolled steel tubing with zinc coating on the outside and protected on the inside with zinc enamel or equivalent corrosion-resistant coating.
• Conduit may be installed in dry construction in furred spaces, in partitions other than concrete, solid plaster or exposed work. EMT shall not be installed where it will be subject to severe physical damage or severe corrosive influence, where trade size is larger than 2", or where tubing, elbows, couplings, and fittings would be in concrete or in direct contact with the earth.
• Couplings shall be in the compression type with all joints made tight.
• Follow installation practices as specified in section 5.A.3.a. Rigid metallic conduit.

c. PVC Conduit
• PVC conduit is not acceptable in new construction except in poured concrete slabs.
• Protection against physical damage must be provided before and during the process of pouring.
• During installation, all runs left unfinished or unattended must be capped. Manufactured fittings shall be used for this purpose.
• PVC conduit may be installed above ceilings on renovation projects where existing conditions would prohibit the use of electrical metallic tubing. This applies only to non-air plenum spaces.

d. Outlet Boxes

Except as noted, all boxes shall be manufactured from galvanized industry standard gauge sheet steel.

(1) Desk outlet box

Desk-communication outlet boxes shall be a minimum of 4 11/16" square, mounted to accommodate a single gang plaster ring for a single gang faceplate. Standard mounting height shall be 18", centered above the finished floor, or equivalent in height to electrical outlets.

(2) Wall outlet box

Wall-mounted telephone outlets with no data requirements shall be a minimum of 4 11/16" square, mounted to accommodate a single gang plaster ring for a single gang faceplate. Standard mounting height shall be 54", centered above the finished floor. ADA requirements for public access phones state that the highest operable part that is essential to the basic operation of the telephone must be a maximum of 48" above the finished floor. The bottom leading edge must be mounted 27" or less above the finished floor. Reference the ADA standards for more details.

(3) Floor outlet box

Rooms that require floor outlets shall be designed by the architect and discussed with the OIT representative to ensure future flexibility for communications wiring. "Trapped conduit" and tombstones are not acceptable.

(4) Junction and pull boxes

Internal diameter dimensions of boxes and the maximum number of cables that may be placed in them are dependent upon the actual requirements for any given building. Consult with the OIT representative for specific details.

A metal pull box should be specified if:
• The length is over 98’
• There are more than two 90° bends
• There is a reverse bend in the run

Pull boxes shall be placed in an exposed manner and location. These shall be readily accessible and not in the false ceiling space, unless immediately above a suitable marked, hinged panel.

Condulet or LB fittings are not acceptable in any case.
B. Vertical System

New multi-level buildings should be designed with IDF rooms placed one above the other in a vertical fashion to facilitate vertical distribution systems. Vertical cable risers make for ease of design, construction, and maintenance. Provide a riser with a minimum of four 4” conduits or sleeves to each IDF room. The total number of conduits or sleeves depends on the number of floors in the building and on the number of tenants/outlets required in the building.

The engineer shall include a single line riser diagram of all conduits as part of the construction documents and drawings. An OIT representative shall approve the conduit sizes and details of this drawing.

6. Horizontal and Vertical Cabling – Voice, Data, AV and Security

A. Horizontal Cabling

The horizontal wiring standard is mandatory for all University renovations and new buildings. The standard is structured to meet the majority of telephony and data communications protocols presently used on the Duke campus. The purpose of this standard is to follow industry standards as they evolve and place the entire campus on a standard wiring scheme to increase flexibility for moves and changes within the University.

The telecommunications contractor is responsible for pulling all voice, data and video intra-building backbone and horizontal cable as specified in the construction documents. The telecommunications contractor is responsible for estimating cable footage and pulling cable from the MDF room up the riser to each IDF room, and throughout the building to each communications outlet.

Apply no more than **25 pounds** of pulling pressure on cable when installed.

It is important to note that for every communications outlet location a quad electrical outlet should be co-located. This ensures that adequate power is available for the end user’s phone and data equipment.

1. Outlet Cabling
   a. Standard Communications Outlet

   The standard wiring for University buildings is two Category 6a (CAT 6a) cables pulled to each communications outlet. The CAT 6a cable shall be installed using two different colored cables (blue and white) per outlet. Outlets will be noted on the electrical drawings by the symbol ▲. There is no deviation from this standard unless written approval is obtained from OIT.

   b. Wall Outlets

   Most wall outlets will contain one CAT 6a cable. Wall outlets will be indicated on the electrical drawings by the symbol ▲.
ADA requirements may dictate different wall phone heights in special construction circumstances such as wheelchair alcoves, columns, and obstructions. Consult with the OIT representative during the design stage.

2. Cable Specifications

Voice and data wiring are four 4-pair (UTP) enhanced CAT 6a cables (24-gauge) terminating on individual 8-position 568B RJ45/Category 6a data jacks (black). Runs shall be continuous with no intermediate terminations. This will support all voice, data and video communications equipment supported by OIT.

B. Vertical Cabling

The vertical wiring standard includes pulling copper, multi-mode fiber, single-mode fiber cables from the MDF room to each IDF room in the building. All fiber cable shall be pulled in innerduct. Quantities of each type of cable depend on the building's occupants and their requirements for voice, data, and video. The telecommunications contractor is responsible for pulling all voice, data, and video intra-building backbone and horizontal cable as specified in the construction documents. Again, early consultation with OIT is required so the quantities of cable and raceway systems can be determined.

7. Wireless Infrastructure Design

Wireless network infrastructure shall be provided in all new buildings and construction projects. Wireless systems must be designed according to plan documents in the schematic design phase. WiFi- 802.11 a/b/g/n coverage across 95%, -67dbmv minimum specification. Estimates for AP coverage to be supplied with construction documents and known building materials. The wireless system design shall require 1" trade size conduit from the raceway system to each wireless node location using a 4 11/16" square box with a sing gang plaster ring. Pull two CAT 6a cables to each wireless node.

8. Cellular Infrastructure Design

Cellular- CDMA/GSM and associated voice/data standards to be enabled across 95% of the area 95% of time, indoors and outdoors. Coverage signal strength to be -92dbmv. Assumptions that building skins will not be permeable to RF signals, therefore all budgets will be prepared as having to provide total coverage.

9. Collaborative Teaching and Learning Spaces

Pull two CAT 6a and one multi-mode duplex fiber cables for voice and data services. The outlet box shall be 4 11/16" square with a double gang plaster ring. The conduit shall be a minimum of 1" trade size to the raceway system.

10. Parking Gates

Parking gates require 1" underground conduit with direct access from the telecommunications entrance room to the gate arm pedestal. Pull two CAT 6a underground rated cables for a mounted gate phone or emergency phone. Also, pull special cable for gate card reader. For wire type and other specific information, contact the Duke Card office at (919) 684-5800.
11. Help Telephone Locations

Requires 3/4" underground conduit with direct access from the telecommunications entrance room to pole or wall location. Include two CAT 6 underground cables with minimum 10'-0” slack at outlet location.

12. Elevator Phones

The purchase and installation of the elevator traveling cable is the responsibility of General Contractor. OIT will provide assistance with the installation of the telephone line.

13. Help Phones Call Box Systems

All telephone instruments located in elevator cabs and help stations are connected to an emergency reporting system staffed by Duke University’s Police Department located at 502 Oregon Street. This system provides a voice channel and location identification when the handset is lifted off hook.

This station is used for the following:

- Vehicle accidents
- Fire
- Suspicious incidents/persons
- Personnel assistance
- Personal assaults
- Sick or injured persons
- Criminal activity

An OIT representative will consult with Duke Police concerning the locations and number of units required. All new help call box locations must be configured to ADA specifications. OIT will coordinate the installation of free-standing tower help telephones with the Duke High Voltage Department. The electrical contractor is responsible for the installation of conduit and cable only.

14. Security Cameras

An OIT representative will consult with Duke University Police Department concerning the locations and number of units required. All security camera locations must be approved by the Duke Police Department. The design shall require 1” trade size conduit from the raceway system to each camera location using a 4” square box, with one CAT 6a cable installed.
STEAM PIT PLAN DETAIL

1. PROVIDE FLOOR DRAIN TO SANITARY IF POSSIBLE. SHOULD A FLOOR DRAIN TO SANITARY NOT BE POSSIBLE, INSTALL A 24"X24"X24" SUMP PIT AND SUMP PUMP (SEE ITEM #2 FOR DETAILS ON SUMP PUMP REQUIREMENTS).

2. SUMP PUMP (IF REQUIRED) SHALL BE ZDELLER HI-TEMP MODEL M181. PROVIDE HIGH WATER LEVEL ALARM TO BE TIED INTO BUILDING CONTROLS.

3. PROVIDE HOT DIPPED GALVANIZED LADDER WITH RUNGS 12" C.C. AND 16" SEPARATION BETWEEN SIDE RAILS. LADDER SHALL HAVE INTEGRAL FEET TO BE BOLTED TO THE FLOOR. PRE-PUNCHED HOLES AT 12" INTERVALS SHALL BE PROVIDED FOR INSTALLING WALL BRACKETS CAPABLE OF BEING BOLTED TO WALL.

4. HIGH PRESSURE Drip LEG AND STEAM TRAP ASSEMBLY, REFER TO DUKE STANDARD DETAILS FOR HIGH PRESSURE Drip TRAP DETAIL.

5. LINSEAL ASSEMBLY MANUFACTURED BY THUNDERLINE CORPORATION OR APPROVED EQUIVALENT. PROVIDE LINK SEAL AT EACH EXTERIOR WALL PENETRATION.

6. BRONZE SWING CHECK VALVE RATED FOR 200 PSI 2" CWP & 125 SWP.

7. TWO PIECE THREADED BRONZE BALL VALVE RATED FOR 400 PSI 2" CWP & 125 SWP.

8. 36"X36" PIT ACCESS CONSTRUCTED FROM STEEL GRATING. PROVIDE HINGES AND HANDLE FOR OPENING HATCH DOOR.

9. PROVIDE STEEL GRATE TO COVER ENTIRE PIT OPENING.

10. PROVIDE HIGH WATER ALARM. ALARM LEVEL SHALL BE SET TO 3" BELOW THE LEVEL OF THE Drip LEG CAP. ALARM SHALL BE TIED INTO BUILDING CONTROLS.

11. SUMP DISCHARGE PIPING SHALL BE HARD PIPED TO SANITARY SYSTEM. FERNGO TYPE FITTINGS WILL NOT BE AN ACCEPTABLE TYPE OF CONNECTION TO SANITARY SYSTEM.

GENERAL NOTES FOR STEAM PIT CONSTRUCTION

1. DETAILS SHOWN IN THIS DRAWING CUTFACE MATERIALS AND METHODS FOR CONSTRUCTING STEAM ACCEPTANCE PITS FOR PROPER ACCESS AND MAINTENANCE OF STEAM AND CONDENSATE PIPING BUILDING AT DUKE UNIVERSITY AND DUKE UNIVERSITY MEDICAL CENTER.

2. ALL PIPE TO BE ASTM A53-B SEAMLESS PIPE. ALL STEAM PIPING 2" AND LARGER AND SUMP PUMP DISCHARGE PIPING SHALL BE SCHEDULE 40. ALL CONDENSATE PIPING AND STEAM SMALLER THAN 2" SHALL BE SCHEDULE 80.

3. VALVES AND FITTINGS AS SPECIFIED IN DETAIL DRAWINGS AND KEYED NOTES.

4. STEAM TRAP ASSEMBLY SHALL BE INSTALLED WITH STEAM TRAP AND ISOLATION VALVES EASILY ACCESSIBLE ONCE ENTERING PIT. TRAP ASSEMBLY SHALL NOT BE INSTALLED WHERE IT COULD BE A TRIP HAZARD DURING PIT ENTRY.

5. MINIMUM CLEARANCE DIMENSIONS ARE FROM OUTER EDGE OF INSULATION.
TRASH DUMPSTER

Serviced by a front load truck

Capacity: 8 cubic yard (standard)

Style: Side Door, Flat Front, Notch Back

Dimensions:
- Depth: 71” minimum, 72” maximum
- Height: 71” minimum, 72” maximum
- Body width: 71” minimum, 72” maximum (with sleeves: 80” – 81” wide)

Bottoms:
- 10 gauge steel
- Reinforced with a 90 degree x 2 3/4” wide “V” crimp containing a 1 1/2” drain and plug (pipe coupling)
- Reinforced additionally with a 2” x 2” x 3/16” angle running length of bottom opposite “V” crimp
- Four (4) caster pads constructed from 3/16” steel plate
- Fully-welded stress areas to aid in liquid retention

Front and Side Walls:
- 11 gauge steel minimum
- Reinforced with 90 degree x 1 1/2” “V” crimps, front and rear, to maintain rigidity

Side Doors:
- Side door opening (on the left and right sides) 28” x 28”
- 44” maximum height from ground to bottom of side door opening
- Full access to the 28” x 28” opening is required with the door in the open position

Front Bumper Pads and Side Lifting Sleeves:
- 3/16” thick, 36” long (maximum) sleeves
- 3/16” gussets for support
- 3/16” plate guides to assist fork arm e

Lids:
- Plastic Double wall construction with “V” crimp
- Contact the Sanitation and Recycling Office for paint color options
ROLL-OFF CONTAINER
Theatres, art studios, and maintenance shops often produce bulky waste that cannot be collected in front load dumpsters. Open top roll-off containers must be sited in some instances.

Concrete Information:
• The pad should be a minimum of 3,000 PSI concrete, with #4 bars at 12” on center each way, and 6” thick.
• Pour the pad on compacted earth with a minimum base of 4” ABC stone. These are minimum requirements.
• Final structural design of the pad shall be based on project requirements.

FOOD BINS
When the building contains food service operations, containers and exterior space must be allocated for grease collection and food waste recycling (composting). Check with Auxiliary Services/Campus Dining Services for specifications for grease recycling (required by state law) and food waste recycling space needs.

Ramp:
• If the design includes, or may in the future include, outdoor recycling or compost bins, it MUST include specifications for a ramp at least 5’ wide for access to the recycling containers.
The Sanitation and Recycling Office suggest that copier, mail and work rooms have a trash can and two recycling bins (one for office fiber and one for newspaper/magazines) and that public areas have a trash can, bottle/can bin, and newspaper/magazine bin. In some situations, office fiber bins are also needed in public areas.

Buildings, such as residential halls, dining halls, athletic facilities, theaters, conference centers, shipping and receiving areas, animal quarters, etc. may have special needs. Consult the Sanitation and Recycling Office for assistance with planning space for indoor recycling in these areas.
OUTDOOR RECYCLING CARTS
Ideally, the recycling carts and dumpsters will be on the same pad and enclosure. However, in some cases it is necessary for a standalone recycling cart area. It is imperative that the Sanitation and Recycling Office be contacted to help determine the number of recycling bins needed and any additional programs that should be included; dimensions for carts and configurations should be reviewed with the Sanitation and Recycling Office for approval.

Pad Dimensions:
• One measures 9’4” x 11’4” and has 3 carts parallel to one another. The other configuration has 6 carts in a line and measures 17’4” x 8’4”.

Ramp:
• There MUST be a ramp at least 5’ wide for access to the recycling containers.

Drainage:
• The floor of the enclosure (or the pad) shall slope 1/8” per foot to allow rainwater and other liquids to drain off without puddling.

CARDBOARD DUMPSTER
Serviced by a front load truck  
Capacity: 8 cubic yards (inside capacity)  
Style: Standard  
Dimensions:
• Depth: 66”  
• Width: 80” minimum, 84” maximum  
• Body width: 72” wide, with sleeves: 81” wide  
Slots:
• Horizontal slots on front  
• Slot position: centered 68” from ground (66” from bottom of container) to bottom of opening  
• Dimensions: 6” high x 56” long  
• Opening to be framed with 3/16” x 1 ½” channel iron
**Bottoms:**
- 12 gauge steel
- Reinforced with a 90 degree x 2 ¾” wide “V” crimp containing a 1 ½” drain and plug (pipe coupling)
- Reinforced additionally with a 2” x 2” x 3/16” angle running length of bottom opposite “V” crimp
- Four (4) caster pads constructed from 3/16” steel plate
- Fully-welded stress areas

**Front and Side Walls:**
- 11 gauge steel (minimum)
- Reinforced with 90 degree x 1 ½” “V” crimps, front and rear, to maintain rigidity

**Front Bumper Pads and Side Lifting Sleeves:**
- 3/16” think, 36” long (maximum) sleeves
- 3/16” gussets for support
- 3/16” plate guides to assist fork arm entry

**Side Doors:**
- Sliding metal side doors with self cleaning tracks
- Welded closed or with means to lock

**Lids:**
- Plastic (standard): Double wall construction with “V” crimp for added strength and Overhead lock bar to secure lids
- Metal: Steel lids must be reinforced and have 4” x ¼” plate hinges with 1” o.d. hinge rods

Contact the Sanitation and Recycling Office for paint color options

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**CARDBOARD BALER**

Due to the complexities in choosing an appropriate baler for an individual building it is imperative that the Sanitation and Recycling Office be contacted for this information.
# V-6030 HD Vertical Baler

<table>
<thead>
<tr>
<th>Performance</th>
<th>V-6030 HD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder (Bore, Rod, &amp; Stroke)</td>
<td>6” x 3.5” x 48” (152mm x 89mm x 1219mm)</td>
</tr>
<tr>
<td>Pump Flow (Gear Pump)</td>
<td>10.5 gpm (39.7 lpm)</td>
</tr>
<tr>
<td>Motor</td>
<td>10 hp (1,750 rpm) (7.46 kW)</td>
</tr>
<tr>
<td>System Pressure</td>
<td>2,000 psi (13790 kPa)</td>
</tr>
<tr>
<td>Maximum System Pressure</td>
<td>2,200 psi (15168 kPa)</td>
</tr>
<tr>
<td>Maximum Platen Force</td>
<td>62,200 lbs. (277 kN)</td>
</tr>
<tr>
<td>Platen Pressure</td>
<td>37 psi (255 kPa)</td>
</tr>
<tr>
<td>Cycle Time</td>
<td>56 sec.</td>
</tr>
</tbody>
</table>

## Electrical Equipment

<table>
<thead>
<tr>
<th>Electrical</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Control Voltage</td>
<td>208/230/460 3-phase</td>
</tr>
<tr>
<td>OFF/ON Security Key Switch; 3-Position Selector Switch; EMERGENCY STOP Button; IEC Motor Starter and Overload, Programmable Smart Relay UL® and CUL® Listed</td>
<td></td>
</tr>
</tbody>
</table>

## Bale Size Data

<table>
<thead>
<tr>
<th>Bale Size</th>
<th>60”W x 30”D x 48”H (1524mm x 762mm x 1219mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bale Volume</td>
<td>50 cu.ft. (1.42 m³)</td>
</tr>
<tr>
<td>Bale Weight (OCC)</td>
<td>Up to 1,100 lbs. (499 kg)</td>
</tr>
<tr>
<td>Number of Bale Ties (14 ga x 14” L)</td>
<td>5</td>
</tr>
<tr>
<td>Total Baler Weight</td>
<td>4,682 lbs. (2124 kg)</td>
</tr>
</tbody>
</table>

## Dimensional Data

<table>
<thead>
<tr>
<th>Dimensional Data</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A - Overall Width</td>
<td>87” (2210mm)</td>
</tr>
<tr>
<td>B - Overall Depth</td>
<td>41⅞” (1054mm)</td>
</tr>
<tr>
<td>C - Overall Depth (w/optional wire guides)</td>
<td>54⅞” (1384mm)</td>
</tr>
<tr>
<td>D - Overall Height</td>
<td>140” (3556mm)</td>
</tr>
<tr>
<td>E - Feed Height</td>
<td>48⅞” (1226mm)</td>
</tr>
<tr>
<td>F - Feed Opening Width</td>
<td>24” x 61” (609mm x 1549mm)</td>
</tr>
<tr>
<td>G - Feed Opening Height</td>
<td>25” (635mm)</td>
</tr>
<tr>
<td>H - Bale Door Clearance</td>
<td>58” (1473mm)</td>
</tr>
</tbody>
</table>
Ideally, the recycling carts and trash and cardboard dumpsters will be on the same pad and enclosure. However, the quantity, size, and type of dumpsters needed are dependent on the building use and size. When volume or special needs dictate a larger dumpster, compactors are recommended. These may be used for trash or cardboard.

**Pad Dimensions:**
- The pad for a 20-30 cubic yard horizontal compactor should be 12’ wide and 40’ long. Additional space may be needed for the electrical unit.
- Elevation drawing and details for outdoor service areas must be shown on the plans.

**Concrete Information:**
- The pad should be a minimum of 3,000 PSI concrete, with #4 bars at 12” on center each way, and 6” thick.
- Pour the pad on compacted earth with a minimum base of 4” ABC stone. These are minimum requirements.
- Final structural design of the pad shall be based on project requirements.
- The floor of the enclosure (or the pad) shall slope 1/8” per foot to allow rainwater and other liquids to drain off without puddling.

(Refer to the following specifications for the preferred Marathon Self-Contained Compactor)
Vert-I-Pack® Self-Contained Compactor/Container

Use for front and rear feed applications

Convert the unit to accommodate a 4, 6, or 8 cubic yard container

Extra-low feed heights

Rigid anchoring platform

Triple interlock

Available from 3 to 8 cubic yard capacities
**Vert-I-Pack® (VIP) Compactor with 4, 6, or 8 Cubic Yard Capacity Container**

**Vert-I-Pack Benefits for the Hauler**

- The Vert-I-Pack vertical compactor is designed to simplify compacted waste dumping, save driver time, and substantially reduce maintenance costs. A front loader operator can attach and empty the container in less than 90 seconds.

- The Vert-I-Pack features a reversible feature that allows the unit to easily be converted to front or rear feed by moving the interchangeable bolt-on container stops. This enables one compactor to be used for a variety of applications.

- The telescoping legs allow the Vert-I-Pack to adjust up and down to accommodate 4, 6, or 8 cubic yard (3.1, 4.59, or 6.12 cubic meter) containers. The process of vertical compaction eliminates all openings in the side of the container from which waste materials can leak or spill. The location of the ram above the refuse prevents trash and liquids from collecting behind the blade, which can foul-up the cylinder or create damage when it freezes in the winter. Integral container guides provide 3-inches (76.2mm) of vertical tolerance, making re-entry fast and smooth.

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**VIP-LOCK®**

Marathon’s patented VIP-LOCK positive container lock-in device prevents container “walking”. The container device “rides over” the compactor device as the truck moves the container into position. In the fully inserted position, the compaction force inside the container prevents the container from moving.

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**Images shown with optional equipment**
Vert-I-Pack® Benefits for the Operator

Marathon's variety of low-profile Vert-I-Packs range in size from 3 to 8 cubic yards (2.29 m³ to 6.12 m³). These are available with feed heights as low as 44 7/8-inches (1140mm) and with front, rear, or side feed configurations. The Vert-I-Pack alleviates the need for all those unsightly containers that draw scavengers and vermin. Your refuse stays inside the unit. The Vert-I-Pack also prevents others from dumping refuse into your container since the Vert-I-Pack is key-operated and controlled. The Vert-I-Pack stores your refuse in an ozone rich atmosphere (with optional ozonation device), which eliminates odors and keeps out insects and their larvae.

The Vert-I-Pack is a real space saver — with more than 13-tons (11,793 kg) of crushing force, it reduces the contents of many open containers into 1 Vert-I-Pack container. This saves your hauler time because the hauler has only one container to pick up. It also prevents weekend overflow, which eliminates the need to schedule those expensive weekend pickups.

The Vert-I-Pack is designed with the operator in mind. It has no heavy or clumsy lids to open and close — just a single easy and simple to open door.

The Vert-I-Pack controls employee pilferage — optional security kit (rear feed and side feed units only) enables the unit to be fed from inside the building, eliminating the temptation to employees to put merchandise into a box, stash the box in the trash container, and return later to retrieve your merchandise.

Vert-I-Pack Triple Lock

The mechanical door interlock prevents the door from being opened at all times except when the unit is in the proper feeding position. A second interlock prevents the unit from cycling (operating) when the door is in the open position. The third interlock prevents the unit from functioning when the container is not in the proper position.

Simple User Operation

Step 1

The operator inserts the key and turns it to the “UP” position. The ram moves from the mid-point position to the up position. The door can now be opened.

Step 2

The large opening allows even 30 gallon (114 liter) containers to be emptied easily.

Step 3

After feeding the operator closes the door and removes the key. The unit then cycles automatically when the door is closed. With more than 13-tons (11,793 kg) of crushing power, the Vert-I-Pack forces the ram 18-inches (457.2mm) in to the container.

Step 4

After the ram reaches maximum penetration, it automatically reverses itself. The unit automatically shuts down when the ram reaches the mid-point position at the top of the container. The ram remains in this position until the next use, sealing off the top of the container and applying constant pressure to the refuse. This helps to increase compaction and reduce spring-back.
Vert-I-Pack® Self-Contained Compactor

Dimensions and Specifications

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Model</th>
<th>Size</th>
<th>Feed Height</th>
<th>Complete Assembly Weight</th>
<th>Container Weight</th>
<th>Overall Height</th>
<th>Overall Length/Width</th>
<th>Overall Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Front-load collection trucks</strong></td>
<td>Front feed</td>
<td>3 cu yd</td>
<td>46 1/2&quot;</td>
<td>118 7/8&quot;</td>
<td>1187mm</td>
<td>1571 kg</td>
<td>86 1/2&quot;</td>
<td>2197mm</td>
</tr>
<tr>
<td></td>
<td>Front/Rear feed</td>
<td>4 cu yd</td>
<td>41 1/2&quot;</td>
<td>114&quot;</td>
<td>1140mm</td>
<td>1600 kg</td>
<td>82 1/2&quot;</td>
<td>2105mm</td>
</tr>
<tr>
<td></td>
<td>Front/Rear feed</td>
<td>6 cu yd</td>
<td>46 1/2&quot;</td>
<td>143 5/8&quot;</td>
<td>1435mm</td>
<td>1973 kg</td>
<td>96 1/2&quot;</td>
<td>2401mm</td>
</tr>
<tr>
<td></td>
<td>Front/Rear feed</td>
<td>8 cu yd</td>
<td>56 1/2&quot;</td>
<td>189 5/8&quot;</td>
<td>1895mm</td>
<td>2341 kg</td>
<td>115&quot;</td>
<td>2921mm</td>
</tr>
<tr>
<td></td>
<td>Side feed</td>
<td>6 cu yd</td>
<td>56 1/2&quot;</td>
<td>156 9/16&quot;</td>
<td>1569mm</td>
<td>1993 kg</td>
<td>106 1/4&quot;</td>
<td>2540mm</td>
</tr>
<tr>
<td></td>
<td>Side feed</td>
<td>8 cu yd</td>
<td>79 3/4&quot;</td>
<td>202 1/2&quot;</td>
<td>2025mm</td>
<td>2341 kg</td>
<td>98&quot;</td>
<td>1900mm</td>
</tr>
<tr>
<td><strong>Rear-load collection trucks</strong></td>
<td>Front feed</td>
<td>4 cu yd</td>
<td>52&quot;</td>
<td>132 1/4&quot;</td>
<td>1321mm</td>
<td>1736 kg</td>
<td>98&quot;</td>
<td>2438mm</td>
</tr>
<tr>
<td></td>
<td>Rear feed</td>
<td>4 cu yd</td>
<td>52&quot;</td>
<td>132 1/4&quot;</td>
<td>1321mm</td>
<td>1736 kg</td>
<td>98&quot;</td>
<td>2438mm</td>
</tr>
</tbody>
</table>

* Reversible/adjustable feature not available on Side Feed models

Also available as Green Built®, featuring Solar and other environmentally friendly components. Marathon’s solar option is not UL and CUL Listed.

Compactor Rental and Leasing Programs Available

For detailed specifications, recommendations, or free economic studies comparing various systems, contact Marathon Customer Care at 1-800-633-8974.

Authorized Dealer:

Stoaday and self-contained compactors.
**Typical MDF Design Requirements**

**Power**
- All communications room receptacles shall be fed from dedicated IT panel and tied into emergency power system.
- Power receptacles (convenience):
  1. 20 AMP duplex receptacle on normal power centered on each wall, and
  2. 20 AMP duplex receptacle per wall mounted equipment.
- Power receptacles (rack mounted):
  - Where emergency power is available:
    1. Dedicated, NEMA L5-20R 20A/120V receptacle at each side of center rack.
  - Where emergency power is not available:
    1. Dedicated, NEMA L5-20R 20A/120V quad receptacle at each side of center rack.

**HVAC**
- Mount power receptacles at 6" AFF to bottom of junction box.
- Rack within backside of vertical wire manager.
- Provide 10,000 BTU/HR sensible cooling per equipment rack.

**Lighting**
- Fixtures shall be placed running parallel with equipment racks.
- Provide min. 50 FC at 3'-0" AFF. Provide min. 1 lamp on emergency power.

**MEP Coordination Notes**
- Provide 10,000 BTU/HR sensible cooling per equipment rack.
- Fixtures shall be placed running parallel with equipment racks.
- Provide min. 50 FC at 3'-0" AFF. Provide min. 1 lamp on emergency power.

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**Drawing Information**
- Duke University
- Communications Room
- Drawing Date: 11/3/2017
- Scale: 1/2" = 1'-0"
COMMUNICATIONS

TR RACK ELEVATION

1. RACK ELEVATION - FRONT OF RACKS

3/4" = 1'-0"

2. SECTION THRU WIRE MGR

3/4" = 1'-0"

DUKE UNIVERSITY

COMMUNICATIONS

RACK ELEVATION

TYPICAL 24-PORT 2U PATCH PANEL DETAIL

3" = 1'-0"

OVERHEAD RUNWAY SYSTEM

POWER CONDUIT INSIDE REAR OF WIRE MANAGER

MIN. 3'-0" CLR.

RACK POWER FED FROM ABOVE

PB TYPE CONDUIT FITTING

EXTEND CONDUIT PAST FRONT OF OVERHEAD RUNWAY

OVERHEAD RUNWAY SYSTEM

POW CONDUIT (HICKS VERTICAL WIRE MANAGER)

REAR FACING POWER RECEPTACLES ON DOUBLE GANG BOXES - SEE TB1

CENTERLINE OF RACK POSTS

OF RACKS
POWER RECEPTACLES REAR OF RACKS - EMERGENCY POWER

1. Available

1" = 1'-0"

2. Not Available

1" = 1'-0"
USE SNAP IN LABELING KIT TO LABEL BLOCK WITH ORIGINATION MDF ROOM

USE SNAP IN LABELING KIT TO LABEL BLOCK WITH DESTINATION IDF ROOM

Siemon S110A(X)2-100FT Labeling at IDF

Siemon S110AA2-300FT Labeling at MDF

Siemon #S110AA2-300FT 300 PAIR FIELD TERMINATION KIT

50 PAIR TIE CABLE FROM MDF TO EACH IDF

SUPERIOR ESSEX #18-789-33 (RISER)

USE SNAP IN LABELING KIT TO LABEL BLOCK WITH ORIGINATION MDF ROOM

USE SNAP IN LABELING KIT TO LABEL BLOCK WITH DESTINATION IDF ROOM

Siemon S110A(X)2-100FT Labeling at IDF

Siemon S110AA2-300FT Labeling at MDF

Siemon #S110A(X)2-100FT 100 PAIR FIELD TERMINATION KIT

25 PAIR x 50 FT. TIE CABLE WITH 90 DEGREE FEMALE AMP CONNECTOR (TYP. IN EACH IDF)

50 PAIR TIE CABLE FROM MDF TO EACH IDF

SUPERIOR ESSEX #18-789-33 (RISER)

Siemon #S110A(X)2-300FT 300 PAIR FIELD TERMINATION KIT

Typical Copper Riser Diagram - Duke University

6" = 1'-0"
Room## Label

Faceplates within each room to be labeled numerically starting at point "1" and then clockwise.

Patch panel port to be labeled with patch panel port #.

Outlet label: Pull Cord

Cable label area: Category UTP cable

Conduit by E.C.

Single gang Hubbel Decorator Faceplate

(4) 8P8C Modular Jack (Black) Siemon Z6A-01

Designer Mounting Frame (White) Siemon MX-D4Z-02

4 1 11/16" X 4 11/16" Square x 3" deep (PL) backbox

12" = 1'-0"

Bard, Rao + Athanas Consulting Engineers, LLC
10 Guest St., 4th Floor
Boston, MA 02135
tel 617.254.0016     fax 617.924.9339
www.brplusa.com

Project:
Description:
Checked:
Scale:
Drawn:
Date:
Job No.:
Sketch:
Rev. Dwg:

As indicated

T503

DUKE UNIVERSITY

OIT COM

COMMUNICATIONS ROOM REQUIREMENTS

TYPICAL OUTLET LABELING DETAIL

N.T.S.

TYPICAL FACEPLATE LABELING

12" = 1'-0"
STEAM VAULT PLAN DETAIL

1. PROVIDE GRAVITY DRAIN WITH BACKWATER VALVE TO STORM IF POSSIBLE. SHOULD A GRAVITY DRAIN TO STORM NOT BE POSSIBLE, INSTALL A 30"x30"x30" SUMP PIT AND SUMP PUMP (SEE ITEM #2 FOR DETAILS ON SUMP PUMP REQUIREMENTS).

2. SUMP PUMP (IF REQUIRED) SHALL BE ZOELLER Hi-TEMP MODEL M5181 OR WATSON McDaniel Pit Boss (TYPE OF PUMP TO BE DETERMINED BY DUES DURING DESIGN).

3. PROVIDE LADDER LADDER WITH RUNGS 12" O.C. AND 18" SEPARATION BETWEEN SIDE RAILS. SIDES OF LADDER SHALL BE 3"X2" GALVANIZED FLAT BAR. LADDER RUNG SHALL BE MUNCOHOL TRACTION TREAD TYPE - GALVANIZED, 13 GA, 4 ROW, 2.25" WIDE (ITEM# M3LSTR4460). LADDER SHALL HAVE INTEGRAL FEET TO BE BOLTED TO THE FLOOR. PRE-PUNCH HOLES AT 12" INTERVALS SHALL BE PROVIDED FOR INSTALLING WALL BRACKETS CAPABLE OF BEING BOLTED TO WALL.

4. HIGH PRESSURE DRIP LEG AND STEAM TRAP ASSEMBLY, REFER TO DUKE STANDARD DETAILS FOR VAULT HIGH PRESSURE DRIP TRAP DETAIL.

5. LINKSEAL ASSEMBLY MANUFACTURED BY THUNDERLINE CORPORATION OR APPROVED EQUIVALENT. PROVIDE LINK SEAL AT EACH EXTERIOR WALL PENETRATION.

6. BRONZE SWING CHECK VALVE RATED FOR 200 PSIG CMP & 125 SWP.

7. TWO PIECE THREADED BRONZE BALL VALVE RATED FOR 400 PSIG CMP & 125 SWP.

8. 3" MANGHOLE ACCESS LID SHALL BE CONSTRUCTED FROM COMPOSITE MATERIAL WITH AN HS20 LOAD RATING. MANHOLE ACCESS SHALL BE STAMPED INTO LID FOR IDENTIFICATION.

9. 24" MANGHOLE ACCESS LID SHALL BE CONSTRUCTED FROM COMPOSITE MATERIAL WITH AN HS20 LOAD RATING. MANHOLE ACCESS SHALL NOT BE OBSTRUCTED BY ANY PIPING OR INSULATION BELOW. "STEAM" SHALL BE STAMPED INTO LID FOR IDENTIFICATION.

10. SUMP PIT SHALL BE LOCATED NEAR 24" MH OPENING WITHOUT ENCROACHING WITHIN CIRCUMFERENCE OF MH OPENING. GRATING MATERIAL SHALL BE COMPOSITE, DARK GREY 1.5" THICK WITH 1.5" SQUARE OPENINGS. MATERIAL SHALL BE CAPABLE OF SUPPORTING 500 LBS AT 212° F.

11. SUMP DISCHARGE PIPING SHALL BE HARD PIPED TO STORM SYSTEM. FLEXIBLE FITTINGS WILL NOT BE AN ACCEPTABLE TYPE OF CONNECTION TO STORM SYSTEM PIPING.

12. LOCATE VALVE AS CLOSE TO MAIN TAKE-OFF AS POSSIBLE.

13. LOCATE GFCI RECEPTACLE AS HIGH AS POSSIBLE IN MH CLOSE TO THE LADDER.
STEAM VAULT SECTION - A

NOT TO SCALE
GENERAL NOTES FOR STEAM VAULT CONSTRUCTION

1. DETAILS SHOWN IN THIS DRAWING OUTLINE MATERIALS AND METHODS FOR DESIGNING AND CONSTRUCTING STEAM VAULTS FOR PROPER ACCESS AND MAINTENANCE OF STEAM AND CONDENSATE DISTRIBUTION PIPING AT DUKE UNIVERSITY AND DUKE UNIVERSITY MEDICAL CENTER.

2. MINIMUM DIMENSIONS FOR STEAM VAULTS ARE 8’x6’x6’. STEAM VAULT SHALL INCREASE IN SIZE TO PROVIDE ADEQUATE CLEARANCE TO ACCESS VALVES, TRAPS, PUMPS, PIPING, ETC.

3. VALVES AND FITTINGS AS SPECIFIED IN DETAIL DRAWINGS AND KEYED NOTES.

4. STEAM TRAP ASSEMBLY SHALL BE INSTALLED WITH STEAM TRAP AND ISOLATION VALVES EASILY ACCESSIBLE ONCE ENTERING VAULT. TRAP ASSEMBLY SHALL NOT BE INSTALLED WHERE IT COULD BE A TRIP HAZARD DURING VAULT ENTRY.

5. MINIMUM CLEARANCE DIMENSIONS ARE FROM OUTER EDGE OF INSULATION.

6. ALL PIPING TO BE ASTM A53 GRADE B OR ASTM A 106 SEAMLESS PIPE. ALL STEAM PIPING LARGER THAN 2” AND SUMP DISCHARGE PIPING SHALL BE SCHEDULE 40. STEAM PIPING LESS THAN 2” SHALL BE SCHEDULE 80. ALL CONDENSATE PIPING SHALL BE SCHEDULE 80.

7. ALL STEAM AND CONDENSATE VALVES SHALL BE CARBON STEEL OF BUTTWELDED OR SOCKET WELDED CONNECTION TYPE. STEAM VALVES SHALL BE CLASS 300. PUMPED CONDENSATE VALVES SHALL BE CLASS 150. ALL VALVES 2” AND SMALLER SHALL BE CLASS 800.
STEAM PIT SECTION - A

1

NOT TO SCALE
STEAM PIT PLAN DETAIL

NOT TO SCALE

EXTERIOR WALL

CLASS A DIRECT BURIED CONDENSATE PIPING (SIZE VARIES)

MIN. 24"

MIN. 36"

HIGH WATER ALARM

30" x 30" x 30" SUMP PIT

STEAM PIT DISTRIBUTION

STEAM ENERGY DISTRIBUTION

STEAM PIT

06/16/2015
1. PROVIDE FLOOR DRAIN TO SANITARY IF POSSIBLE. SHOULD A FLOOR DRAIN TO SANITARY NOT BE POSSIBLE, INSTALL A 30"x30"x30" SUMP PIT AND SUMP PUMP (SEE ITEM #2 FOR DETAILS ON SUMP PUMP REQUIREMENTS.

2. SUMP PUMP (IF REQUIRED) SHALL BE ZOELLER HI-TEMP MODEL M3161. PROVIDE HIGH WATER LEVEL ALARM TO BE TIED INTO BUILDING CONTROLS.

3. PROVIDE LADDER LADDER WITH RUNGS 12" O.C. AND 18" SEPARATION BETWEEN SIDE RAILS. SIDES OF LADDER SHALL BE 3"x3" GALVANIZED FLAT BAR. LADDER RUNG SHALL BE McNICHOLS TRACTION TREAD TYPE - GALVANIZED, 13 GA, 4 ROW, 2.25" WIDE (ITEM# M3LRRST4460) LADDER SHALL HAVE INTEGRAL FEET TO BE BOLTED TO THE FLOOR. PRE-PUNCHEO HOLES AT 12" INTERVALS SHALL BE PROVIDED FOR INSTALLING WALL BRACKETS CAPABLE OF BEING BOLTED TO WALL.

4. HIGH PRESSURE DRIP LEG AND STEAM TRAP ASSEMBLY. REFER TO DUKE STANDARD DETAILS FOR HIGH PRESSURE DRIP TRAP DETAIL.

5. LINKSEAL ASSEMBLY MANUFACTURED BY THUNDERLINE CORPORATION OR APPROVED EQUIVALENT. PROVIDE LINK SEAL AT EACH EXTERIOR WALL PENETRATION.

6. BRONZE SWING CHECK VALVE RATED FOR 200 PSIG CWP & 125 SWP.

7. TWO PIECE THREADED BRONZE BALL VALVE RATED FOR 400 PSIG CWP & 125 SWP.

8. 36"x36" PIT ACCESS CONSTRUCTED FROM STEEL GRATING. PROVIDE HINGES AND HANDLE FOR OPENING HATCH DOOR.

9. PROVIDE STEEL GRATE TO COVER ENTIRE PIT OPENING.

10. PROVIDE HIGH WATER ALARM. ALARM LEVEL SHALL BE SET TO 3" BELOW THE LEVEL OF THE DRIP LEG CAP. ALARM SHALL BE TIED INTO BUILDING CONTROLS.

11. SUMP DISCHARGE PIPING SHALL BE HARD PIPED TO SANITARY SYSTEM. FERNCO TYPE FITTINGS WILL NOT BE AN ACCEPTABLE TYPE OF CONNECTION TO SANITARY SYSTEM.
GENERAL NOTES FOR STEAM PIT CONSTRUCTION

1. DETAILS SHOWN IN THIS DRAWING OUTLINE MATERIALS AND METHODS FOR CONSTRUCTING STEAM ACCEPTANCE PITS FOR PROPER ACCESS AND MAINTENANCE OF STEAM AND CONDENSATE PIPING BUILDING AT DUKE UNIVERSITY AND DUKE UNIVERSITY MEDICAL CENTER.

2. ALL PIPE TO BE ASTM A106 SEAMLESS PIPE. ALL STEAM PIPING 2" AND LARGER AND SUMP PUMP DISCHARGE PIPING SHALL BE SCHEDULE 40. ALL CONDENSATE PIPING AND STEAM SMALLER THAN 2" SHALL BE SCHEDULE 80.

3. VALVES AND FITTINGS AS SPECIFIED IN DETAIL DRAWINGS AND KEYED NOTES.

4. STEAM TRAP ASSEMBLY SHALL BE INSTALLED WITH STEAM TRAP AND ISOLATION VALVES EASILY ACCESSIBLE ONCE ENTERING PIT. TRAP ASSEMBLY SHALL NOT BE INSTALLED WHERE IT COULD BE A TRIP HAZZARD DURING PIT ENTRY.

5. MINIMUM CLEARANCE DIMENSIONS ARE FROM OUTER EDGE OF INSULATION.
NOTES
1. ISOLATION VALVE SHALL BE BRONZE BALL VALVE RATED FOR 600 CWP, 150 SWP. IF GAUGE IS INSTALLED BETWEEN ISOLATION VALVES ON PRV STATION, REFER TO PRV STATION DETAILS FOR FURTHER CLARIFICATION. ALL OTHER INSTANCES, ISOLATION VALVE SHALL BE CLASS 800 CARBON STEEL GATE VALVE.

KEYED NOTES
1. SPRAX SARCO MODEL FT-30 STEAM TRAP, NPT CONNECTION.
2. WYE-STRAINER, NPT CONNECTION, FINE MESH SCREEN.
3. BRONZE BALL VALVE WITH STAINLESS STEEL BALL AND STEM, RATED FOR 600 PSI @ 150 SWP, FINISH WITH SHOULDER NIPPLE AND CAP.
4. CLASS 800 CAST STEEL GATE VALVE, SOCKET-WELD CONNECTION.
5. BLOWDOWN TEST TEE, FORGED STEEL FITTING, WITH SAME BRONZE BALL VALVE INSTALLED ON Y-STRAINER AND DETAILED IN ITEM 95.
6. DFT MODEL SCV STAINLESS STEEL CHECK VALVE WITH X-780 SPRING, NPT CONNECTION.
7. PIPE UNION, FORGED STEEL, NPT CONNECTION.
8. FULL LINE-SIZE DRAIN POCKET UP TO 6" NPS. HALF OF LINE SIZE DRAIN POCKET FOR ALL DIA. OVER 6", BUT NEVER LESS THAN 6".
GENERAL NOTES FOR STEAM TRAP STATION CONSTRUCTION

1. DETAILS SHOWN IN THIS DRAWING OUTLINE MATERIALS AND METHODS FOR CONSTRUCTING STEAM TRAP STATIONS FOR PROPER STEAM CONDENSATE DRAINAGE AT DUKE UNIVERSITY AND DUKE UNIVERSITY MEDICAL CENTER.

2. ALL PIPE TO BE ASTM A53-B SEAMLESS PIPE, SCHEDULE 40 WALL THICKNESS.

3. VALVES AND FITTINGS AS SPECIFIED IN DETAIL DRAWINGS AND KEYED NOTES.

4. TRAP STATIONS TO UTILIZE WELD CONNECTIONS ON UPSTREAM AND DOWNSTREAM ISOLATION VALVES. ALL COMPONENTS AND FITTINGS BETWEEN THE ISOLATION VALVES TO UTILIZE NPT (THREADED) CONNECTIONS.

5. LOCATE UPSTREAM ISOLATION VALVE AS CLOSE AS POSSIBLE TO DIP LEG.

6. LOCATE DOWNSTREAM STEAM TRAP ISOLATION VALVE AS CLOSE AS POSSIBLE TO CONDENSATE RETURN MAIN.

7. INSTALL DIP LEG BLOWDOWN VALVES IN DOWNWARD VERTICAL DIRECTION. IF AVAILABLE SPACE DOES NOT ALLOW FOR THIS METHOD, REVIEW POSSIBLE SOLUTIONS WITH DUKE UTILITIES AND ENGINEERING SERVICES.

8. FINISH ALL BLOWDOWN VALVES WITH OUTLET SIDE PIPE NIPPLE AND CAP. TURN ALL BLOWDOWN PIPING AWAY FROM EQUIPMENT AND PIPING COMPONENTS IN SERVICE. EXTEND PIPING TO GRADE AS NECESSARY TO COMPLY.
TWO-STAGE PRV STATION

KEYED NOTES, DWG. #1

1. 2½" A. LARGER; ANSI CLASS 150. CARBON STEEL GATE VALVE, BUTT-WELD CONNECTION. 2" & SMALLER; ANSI CLASS 300. CARBON STEEL GATE VALVE. SOCKET-WELD CONNECTION.

2. HPS-NPS PRESSURE REDUCING VALVES TO BE ANSI CLASS 250/300 RATED BODY AND CONNECTION.

3. NPS-SPS PRESSURE REDUCING VALVES TO BE ANSI CLASS 125/150 RATED BODY AND CONNECTION.

4. 2½" A. LARGER; ANSI CLASS 150. CARBON STEEL GATE VALVE, BUTT-WELD CONNECTION. 2" & SMALLER; ANSI CLASS 300. CARBON STEEL GATE VALVE, SOCKET-WELD CONNECTION.

5. MINIMUM 6" DIAMETER LIQUID-FILLED PRESSURE GAUGE, WHITE FACE, STAINLESS STEEL INNEALS AND CASING, RATED FOR 600 PSI SERVICE. PROVIDE WITH CLASS 600 O-RING VALVE, SOCKET-WELD CONNECTION AND ANTI-ISPION METAL.

6. BLOWDOWN VALVE SHALL BE BRONZE RATED FOR 600 PSI CVAP & 150 PSI SWP AT 300°F. BLOWDOWN PIPING SHALL BE RATED TO FLOOR, TERMINATED WITH CAP. BLOWDOWN SHALL NOT DISCHARGE ON ANY PIPING, VALVES, OR EQUIPMENT.

7. BLOWDOWN VALVE SHALL BE 3/4" ANSI CLASS 800 CARBON STEEL GATE VALVE, SOCKET-WELD CONNECTION. VALVE SHALL BE VERTICALLY ORIENTED DOWNWARD, ALLOW MIN. 6" BETWEEN BOTTOM OF BLOWDOWN AND FINISHED FLOOR, TERMINATE WITH CAP.

8. CONSTRUCT PER "MEDIUM-PRESSURE STEAM TRAP STATION" DETAIL.

9. CONSTRUCT PER "LOW-PRESSURE STEAM TRAP STATION" DETAIL.

10. ROUTE PRV VENT PIPE TO EXTERIOR INDEPENDENTLY. DO NOT TIE TO FLASH TANK OR C/A, VENT PIPE.

11. PLACE VALVE AS NEAR AS POSSIBLE TO REVER PIPE. MIN. 10 PIPE DIAMETERS STRAIGHT LENGTH DOWNSTREAM OF PRV.

12. USE OF NOISE SUPPRESSOR AT DISCRETION OF DESIGNER.

13. FOR LONG DISTANCES OF RELIEF PIPING WHERE THERMAL EXPANSION AT DISCHARGE IS A CONCERN, DESIGNERS MAY USE EXPANSION COMPENSATOR IN LIEU OF DRAIN PAN ELBOW.

14. VERIFY ACCELERATING STEAM METER, REQUIRES NO UPSTREAM OR DOWNSTREAM STRAIGHT LENGTHS OF PIPING.

15. 3/4" DRAIN VALVE, INSTALL WITH THREAD-LET, BRONZE BALL VALVE RATED FOR 600 PSI CVAP & 150 PSI SWP AT 300°F WITH SHORT PIPE NIPPLE.

16. MINIMUM 4" DIAMETER LIQUID-FILLED PRESSURE GAUGE. WHITE FACE, STAINLESS STEEL INNEALS AND CASING, RATED FOR 600 PSI SERVICE. PROVIDE WITH BRONZE BALL VALVE, NPT CONNECTION RATED FOR 600 PSI CVAP & 150 PSI SWP AT 300°F AND ANTI-ISPION METAL.
GENERAL NOTES

1. THIS DRAWING IS INTENDED AS A CONCEPTUAL GUIDE ONLY. MECHANICAL DESIGNER

2. ALL PIPING SHOWN WITHOUT INSULATION FOR ILLUSTRATIVE PURPOSES.

3. DESIGNER RESPONSIBLE FOR PROPER PIPE SIZING, PRESSURE REDUCING VALVE SIZING, AND ANCILLARY COMPONENT SELECTION. DESIGNER AND/OR INSTALLING CONTRACTOR EXPECTED TO PROVIDE FINITE ELEMENT ANALYSIS OF PIPE STRESSES AND THERMAL EXPANSION IN STEAM SYSTEM PRIOR TO INSTALLATION.

4. ROTATE VALVES AND VALVE HANDLES RADially AS NEEDED FOR ACCESSIBILITY AND OPERATION.
NOTE: IF NO MEDIUM PRESSURE STEAM USERS EXIST, BUT 2-STAGE PRESSURE REDUCTION IS DESIRED FOR PROPER PRV OPERATION, DESIGNER MAY ADD SAFETY RELIEF VALVE FOR MPS.

MATCH LINE A-A

MATCH LINE B-B

TWO-STAGE PRV STATION

2017 - Q3
Sustainable Building

1. GENERAL

A. In 2015 The Duke University Board of Trustees adopted the Duke Sustainable Building Policy, which will allow Duke University to continue to be a leader in sustainability and reinforces recommendations of the 2009 Duke Climate Action Plan. This Policy is overseen by the Board of Trustee’s Facilities & Environment (F&E) Committee. The Guideline described herein supports the Sustainable Building Policy serving architecture, engineering, and construction teams working for Duke in addressing energy and water efficiency goals for building projects.

B. Duke University designs and constructs sustainable and efficient facilities on Campus.

C. Duke University decides on a project-by-project basis whether or not third-party green building certification will be pursued, and if so, what level of certification is desired. Project Initiation documentation, provided to the F&E committee, must indicate this information.

2. REFERENCED DOCUMENTS

D. Duke University Sustainable Building Policy

E. Energy Modeling Information Form

F. Sustainable Guideline Checklist

G. Duke Master Planning Principles document

3. SUSTAINABLE DESIGN

A. Duke University designs sustainable and efficient facilities on campus.

B. New construction and major renovation projects should be designed to achieve a 30% energy performance improvement over baseline design as outlined by ASHRAE 90.1-2007, Appendix G, requiring the development of an accurate Whole Building Energy Simulation model. Note that this performance goal is based on energy savings, not cost savings.

C. Project teams should design new construction and major renovation projects to achieve a 35% water consumption savings over baseline design as outlined in the LEED v 2009 baseline calculation.

D. The accuracy of the model is critical to prediction and budgeting for the life cycle cost of our buildings. Additionally, an accurate energy simulation model will aid in maximizing available LEED credits, and the selected credits are meant to ensure accuracy of the
model. To encourage the effort and to ease communication, the modeler should use the attached forms for identifying modeling input and output values for Duke review.

E. Design teams should utilize building energy modeling during all phases of the project, beginning in early schematic design, through complete construction documentation.

F. Whole Building Energy Simulation

1. Project designers should generally use the “purchased utilities” option when developing the energy model, as central chilled water, heating hot water, steam, and electrical services are generally provided to buildings at Duke. This is preferred to modeling a “virtual plant.”

2. The choice of software is left to the modeler; however, Trane TRACE, DOE 2.x- or EnergyPlus-based systems are recommended due to ubiquity in the engineering and design community.

3. Designers will provide to Duke FMD both hard and electronic copies of the input and output information developed during the whole building energy simulation process. These should be provided in .pdf or other commonly-distributed file formats, such that the native modeling software is not required to review the information.

4. Designers and modelers should reference and provide the requested information on the attached, Duke FMD-provided Energy Modeling Information Form in addition to other model output deliverables. This form allows summary information to be easily communicated to the project team.

G. Life Cycle Cost Modeling for Energy, Water, and Other Utilities

1. Project designers should use the resultant energy and water consumption information to develop a Life-Cycle Cost Analysis that should be used to inform the design process. A 20-year time period should be the typical consideration.

2. The “value engineering” process should specifically avoid the reduction or removal of design strategies that demonstrate long-term energy and water efficiency or demonstrate a positive impact on overall life cycle cost of a facility.

4. **GREEN BUILDING CERTIFICATION (IF APPLICABLE)**

H. Pursuant to the Sustainable Building Policy, Project Initiation documentation provided to the Board of Trustee’s Facilities & Environment Committee shall indicate if LEED certification through the USGBC is planned on being achieved for a project, and at what target certification level.

I. Specific Credit Guidance, LEED v2009

1. All Sustainable Sites (SS) credits should be considered during the design process.
2. The following Water Efficiency (WE) credits should be pursued, with the displayed minimum point accrual goals:
   a. WE credit 3, Water Use Reduction
   b. *WE credit 1 and WE credit 2 should typically be avoided, unless specifically identified as a project goal.*

3. The following Energy & Atmosphere (EA) credits should typically be pursued:
   a. EA credit 1, Optimize Energy Performance
   b. EA credit 3, Enhanced Commissioning
   c. EA credit 5, Measurement and Verification (typically Option D)
   d. *EA credit 6 should typically be avoided, unless specifically identified as a project goal.*
   e. All other EA credits should be considered during the design process.

4. All Materials and Resources (MR) credits should be considered during the design process.

5. The following Indoor Environmental Quality (IEQ) credits should typically be pursued
   a. IEQ credit 6.1, Lighting Controllability
   b. IEQ credit 6.2, Thermal Comfort Controllability
   c. All other IEQ credits should be considered during the design process.

6. Potential Innovation in Design credits should be explored during the design process.

7. Regional Priority credits should be considered during the design process.

J. Guidance, Future Green Building Standards

1. This document and associated reference documents will be updated as required as projects should Duke pursue future versions of green building rating systems.

5. Project Approval Steps

2. Design Approval documentation provided to the F&E committee will include:
   a. target energy use in kBtu/GSF per year for the project
   b. and target LEED certification level, if applying for LEED

3. Construction Approval documentation provided to the F&E committee will include:
a. Target energy use in kBtu/GSF per year for the project

b. Anticipated level of LEED certification, if applying for LEED

c. A projected LEED scorecard point total, if the project were to be submitted, for internal use at Duke.

6. Data Collection & Design Feedback

K. As part of the Commissioning process, Duke FMD conducts a collaborative review of 10-month post-occupancy/warranty item review.

L. After 18 months of building occupancy, Duke FMD will host a collaborative building performance review with architecture, engineering, and construction team members. At this time, the team will review energy and water consumption data, and if required, discuss ways to mitigate poor building performance and inefficiency.