Washington University

Design Guidelines for Engineered Building Systems

Office of Facilities Planning & Management Department
Washington University
St. Louis, MO 63130

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# WASHINGTON UNIVERSITY

Design Guidelines
for
Engineered Building Systems

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WASHINGTON UNIVERSITY

DESIGN GUIDELINES
FOR
ENGINEERED BUILDING SYSTEMS

PART 1  INTRODUCTION

The administration of Washington University manages design and construction of new and existing facilities on the campus through the Facilities Planning and Management Department, hereinafter called the Owner. It is the responsibility of this department to assure that all design and construction is carried out in a manner consistent with the policies of the Board of Trustees of the University and in such a way as to provide maximum support for the mission of the institution.

To that end, the Owner encourages all design professionals engaged in these activities on behalf of the University to exercise their highest degree of professional skills and expertise consistent with these objectives, as defined by the following parameters. Furthermore, the department will strive to work with both the designers and the installing contractors in a cooperative manner to assist them in successfully achieving the objectives of the respective project.

For the purposes of this document, Engineered Systems shall include HVAC, Plumbing, Fire Protection, Natural Gas, Fuel Oil, Electric, Safety, Communication, Data, Sewage, and Drainage systems.

PART 2  GENERAL

All engineered systems shall be designed with optimum consideration for the following parameters which will be monitored closely by the University, who will assist the designers in every reasonable way but who will in no way interfere with the designers responsibility for affecting a design which complies in all respects with the objectives and constraints stated herein.

Objectives

The basic objective of each design shall be to provide the respective systems for the building program as established in conferences and workshops among the Owner, Architect and Representatives of the respective engineering disciplines.

The program statements shall be complemented by established standards of performance and statistical variables which shall be established in the early phases of design so as to avoid any later misunderstanding relating thereto.

In addition to these primary objectives, there shall be a series of secondary objectives which shall serve as design parameters. Where applicable, the designs shall employ University Standards - which, along with these parameters shall be mandatory for all University Projects. If, in any event, such standards are determined by the engineer to be inconsistent with accepted design practice, safety standards, normal standards of care, or the engineer's best judgment, he shall so inform the Owner prior to commencing with the project so that the Owner may waive a specific requirement.
or the engineer may be relieved of the assignment, whichever is applicable.

PART 3 DESIGN PARAMETERS

In the selection and design of mechanical, fluid and electrical systems the following parameters shall be addressed.

- Performance
- Simplicity
- Power and Energy
- Cost
- Reliability
- Durability, Maintainability & Serviceability
- Operational Considerations
- Flexibility

A brief description of the objectives and baseline requirements for each of these parameters follows. It will readily be seen that there are close interrelationships among all of the parameters. Properly executed they are all inter-supportive, and "tradeoffs" are seldom required; i.e., a simple system is usually a less expensive system; a less expensive system, well engineered, is often a more energy conservative system, etc.

Performance

All systems shall be designed to provide indoor environmental conditions necessary for human comfort and health at all times of occupancy and maintain the space under control at pre-established conditions during non-occupancy hours. These conditions shall include control of temperature, humidity, air motion, mean radiant temperature, air quality (purity), thermal consistency, light and sound. Precise environmental conditions shall be in accordance with appropriate ASHRAE and IES standards or as agreed to between the designer and the Owner. Performance of other systems shall be in accordance with the appropriate standards and codes.

Simplicity

Albert Einstein once said "everything should be made as simple as possible but not simpler". Recognizing that the successful accomplishment of the design objectives for a contemporary building requires a certain level of technical complexity should not prevent the designer from striving for the goal "as simple as possible". Simplicity will enable the contractor and his tradesmen to more clearly understand and to more accurately and successfully carry out the objective of the designer. Simplicity will enable the University operations staff to more successfully operate the system in accordance with the concepts envisioned by the engineer. And simplicity will, through numerous channels of maintenance, service, and operational success, promote the longevity of the system and prevent early obsolescence.

In incorporating simplicity into the designs the following guidelines should be followed and will be used as a basis of design review by the Owner:

1. All energy distribution and conveying systems including air ducts, steam and water piping, drain piping, electric power conduits and control cables, fire protection and sprinkler piping should be geometrically analyzed to provide the shortest lengths possible between the sources and each terminal device or
connection, while maintaining symmetrical distribution and 90 degree or parallel geometry.

2. Efforts should be made to avoid confusion in the purpose of various subsystems that relate to one another. As an example, ventilation air (which is that outdoor air which is introduced into and removed from the building to provide a safe environment free of harmful gases and odors) should preferably not be confused with outdoor air being introduced for thermal purposes (economizer cycle). Another example would be that energy conservation efforts such as varying the speed of a fan or pump should not be confused with on-line control devices such as control valves and dampers that are inherent components of variable flow control systems.

3. Temperature control systems should be kept as simple as possible.

4. Temperature control systems and fluid systems should be designed in modular concept with interlocked communication with the system as a whole; thus, each module shall be limited to a readily understandable and definable unit. As an example, a given air handling system shall have a control "system" totally capable of providing all control functions related to that specific unit. It shall then be connected to a building wide system capable of monitoring each such subsystem, providing operational mode signals, reset functions, etc. The building-wide system shall, in turn, be connected to the campus Ethernet for information and command exchange with the campus system, which shall have similar information and command exchange capabilities. Another example would be extensive hydronic fluid systems in which the use of decoupled secondary pumping circuits would provide modular subsystems which could be readily understood, diagnosed and controlled.

Power and Energy

In the design of its buildings, the University considers the conservation of energy a fundamental ethic and expects all design professionals to employ this ethic in the implementation of their respective designs. Realistically, cost constraints and simplicity will limit more complex or extreme measures related to energy conservation, but application of the principles described herein is mandatory for all designs on the University Campus.

Power as it is incorporated into building designs relates to the size of the machine or apparatus required to accomplish a task. Since cost in turn is directly proportional to size, if the power can be held to a minimum the cost will be held to a minimum. Below are a series of limitations on power that is mandated for all campus building designs. If, due to unique performance requirements, or the need to satisfy other parameters, power levels in excess of those stated are required, the designer shall apply for and receive a variance from the Owner. To apply for such a variance he shall submit sufficient calculations and data to the Owner.

Power and power related limitations for building systems shall be as follows. Design power requirements less than these values are certainly encouraged.

Lighting: ASHRAE Standard 90.1

Building Envelope: ASHRAE Standard 90.1
Design conditions for heating and cooling loads:

- Summer: Indoor 72°F db, 50% rh
- Outdoor 95°F db, 78°F wb
- Winter: Indoor 70°F db
- Outdoor 0°F db

Equipment Rooms: 85°F maximum, 65°F minimum

Ventilation: Minimum "standard" CFM as established by latest edition of ASHRAE Standard 62, including addendums or the process requirement

Maximum air circulation rate for space cooling: 1 CFM per square foot of conditioned space

Total air system pressure requirement limit for space conditioning system for the total of the supply and return air fan systems: 5 inches water column

Total water system head loss (Cooling or Heating): 70 feet

Water chiller power: 0.6 kilowatts per ton

Water chiller auxiliary power: 0.15 kilowatts per ton

Unitary cooling system power: 1.0 kilowatts per ton

Boiler Efficiency (non-condensing): 84%

Domestic Hot Water (condensing): 94% at 100°F EWT

Energy use shall be minimized by the sequential application of the following techniques:

1. Design to hold all power requirements at their lowest possible value.

2. Provide a controlled unoccupied cycle for all HVAC systems to hold the unoccupied space at a predetermined setback temperature in the winter, hold the indoor dew point at a predetermined setpoint in the summer, reduce or eliminate ventilation air, and reduce air circulation rates to the lowest possible level to maintain the conditions, while consuming a minimal amount of primary and auxiliary system energy.

3. Reduce the flow rates with reduction in load for all air systems (VAV) to the extent possible while maintaining adequate space air circulation. Configure system design to approximate the cubic reduction in power with flow reduction.
4. Reduce water system flow rates with reduction in load (variable flow systems). Configure system design to approximate the cubic relation in turndown with flow reduction.

5. Where laboratory hoods are used in science facilities, special precautions shall be taken to minimize their adverse impact upon the space conditions and the energy and power requirements to operate the hoods. Such steps shall include methods to turn off hoods when not in use, diversity considerations in exhaust and makeup air systems, conditioning of all makeup air, variable capacity of exhaust quantities with variations in hood requirements, variable capacity of makeup air with variations in hood requirements and heat recovery between exhaust and supply air.

6. Provide systems for thermal interchange between exhaust air and make-up air, limiting the cost of such systems to no more than five times the annual energy cost avoidance.

7. In addition, all building materials, systems, and equipment shall comply with the latest publication of the applicable standard in the ASHRAE Standard 90 Series.

8. Domestic hot water systems shall be distributed type, utilizing minimum piping and arranged for “off cycling” during non-occupied hours.

9. All three-phase electric motors shall be NEMA Premium energy efficient motors. Motors shall not be oversized for actual load. Motor efficiency and power factor significantly decreases below 50% motor load.

Comparative analysis should be based upon the following energy rates. First cost data to be used only when actual cost are not yet know.

<table>
<thead>
<tr>
<th>Energy</th>
<th>Rate</th>
<th>Description</th>
<th>Cost</th>
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<tbody>
<tr>
<td>Electricity</td>
<td>$150/kVA Demand</td>
<td>(First Cost)</td>
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<tr>
<td></td>
<td>4¢/KWh Energy</td>
<td></td>
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<tr>
<td>Natural Gas</td>
<td>85¢/therm Energy</td>
<td></td>
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<tr>
<td>Steam</td>
<td>$60/MBH Demand</td>
<td>(First Cost)</td>
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<tr>
<td></td>
<td>$12/million Btu Energy</td>
<td></td>
<td></td>
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<tr>
<td>Chilled Water</td>
<td>$1,250/Ton Demand</td>
<td>(First Cost)</td>
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<tr>
<td></td>
<td>4¢/Ton Hour Energy</td>
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Cost Control

Each Building or project will have a unique budget assigned which will represent the current construction market condition, construction cost indices, and type of facility. Regardless of the specific budget, however, designers of all mechanical, electrical, plumbing and safety system shall exercise certain controls beginning with the conceptual designs to maintain the construction costs at the lowest level consistent with the other design parameters. The following steps of cost control through design shall be followed on all projects:

1. The engineer for each component of the work (i.e. HVAC, plumbing, electrical, etc.) shall participate in the establishment of the budget for each component
respectively and shall certify that in his professional opinion, the scope of work can be accomplished within that budgetary amount before proceeding with the design.

2. Designs shall not employ "hidden" safety factors. However, safety factors considered by the design engineer to be necessary and to be within the limits of accepted practice shall be employed, but shall be clearly identified during design reviews.

3. Lengths of all piping, power, communication and all distribution systems shall be held to a minimum through use of multiple source systems (such as fan systems) and geometric analyses of configurations and network options.

4. Where square or rectangular ducts are used, aspect ratios of all air ducts shall be held as close as practical to unity. All fittings shall be designed to minimize flow separation and to have the lowest practical $C_a$ value.

5. Air systems shall be designed as low pressure, low velocity.

6. Air flow quantities shall be held to the minimum quantities required to serve the loads or satisfy relevant standards or building codes.

7. Materials employed shall represent the best available technology and shall be suitable for the purposes intended, but shall not employ material weights, thickness, or surface conditions in excess of the lowest value necessary for performance and safety, and consistent with accepted industry practice.

8. Unless there are extenuating circumstances or overriding University standards, (see Part 7) a minimum of three manufacturers shall be specified for all items of equipment.

Reliability

In the design of all systems and machinery, consideration shall be given to total systems reliability commensurate with the requirements of the respective building or space. Use of redundant or "stand-by" machinery is discouraged unless for special requirements because of its impact upon first cost and ownership burden. Adequate reliability in most situations is inherent in equipment and machinery of the standard of quality described elsewhere in this guideline and shall be inherent in the design philosophy employed. Examples of design techniques to enhance reliability are:

1. When designing pumping systems, multiple pumps in parallel are recommended such that if an "on" pump fails or is otherwise out of service, the remaining pump or pumps can provide continued service at a modest reduction in capacity. Stand-by pumps are discouraged.

2. When designing an electronic variable speed motor drive (VSD) into a circuit, a three contactor bypass, and magnetic starter shall be provided to assure service when the VSD is unavailable.
3. All temperature control systems and devices shall be designed to fail in a pre-determined "fail-safe" mode, which mode shall specifically be described in the sequence of operation. All safeties shall be hardwired and operate without power.

4. Electric or electronic safety and signal systems shall be provided with a self monitoring feature to signal when a circuit or component is not functional or otherwise is out of service. If this is not practical, a simple, integral test cycle shall be employed.

Specific reliability shall be reviewed with the Owner, and to accommodate considerations of anticipated failures, adequate load shedding or other relevant techniques shall be developed early in the design process.

Durability, Maintainability, Serviceability

Only institutional quality machinery, materials, fixtures and equipment shall be utilized in the mechanical and electrical systems unless specifically requested by the owner. Appliance quality or commercial quality machinery shall not be used. Decisions regarding the selection shall be based upon the following:

1. No below-grade equipment rooms (electrical and/or mechanical) will be allowed if they are below the level that would allow gravity drainage through the sanitary or combination sewer system. In addition, such below-grade equipment rooms shall be provided with no smaller than 6" floor drains appropriately spaced, one of which shall be located in a sump sized for the emergency installation of an emergency high capacity sump pump. All sanitary drain lines from below-grade equipment rooms shall be provided with a backflow (check) valve at the manhole connection.

2. Storm drains shall exit the building at the highest allowable location. For buildings with a lower level the storm piping should not continue to below the lower level floor if they can exit at a higher elevation.

3. Main equipment room shall be provided with a sink, electric water cooler, and safety shower.

4. Equipment rooms shall be designed to maintain 8 foot clear below piping, ducts and equipment

5. Building service transformers and primary switching shall be installed indoors above-grade level (preferably) or in a below-grade equipment room when possible. If this is deemed impractical, they shall be installed outdoors on-grade. No piping containing water or waste, including fire protection mains, shall be installed in rooms housing main electrical switchgear.

5. Accessibility for service shall be provided to all moving or wearing parts and components that require inspection, cleaning, adjusting, connection or replacing.

6. Construction contracts shall require complete Maintenance and Service manuals for all mechanical, electrical, and electronic equipment, and the engineer for the respective system shall take reasonable steps to assure that no requirements for such maintenance have been overlooked.
7. Equipment shall be capable of no less than 30 years of service, free of rattles, vibration, corrosion, erosion, wear, or other failure of non-maintainable or readily replaceable components. If, in special cases, it is deemed necessary to install equipment of less anticipated service life, such cases shall be limited to unitary type equipment which can be replaced in whole as a shorter term maintenance requirement.

8. If possible, equipment shall be employed which does not require special technical skills for operation, maintenance or service, and which utilizes readily available components.

9. If special skills are required for service or maintenance they must be readily available from local service agencies. Components shall be available from local stock or obtainable by overnight delivery.

10. The design of all machinery and apparatus must be arranged for easy inspection, maintenance, service and removal. Major components such as coils and tubes must be readily cleanable and removable without removing any building element.

11. All electrical equipment shall be designed to NEMA standards where applicable.

Operational Considerations

Systems and equipment selection shall consider understandability and ease of operation in all regards. The systems shall be designed such that failure of control system power will move the controls to a predetermined fail-safe operating mode. All fail-safe features shall be reviewed during the schematic design review. Unless there are more overwhelming reasons that dictate, heating/cooling systems shall fail-safe in the "heating" mode.

All systems and devices shall be capable of remote setpoint adjustments, operating mode selections, and performance monitoring by the campus energy management system.

Flexibility

The campus facilities are continually in a state of change and modification. Thus, all systems shall be designed such that they will be readily adaptable to modifications in terminal configuration, expansion, capacity changes, and system supplements. Adequate spaces shall be allowed in all buildings to reasonably accommodate future needs for conduits, pipes, duct work and machinery.

Structural, mechanical, and electrical systems shall be established during the schematic design phase and the coordination between these designs shall be such that serious constraints are not placed upon the flexibility of any of these systems either as the design progresses or as subsequent needs might dictate.

PART 4 DRAWINGS AND SPECIFICATIONS

The drawings and specifications for the MEP systems represent a major component of the contract documents. As such, they should mutually describe in a clear and concise manner the full intent of the design and the responsibilities of the installing contractors from preliminary matters through post-construction services. During the planning phase and the development of the documents, the
drawings are to serve as communication documents.

The drawings and specifications shall contain any and all information which in the judgment of the architect/engineer is necessary to achieve the contractual objectives. There will be three stages of formal review, and the engineer shall not proceed to the subsequent phase of the project until approval of the respective phase has been obtained. As a minimum the documents for each respective phase shall include the following information:

Schematic Design Phase:

A review of these documents will take place at the completion of the preliminary design phase and prior to the initiation of design development documents. Documents and information submitted shall include the following as applicable:

- Budget estimate of construction cost with documentation.
- Flow diagrams of all fluid systems (ladders format for liquid systems) including flow values.
- Air system balances and flow diagrams including flow values.
- Equipment location and routing of pipe and duct mains.
- Preliminary draft of all specification data with types and sizes of all major equipment.
- Evidence of compliance with all applicable codes.
- Temperature control schematic diagrams with sequence of operations.
- Proposed or tentative material list for all materials, devices, and fixtures.
- Preliminary electrical load schedules, including standby power loads.
- Power riser diagrams.
- Electrical safety and signal systems; locations of devices and logic diagrams
- Scope and routing of communications and data systems.
- Typical plumbing chase layouts.
- Preliminary energy analysis and annual energy cost estimates.
- Fire protection and sprinkler zones, fire department connection location.
- Fire protection piping flow diagrams.
- Preliminary analyses of fire protection hydraulic (flow and pressure) requirements.
- Domestic hot and cold water system (flow and pressure) analyses.
- Summary of utility systems (cooling, heating, electric, water, gas) requirements - demands and consumptions.
- HVAC load calculations.
- ASHRAE 90.1 building envelope calculation.
- ASHRAE 90.1 lighting calculation.

Design Development Phase:

- Updated cost estimates with documentation
- Statement of any changes in scope (increases or decreases).
- Review of all user interface requirements and locations.
- Duct routing - floor plans and sections.
- Pipe and conduit routing.
- Equipment room layouts.
- Equipment schedules.
- Update of schematic diagrams of all systems, including flow values, submitted in the schematic design phase.
- Update of energy requirements including annual cost estimate.
- Update of HVAC load calculations.
Update of ASHRAE 90.1 building envelope calculation.
Update of ASHRAE 90.1 lighting calculation.
Electrical short circuit study and coordination study.
Maintenance - Service Clearances.
Equipment Access.
Weights of major machinery and equipment and dynamic loading information.
Wall and roof openings.
Plumbing fixtures and fittings.
Lighting fixture layout, selections and schedules.
Reflected ceiling plans showing lighting, diffusers and proposed sprinkler head locations.

Construction Documents:

There will be numerous revisions during the development of the construction documents on most projects. No project will be allowed to proceed to the bidding phase until and unless completed documents have been reviewed and have been found to comply with these requirements and have been found to include, as a minimum, the following information:

- Updated construction cost estimate with documentation.
- Statement of any changes in scope (increases or decreases).
- Completed floor plans, sections, and elevations showing routing and sizing of all wiring, (except routing of branch circuiting), piping, and ductwork, and location of all equipment, panels, and machinery.
- Construction details showing methods of construction, joining, supporting, instrumentation, and other data necessary to fully establish and to inform the installers as to the intended methods of construction and installation.
- Piping connection details, isometrics, and appropriate riser diagrams.
- Flow diagrams (ladder format where applicable) for all liquid fluid systems and air systems, including flow rates, sizes, capacities, etc.
- Electrical power riser diagrams showing sizes (capacities) of all transformers, panels, conduits, cables, fuses, switches and circuit breakers.
- Auxiliary electrical system riser one-line diagrams showing number and types of cables, connections, devices, and locations, as appropriate, for all control, alarm, communication and other ancillary electrical system.
- Schedules of fixtures, materials, motors, and equipment requirements.
- Specifications appropriately describing contractor responsibility, construction methods and all material and equipment.
- Final energy analysis and utility cost estimate.
- Final electrical short circuit study and coordination study.
PART 5  UTILITY SERVICES

The city limits, code authorities, and utility services vary for different areas of the Campus. The following provide an overview of the different areas of Campus.

PART 5A  DANFORTH UTILITY SERVICES

Code Authority: The Danforth Campus is located in unincorporated St. Louis County and the fire protection is contracted with the city of Clayton.

Electricity: Electric service on campus is available from the campus distribution system at a primary voltage of 4160 volt 3 wire wye. The distribution system is a ‘Loop’ configuration. Each loop is protected by a pair of Cutler-Hammer 400E boric acid expulsion fuses. The building design shall coordinate with the 400E fuses. Service to new buildings shall be provided through (2) 600 Amp non-fused loop switches, fused main switches, and transformation to utilization voltage. For existing facilities, service for modifications or additions shall be integrated with existing building service. The available campus short circuit capacity from the utility company is 20,000 Amps. Each building is to be provided with an electric meter with a demand register.

Steam: The campus is changing from a 125 psig high pressure steam central plant operated from approximately October 15 to May 15, to distributed 10 psig low pressure steam plants operated year round. The Owner shall be consulted for information concerning the availability, location and pressure of steam at any given building site. A 5 psig steam to hot water heat exchanger shall be used for space heating. Campus steam shall not be used for humidification or heating domestic hot water. Steam to each building shall be metered.

Natural Gas: Natural gas is available at most locations from the campus gas distribution system. The gas pressure of the distribution system is 20 psig. The Owner shall be consulted for information concerning the availability, location and pressure of gas at any given building site. Natural gas to each building shall be metered.

Water: The campus water is supplied by Missouri-American and is master metered. The available water pressure on campus is nominally 100 psig. Water for fire protection is nominally 100 psig static. Residual pressures at various flows shall be measured by an actual flow test. There is one water system for both domestic water and fire water. Connections to water mains shall include necessary isolation service valves and back-flow preventers. Domestic water service to each building shall be metered. Fire water service is not to be metered. Fire pumps are prohibited.

Chilled Water: The campus buildings are connected to a one pipe chilled water loop. Space conditions for human comfort and all other loads which are not humidity critical, or not required for critical operation, shall be served by chilled water from the chilled water loop. The nominal temperature of the supply chilled water will vary from 45°F to 50°F, and systems are to be designed to provide comfort conditions with 50°F entering water temperature and no more than 2.4 gpm per ton. When it becomes necessary, as determined by the Owner, to install a loop chiller within a building, the chiller shall be sized as instructed by the Owner and installed in
Drainage: The campus sewer is a combination sanitary/storm drainage system. Building drainage systems shall maintain full separation between storm and sanitary drainage, and connections shall be made to the appropriate system outside the building. Buildings shall drain by gravity flow to sewer mains. The use of pumps is prohibited.

Fire Alarm: The campus fire alarm system is a Simplex Model 4100 Multiplex System with point ID capability, which is designed for an ultimate configuration which will monitor all buildings on the campus. Building fire alarms systems shall be provided to comply with all applicable codes. In addition the University requires smoke detectors in common corridors spaced at a maximum 30’ and in public restrooms. Building fire alarms systems shall interface with the campus system; the building system shall include a network card.

Tele-Communications: A Plexar Telephone System serves the campus; building phone systems will be integrated with this system. The phone cables home run to Brookings Hall. The Owner will determine the point of connection and route to the building’s Service Entrance and Termination Room. The inner building voice system infrastructure is a Category 5E twisted pair solution. Building designers shall coordinate the requirements with the Owner, and under the building contract, a complete system shall be provided.

Data System: The data system runs off a fiber optic backbone that shall be provided with a connection from a regional hub into the building terminating in a fiber enclosure in the Service Entrance and Termination Room. The inner building data system infrastructure is a Category 6E twisted pair solution. Building designers shall coordinate the requirements with the Owner, and under the building contract, a complete system shall be provided.

Campus Lighting: Electric power for campus or building exterior lighting shall be provided from the building service. Exterior lighting shall follow the Campus Site Lighting Standard.

PART 5B SOUTH FORTY UTILITY SERVICES

Code Authority: The South Forty Campus is located in the City of Clayton.

Electricity: Electric service on campus is available from the campus distribution system at a primary voltage of 4160 volt 3 wire wye. The distribution system is a ‘Loop’ configuration. Each loop is protected by a pair of Cutler-Hammer 400E boric acid expulsion fuses. The building design shall coordinate with the 400E fuses. Service to new buildings shall be provided through (2) 600 Amp non-fused loop switches, fused main switches, and transformation to utilization voltage. For existing facilities, service for modifications or additions shall be integrated with existing building service. The available campus short circuit capacity from the utility
company is 20,000 Amps. Each building is to be provided with an electric meter with a demand register.

**Heating Water:**

The campus is changing from a central 2-pipe hot/chilled system, to a central year round 2-pipe chilled water system and distributed heating water plants. The Owner shall be consulted for information concerning heating water availability and location at any given project site. Heating water to each building shall be Btu metered.

**Natural Gas:**

Natural gas is available at most locations from the campus gas distribution system. The gas pressure of the distribution system is 5 psig. The Owner shall be consulted for information concerning the availability, location and pressure of gas at any given building site. Natural gas to each building shall be metered.

**Water:**

The campus water is supplied by Missouri-American and is master metered. The available water pressure on campus is nominally 100 psig. Water for fire protection is nominally 100 psig static. Residual pressures at various flows shall be measured by an actual flow test. There are separate systems for domestic water and fire water. Connections to water mains shall include necessary isolation service valves and back-flow preventers. Domestic water service to each building shall be metered. Fire water service is not to be metered. Fire pumps are prohibited.

**Chilled Water:**

The campus is changing from a central 2-pipe hot/chilled system, to a central chilled water system and distributed heating water plants. The system is a primary/secondary plant, with the buildings having tertiary pumps. The system has a 45°F supply temperature with a 12°F temperature difference. Chilled water to each building shall be Btu metered.

**Drainage:**

The campus sewer is a combination sanitary/storm drainage system. Building drainage systems shall maintain full separation between storm and sanitary drainage, and connections shall be made to the appropriate system outside the building. Buildings shall drain by gravity flow to sewer mains. The use of pumps is prohibited.

**Fire Alarm:**

The campus fire alarm system is a Simplex Model 4100 Multiplex System with point ID capability, which is designed for an ultimate configuration which will monitor all buildings on the campus. Building fire alarms systems shall be provided to comply with all applicable codes. In addition the University requires smoke detectors in common corridors spaced at a maximum 30’ and in public restrooms. Building fire alarms systems shall interface with the campus system; the building system shall include a network card.

**Tele-Communications:**

A Plexar Telephone System serves the campus; building phone systems will be integrated with this system. The phone cables home run to Danforth Residence Hall. The Owner will determine the point of connection and route to the building’s Service Entrance and Termination Room. The inner building voice system infrastructure is a Category 5E twisted pair solution. Building designers
shall coordinate the requirements with the Owner, and under the building contract, a complete system shall be provided.

**Data System:** The data system runs off a fiber optic backbone that shall be provided with a connection from a regional hub into the building terminating in a fiber enclosure in the Service Entrance and Termination Room. The inner building data system infrastructure is a Category 6E twisted pair solution. Building designers shall coordinate the requirements with the Owner, and under the building contract, a complete system shall be provided.

**Campus Lighting:** Electric power for campus or building exterior lighting shall be provided from the building service. Exterior lighting shall follow the Campus Site Lighting Standard.

**PART 5C DANFORTH EAST SIDE OF CAMPUS UTILITY SERVICES**

**Code Authority:** Part of the east side of campus is located in unincorporated St. Louis County and the fire protection is contracted with the city of Clayton. Part of east side of campus is located in St. Louis City. Contact the project manager to determine which codes will apply to the project.

**Electricity:** Electric service on campus is available from the campus distribution system at a primary voltage of 4160 volt 3 wire wye. The distribution system is a ‘Loop’ configuration. Each loop is protected by a pair of Cutler-Hammer 400E boric acid expulsion fuses. The building design shall coordinate with the 400E fuses. Service to new buildings shall be provided through (2) 600 Amp non-fused loop switches, fused main switches, and transformation to utilization voltage. For existing facilities, service for modifications or additions shall be integrated with existing building service. The available campus short circuit capacity from the utility company is 20,000 Amps. Each building is to be provided with an electric meter with a demand register.

**Heating Water:** There is a hot water heating plant located in Whitaker Hall to serve buildings located north of Brookings Drive. There is a hot water heating plant located in the Kemper Gallery building to serve buildings located south of Brookings Drive. Both systems are primary/secondary plants, with the buildings having tertiary pumps. Both systems have a 200°F supply temperature with a 40°F temperature difference. Heating water to each building shall be Btu metered.

**Natural Gas:** Natural gas is available at most locations from the campus gas distribution system. The gas pressure of the distribution system is 20 psig. The Owner shall be consulted for information concerning the availability, location and pressure of gas at any given building site. Natural gas to each building shall be metered.

**Water:** The campus water is supplied by St. Louis City and is master metered. The available water pressure on campus is nominally 80psig. Water for fire protection is nominally 80 psig static. Residual pressures at various flows shall be measured.
by an actual flow test. Connections to water mains shall include necessary
isolation service valves and back-flow preventers. Domestic water service to each
building shall be metered. Fire water service is not to be metered. Fire pumps are
prohibited.

**Chilled Water:**

The campus buildings are connected to a one pipe chilled water loop. Space
conditions for human comfort and all other loads which are not humidity critical,
or not required for critical operation, shall be served by chilled water from the
chilled water loop. The nominal temperature of the supply chilled water will vary
from 45°F to 50°F, and systems are to be designed to provide comfort conditions
with 50°F entering water temperature and no more than 2.4 gpm per ton. When it
becomes necessary, as determined by the Owner, to install a loop chiller within a
building, the chiller shall be sized as instructed by the Owner and installed in
accordance with the University Standards. (See Part 6) Chilled water to each
building shall be Btu metered.

**Drainage:**

The campus sewer is a combination sanitary/storm drainage system. Building
drainage systems shall maintain full separation between storm and sanitary
drainage, and connections shall be made to the appropriate system outside the
building. Buildings shall drain by gravity flow to sewer mains. The use of pumps
is prohibited.

**Fire Alarm:**

The campus fire alarm system is a Simplex Model 4100 Multiplex System with
point ID capability, which is designed for an ultimate configuration which will
monitor all buildings on the campus. Building fire alarms systems shall be
provided to comply with all applicable codes. In addition the University requires
smoke detectors in common corridors spaced at a maximum 30’ and in public
restrooms. Building fire alarms systems shall interface with the campus system;
the building system shall include a network card.

**Tele-Communications:**

A Plexar Telephone System serves the campus; building phone systems will be
integrated with this system. The phone cables home run to Brookings Hall. The
Owner will determine the point of connection and route to the building’s Service
Entrance and Termination Room. The inner building voice system infrastructure
is a Category 5E twisted pair solution. Building designers shall coordinate the
requirements with the Owner, and under the building contract, a complete system
shall be provided.

**Data System:** The data system runs off a fiber optic backbone that shall be provided with a connection
from a regional hub into the building terminating in a fiber enclosure in the
Service Entrance and Termination Room. The inner building data system
infrastructure is a Category 6E twisted pair solution. Building designers shall
coordinate the requirements with the Owner, and under the building contract, a
complete system shall be provided.

**Campus Lighting:**

Electric power for campus or building exterior lighting shall be provided from the
building service. Exterior lighting shall follow the Campus Site Lighting
Standard.
PART 5D  WEST CAMPUS UTILITY SERVICES  (Discuss with FPM)

Code Authority: The West Campus is located in the City of Clayton.

PART 5E  NORTH CAMPUS UTILITY SERVICES  (Discuss with FPM)

Code Authority: The North Campus is located in St. Louis City.

PART 5F  CAMPUS UTILITY RELIABILITY

Cooling: The campus cooling system shall not be used for critical spaces or loads. Critical spaces or loads shall be provided with a process chiller, as approved by the Owner.

Electric: Loads that cannot tolerate any power interruptions, including 15 second automatic switching operations, shall be provided with an uninterruptible power supply. Loads that cannot tolerate extended (24 hour) power outage, or loads required by Code, shall be provided with engine generator back-up, as approved by Owner. Power quality is that as supplied by the Utility Company. Loads that require higher power quality shall be provided with a power conditioning unit.
PART 6  STANDARDS OF INTERFACE AND MACHINERY CONNECTIONS

The standards for connection and interfacing building services with campus systems are shown in the figures and related descriptive data on the following pages. The figures are diagrammatic in that they are not intended to show the specific arrangement and configuration of each element of pipe, elbows, offsets, dimensions, etc., but are intended to show the hydraulic requirements, metering methods, electrical switching and protection requirements, etc.

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NOTES:

1) REFER TO SECTION 15120 - PIPING SPECIALTIES FOR CONDENSATE AND HEATING WATER METERS.

2) EXTERIOR PIPING SHALL BE LOCATED BETWEEN 3 FT. MINIMUM AND 5 FT. MAXIMUM FROM FINISHED GRADE.

3) CONDENSATE PUMP HEAD SIZED FOR 3'/100 FT EQUIVALENT PIPE LENGTH PLUS ELEVATION RISE BACK TO THE PLANT.

FIGURE 6-1
LOW PRESSURE STEAM AND CONDENSATE
ENTRANCE DIAGRAM
NOTES:

1) REFER TO SECTION 19120 - PIPING SPECIALTIES FOR HEATING WATER METER.

2) EXTERIOR PIPING SHALL BE LOCATED BETWEEN 3 FT. MINIMUM AND 5 FT MAXIMUM FROM FINISHED GRADE.

FIGURE 8-2
HEATING WATER SERVICE ENTRANCE DIAGRAM
FAST CAMPUS AND S. 40
3 TERMINAL TEST STATION W/ 12"x12"x4" CONCRETE PAD

GRADE

WARNING TAPE

HDPE PIPING 12"

CONTINUOUS PURPLE TRACE WIRE

PREINSULATED STEEL PIPING

MINIMUM UNOBSERVED STRAIGHT LENGTH PIPING DISTANCES.

10 PIPE DIA.

1-1/2" DRAIN VALVES W/HOSE END

SERVICE VALVE (TYPICAL)

MECHANICAL RUBBER SEAL (TYPICAL)

CWS

CWR

CHILLED WATER TO AND FROM BUILDING LOADS

TEMPERATURE SENSORS WITH CALIBRATION WELL

TYPE 1 BUILDING CONNECTION INDICATED ABOVE, SEE FIGURE 6-4 FOR TYPE 2 & 3 METER & SENSOR LOCATIONS.

TYPE 1 BUILDING CONNECTION INDICATED ABOVE, SEE FIGURE 6-4 FOR TYPE 2 & 3 METER & SENSOR LOCATIONS.

NOTES:

1) REFER TO SECTION 1512D - PIPING SPECIALTIES FOR CHILLED WATER METER.

2) EXTERIOR PIPING SHALL BE LOCATED BETWEEN 3 FT. MINIMUM AND 5 FT MAXIMUM FROM FINISHED GRADE.

3) HDPE TO CARBON STEEL TRANSITION PIECE IS A STANDARD MANUFACTURED PIECE FROM THE HDPE PIPING SUPPLIER. REFER TO FIGURE 6-9 FOR ADDITIONAL INFORMATION.

FIGURE 6-3

CHILLED WATER SERVICE ENTRANCE DIAGRAM
TO DANFORTH CAMPUS ONE PIPES LOOP SYSTEM AND 5-40
FIGURE 6-4
CHILLED WATER CONNECTION DIAGRAMS
TO CAMPUS ONE PIPE LOOP SYSTEM

NOTE: ALL EQUIPMENT SERVICE VALVES AND SPECIALTIES ARE NOT SHOWN.
FIGURE 6–5
GAS METER LOCATED IN AREAWELL
FIGURE 6-6
GAS METER LOCATE ABOVE GRADE

25
NOTES:

1) REFER TO SPECIFICATION SECTION 15120—PIPING SPECIALTIES.

2) HUB DRAIN SIZED TO HANDLE DISCHARGE FLOW OF BACKFLOW PREVENTER.

3) EXTERIOR PIPING SHALL BE LOCATED BETWEEN 3 FT. MINIMUM AND 5 FT MAXIMUM FROM FINISHED GRADE.

4) HDPE TO 304 SS TRANSITION PIECE IS A STANDARD MANUFACTURED PIECE FROM THE HDPE PIPING SUPPLIER.

* IF REQUIRED FOR BUILDING

FIGURE 8-7
DOMESTIC WATER SERVICE ENTRANCE DIAGRAM

26
NOTES:

1) HUB DRAIN SIZED TO HANDLE DISCHARGE FLOW OF DRAIN/TEST.

2) EXTERIOR PIPING SHALL BE LOCATED BETWEEN 3 FT. MINIMUM AND 5 FT. MAXIMUM FROM FINISHED GRADE.

3) HDPE TO 304 SS TRANSITION PIECE IS A STANDARD MANUFACTURED PIECE FROM THE HDPE PIPING SUPPLIER.

4) DANFORTH CAMPUS – THE FIRE WATER AND DOMESTIC WATER SHALL SPLIT INSIDE THE BUILDING FROM A COMMON LINE INTO THE BUILDING.

FIGURE 6-B
FIRE PROTECTION WATER SERVICE ENTRANCE DIAGRAM
* HDPE to Carbon Steel Transition Piece is a standard manufactured piece from the HDPE pipe supplier.

**Figure 6-9**
Chilled Water Piping Transition
FIGURE B-11A
PUMPED PREHEAT COIL
FOR FREEZE PROTECTION
T1 = SYSTEM SUPPLY TEMPERATURE
T2 = SYSTEM RETURN TEMPERATURE
T3 = T2 = LWT
GPM2 = GPM1 + GPM3 (RECOMMENDED COIL TUBE VELOCITY 1–3 FPS)
EWT = [(GPM1 x T1 + GPM3 x T3)/GPM2]

EXAMPLE 1 - PREFERRED 2 TIMES THE SYSTEM FLOW. HALF THE SYSTEM DELTA T.

T1 = 200°F
T2 = 180°F
T3 = T2 = LWT
LOAD = 400,000 BTU/HR
GPM1 = 400,000 BTU/HR / (500 x (200°F - 160°F)) = 20 GPM
PICK GPM3 TO BE EQUAL TO GPM1 = 20 GPM
GPM2 = 20 GPM + 20 GPM = 40 GPM
EWT = (20 GPM x 200°F + 20 GPM x 160°F) / 40 GPM = 180°F
COIL: EWT = 180°F, LWT = 160°F, GPM = 40
PUMP: FLOW = 20 GPM
CONTROL VALVE: FLOW = 20 GPM

SEQUENCE OF OPERATION

WHEN THE UNIT IS NOT OPERATING AND THE OUTDOOR AIR TEMPERATURE IS ABOVE 40°F, THE PREHEAT VALVE SHALL BE FORCED CLOSED BY SOFTWARE.

WHEN THE UNIT IS NOT OPERATING AND THE OUTDOOR AIR TEMPERATURE IS BELOW 40°F, THE PREHEAT VALVE SHALL MODULATE TO MAINTAIN MIXED AIR TEMPERATURE AT 80°F.

THE PREHEAT COIL PUMP SHALL OPERATE WHEN THE OUTDOOR TEMPERATURE IS LESS THAN 40°F, UNIT OPERATING OR NOT. IF THE UNIT IS OPERATING AND THE OUTDOOR TEMPERATURE IS LESS THAN 40°F AND THE PUMP IS NOT OPERATING AS DETERMINED BY THE PUMP CURRENT SWITCH, THEN THE UNIT SHALL BE STOPPED BY SOFTWARE.

A HARDWARE INTERLOCK SHALL OPEN THE HEATING VALVE, OPEN THE COOLING VALVE, STOP THE FANS, RETURN DAMPERS TO THEIR NORMAL POSITIONS, AND START THE PREHEAT COIL PUMP ANY TIME THE FREEZESTAT IS TRIPPED.

DISCHARGE TEMPERATURE CONTROL: THE PREHEAT VALVE SHALL MODULATE IN SEQUENCE WITH ECONOMIZER DAMPERS (IF APPLICABLE), AND CHILLED WATER VALVE TO MAINTAIN DISCHARGE TEMPERATURE SETPOINT.

FIGURE 6-118
PUMPED PREHEAT COIL
FOR FREEZE PROTECTION
SWITCH IF BUILDING HAS 4160V CHILLER

NOTES:

1) 5KV SWITCHES SHALL BE 3 POLE, 600 AMP.

2) BUILDING FUSE, TRANSFORMER, AND MAIN CIRCUIT BREAKER SHALL BE SIZED FOR BUILDING LOAD. TRANSFORMER PRIMARY FUSE SHALL COORDINATE WITH CUTLER HAMMER 400E BORIC ACID EXPULSION FUSE.

3) 5KV CHILLER FUSE SHALL BE SIZED FOR THE CHILLER LOAD.

4) SEE SECTION 18210 - ELECTRICAL UTILITY SERVICES FOR METER REQUIREMENTS.

FIGURE 5-12
ELECTRIC SERVICE ENTRANCE
PRIMARY LOOP SUBSTATION
NOTES:

1) DUCT BANK SHALL BE LOCATED BETWEEN 3 FT MINIMUM AND 5 FEET MAXIMUM FROM FINISHED GRADE.

2) DYE AND WARNING TAPE SHALL BE RED FOR ELECTRIC.

FIGURE B-13
ELECTRIC CONDUIT ENTRANCE DIAGRAM
NOTES:

1) DUCT BANK SHALL BE LOCATED BETWEEN 3 FT MINIMUM AND 5 FEET MAXIMUM FROM FINISHED GRADE.

2) DYE AND WARNING TAPE SHALL BE ORANGE FOR TELECOMMUNICATION/DATA.
SKV ACCEPTABLE CABLE PATTERNS WHICH COMPLY WITH MINIMUM CABLE BENDING RADIUS FOR 500MCM WHEN INSTALLED IN A 48"X48" PULL BOX.

FIGURE 6-15
SKV PULL BOXES
PART 7 MATERIAlS AND EQUIPMENT STANDARDS

The University encourages engineers to incorporate products into the system designs that best suit the need or the objective of the individual system requirement. In some cases, however, because the University has many buildings and systems the operation and care of which are impacted by the selection of materials and equipment, the acceptable manufacturers or products are limited to those included in the following table. If, for any reason, the product(s) or manufacturer(s) included herein are not acceptable to the engineer a variance shall be applied for. When seeking a variance, the specific device from the following listing shall be identified, and the substitute device being requested and the reason for the request must be clearly stated. The materials and equipment standards are subdivided into three groups as follows:

Group A - Proprietary.

Manufacturers or products in this group are to be used with no substitution. To deviate from the requirements in this group a variance must be obtained.

Group B - Limited Options.

Manufacturers or products in this group provide for several options and the engineer is encouraged to specify these products in such a way as to encourage the maximum competition possible consistent with his design requirements. When appropriate, the engineer may specify a product from this group as a proprietary specification when in his judgment there is no "equal" available from the other listed manufacturer(s).

Group C - Preference Only.

Manufacturers or products in this group are intended to indicate a preference, and the engineer is encouraged to use these products in his basic design and specify the products in such a way as to encourage their use but also to maintain maximum competition consistent with the engineer's requirement for a successful system installation. To deviate from the products or manufacturers in this group does not require a variance.
GROUP A – PROPRIETARY

Steam Traps

Drip traps or traps for constant loads for low and high pressure steam systems shall be fixed orifice type.

Load traps for applications with modulating steam control valves shall be modular duodynamic float type.

Design Requirements:

1. Drip traps should be installed with service valves on the inlet and outlet, strainer on the inlet and a dirt leg of at least 6" ahead of the trap connection.

2. Load traps should include strainers ahead of the traps and whatever valves or piping arrangement the engineer requires for maintenance and reliability.

3. When applied to air heating coils that could be subjected to sub-freezing temperature air, the control valve must stay open at all times during outdoor temperature conditions below 35°F and capacity control must be accomplished by face and bypass dampers or some other means that will not result in steam pressure reduction in the coil.

Suggested Specification:

Drip traps or traps for constant loads for low and high pressure steam systems shall be fixed orifice type. The flow of condensate through the trap shall be controlled by a removable and interchangeable orifice module. Access to the orifice module shall be accomplished without removing the trap from the system piping. Trap shall be equipped with an integral wire mesh strainer located at the trap inlet and a separate Y-type strainer with stainless steel screen attached to the inlet connection of the trap. Trap body, orifice module and integral strainer shall be fabricated from stainless steel.

Trap manufacturer shall size the trap and associated orifice. Trap manufacturer shall also verify that the trap is installed in complete accordance with the manufacturer’s requirements and shall assume final responsibility for the proper performance of the trap installation.

Load traps for applications with modulating steam control valves shall be modular duodynamic float type.

Manufacturer: Tech-Fitt, local representative - Steam Management Systems

Steam Pressure/Temperature Regulating Valve

Steam pressure/temperature shall consist of a Spence Engineering Company valve and pressure or temperature pilot. The regulators shall be sized and otherwise designed in strict accordance with recommended practices published by Spence Engineering Company and the latest edition of the appropriate ASHRAE Handbook.
Variable Speed Drives

Variable frequency drives shall be Toshiba Type Q-9 for motors 1 through 200 Horsepower. Drive shall be a pulse width modulated design that has an adjustable carrier frequency between 4 - 12 KHz or higher.

Faucets and Related Plumbing Brass

Faucets and related plumbing brass shall be manufactured by Chicago Faucet Company.

Temperature Control

Johnson Controls, St. Louis, Missouri factory branch office.

Fire Alarm

Simplex, St. Louis, Missouri factory branch office.

Water Treatment

GE Industrial Water, St. Louis, Missouri factory branch office.
Washington University in St. Louis

Design and Material Standards
DIVISION 15 – MECHANICAL

15050 Basic Mechanical Materials and Methods
   15060 Hangers and Supports
   15070 Mechanical Sound, Vibration, and Seismic Control
   15075 Mechanical Identification
   15080 Mechanical Insulation
   15090 Mechanical Restoration and Retrofit

15100 Building Services Piping
   15105 Pipes and Tubes
   15110 Valves
   15120 Piping Specialties
   15130 Pumps
   15140 Domestic Water Piping
   15150 Sanitary Waste and Vent Piping
   15160 Storm Drainage Piping
   15170 Swimming Pool and Fountain Piping
   15180 Heating and Cooling Piping
   15185 Water Treatment
   15190 Fuel Piping

15200 Process Piping
   15210 Process Air and Gas Piping
   15220 Process Water and Waste Piping
   15230 Industrial Process Piping

15300 Fire Protection Piping

15400 Plumbing Fixtures and Equipment
   15410 Plumbing Fixtures
   15440 Plumbing Pumps
   15450 Potable Water Storage Tanks
   15460 Domestic Water Conditioning Equipment
   15470 Domestic Water Filtrating Equipment
   15480 Domestic Water Heaters
   15490 Pool and Fountain Equipment

15500 Heat-Generation Equipment
   15510 Heating Boilers and Accessories
   15520 Feedwater Equipment
   15530 Furnaces
   15540 Fuel-Fired Heaters
   15550 Breechings, Chimneys, and Stacks

15600 Refrigeration Equipment
   15610 Refrigeration Compressors
   15620 Packaged Water Chillers
   15630 Refrigerant Monitoring Systems
   15640 Packaged Cooling Towers
15650  Field-Erected Cooling Towers
15660  Liquid Coolers and Evaporative Condensers
15670  Refrigerant Condensing Units

15700 Heating, Ventilating, and Air Conditioning Equipment
15710  Heat Exchangers
15720  Air Handling Units
15730  Unitary Air Conditioning Equipment
15740  Heat Pumps
15750  Humidity Control Equipment
15760  Terminal Heating and Cooling Units
15770  Floor-Heating and Snow-Melting Equipment
15780  Energy Recovery Equipment

15800 Air Distribution
15810  Ducts
15820  Duct Accessories
15830  Fans
15840  Air Terminal Units
15850  Air Outlets and Inlets
15860  Air Cleaning Devices

15900 HVAC Instrumentation and Controls
15905  HVAC Instrumentation
15910  Direct Digital Controls
15915  Electric and Electronic Control
15920  Pneumatic Controls
15925  Pneumatic and Electric Controls
15930  Self-Powered Controls
15935  Building Systems Controls
15940  Sequence of Operation

15950 Testing, Adjusting, and Balancing

15990 Commissioning
DIVISION 16 – ELECTRICAL

16050 Basic Electrical Materials and Methods
   16060 Grounding and Bonding
   16070 Hangers and Supports
   16075 Electrical Identification
   16080 Electrical Testing
   16090 Restoration and Repair

16100 Wiring Methods
   16120 Conductors and Cables
   16130 Raceway and Boxes
   16140 Wiring Devices
   16150 Wiring Connections

16200 Electrical Power
   16210 Electrical Utility Services
   16220 Motors and Generators
   16230 Generator Assemblies
   16240 Battery Equipment
   16260 Static Power Converters

16270 Transformers
   16280 Power Filters and Conditioners

16300 Transmission And Distribution
   16310 Transmission and Distribution Accessories
   16320 High-Voltage Switching and Protection
   16330 Medium-Voltage Switching and Protection
   16340 Medium-Voltage Switching and Protection Assemblies
   16360 Unit Substations

16400 Low-Voltage Distribution
   16410 Enclosed Switches and Circuit Breakers
   16420 Enclosed Controllers
   16430 Low-Voltage Switchgear
   16440 Switchboards, Panelboards, and Control Centers
   16450 Enclosed Bus Assemblies
   16460 Low-Voltage Transformers
   16470 Power Distribution Units
   16490 Components and Accessories

16500 Lighting
   16510 Interior Luminaires
   16520 Exterior Luminaires
   16530 Emergency Lighting
   16540 Classified Location Lighting
   16550 Special-Purpose Lighting
   16560 Signal Lighting
   16570 Dimming Control
16580 Lighting Accessories
16590 Lighting Restoration and Repair

16700 Communications
  Refer to Appendix

16800 Sound and Video
  16810 Sound and Video Circuits
  16820 Sound Reinforcement
  16830 Broadcast Studio Audio Equipment
  16840 Broadcast Studio Video Equipment
  16850 Television Equipment
  16880 Multimedia Equipment

16900 Fire Alarm
PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 DESIGN REQUIREMENTS

A. HANGERS

1. Pipe hangers, supports, etc. for "cold" piping systems shall have hangers sized for the outside diameter of the insulation in order to maintain a continuous vapor barrier.

2. Hangers, and other supports, anchors, guides, etc. in direct contact with copper piping material shall be copper plated with rubber coating. All others shall be electro-plated for indoor use and hot-dipped galvanized for outdoor use, tunnel use, and other corrosive areas such as natatoriums and pool equipment rooms.

3. Hangers 3" and smaller shall be adjustable ring type. Hangers 4" and larger shall be adjustable clevis type.

4. Roller hangers, saddles, guides/slides, and anchors shall be designed and shown for pipe expansion/contraction.

5. Vertical piping shall be supported at each floor level with riser clamps bearing on the building structure or pipe sleeve.

6. Pipe shields shall be used on insulated piping.
   a. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
   b. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

B. SUPPORTS

1. Indicate pipe supports where piping is not hung from above or where require to take weight off of equipment connections.

2. Where pipe stands are not on a housekeeping pad, the base plate shall be spaced 1" minimum above the finished floor with concrete or grout used to fill the void.

C. HANGER RODS

1. All-thread rod used indoors shall be cadmium or zinc electro-plated, and hot-dipped galvanized for outdoor use, tunnel use, and other corrosive areas such as natatoriums and pool equipment rooms.

D. ANCHORS

1. In all cases, anchor loading shall be based on hanger spacing, weight of the pipe system, contents, insulation, test water, weight of any additional loads imposed upon the anchor, wind loading, seismic loading, quality of the material that the anchor is being installed in, etc.

2. Power driven inserts and attachments are not permitted.

3. In new concrete construction mechanical equipment rooms shall have cast in place inserts placed at a maximum of 4 ft. on center each way.

4. In buildings with steel framing anchors shall be attached to the steel by bolting directly through the void in the bar joist chord or by using the appropriate cataloged type C-clamp or beam clamp. Metal or wood roof decks shall not be used for supporting the piping, ductwork, or equipment.

E. EQUIPMENT PADS

1. Floor mounted equipment shall be located on concrete housekeeping pads. Typical height of 3-1/2 inches with chamfered edges and corners.
2. Equipment pad size shall include required edge spacing for anchor bolts and seismic forces. Reinforcing shall be designed in accordance with ASHRAE Practical Guide to Seismic Restraint or designed by a structural engineer.

PART 2 BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 SPECIFICATIONS

A. Coordinate project specification with the requirements of Part I.

2.2 CONCRETE INSERTS

A. DRAWINGS
1. Clearly identify on mechanical drawings the areas that cast in place inserts are required. If there is a particular layout that is required, then show a detailed layout on the drawings.
2. Coordinate with Structural Engineer to note on structural drawings the areas of cast in place inserts.

B. SPECIFICATIONS
1. Specify cast in place in place anchors in the Hanger and support section of the specification. This section should specify the material and provide the spacing/layout requirements.
2. Coordinate with Architect the Concrete specification scope of work. Division 3 should include the installation of the inserts.

END OF SECTION
PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 GENERAL

A. Valve tag and equipment identification information is required on “as-built” drawing submittals.

B. When adding equipment within an existing building the drawings shall use the same numbering scheme as the existing building and use the next number in the equipment series. Using equipment number xyz-1 must be avoided. Coordinate with the Owner.

1.2 EQUIPMENT IDENTIFICATION

A. All major equipment items (i.e., chillers, air handling units, fans, terminal units, pumps, boilers, etc.) shall be identified with appropriately sized nameplates permanently attached to the respective equipment.

B. Small equipment items (i.e., in-line pumps, pot feeders, etc.) shall be identified with brass valve tags, see requirements for valve tags and chains.

C. Equipment that is controlled by the Building Automation Control System shall be labeled with a 2” x 5” yellow label with black letters:

"CAUTION – THIS EQUIPMENT IS UNDER COMPUTER CONTROL AND MAY CYCLE AT ANY TIME."

D. Interior equipment nameplates shall be 1/16” thick two-ply acrylic plastic 2-1/2” x 1” size minimum with white letters on a black background. Tag size shall be appropriate for equipment name, letters shall be a minimum of ½” high.

E. Exterior equipment shall be identified with nameplates suitable for exterior use or shall be engraved aluminum plates .020” thick, minimum size shall be 4” x 1-1/2” plates.

F. Nameplates shall be attached with corrosion-resistant No. 3 round head or No. 4 sheetmetal screws.

G. The following legend shall be used:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Handling Unit</td>
<td>AHU</td>
</tr>
<tr>
<td>Supply Fan</td>
<td>SF</td>
</tr>
<tr>
<td>Return Fan or Relief Fan</td>
<td>RF</td>
</tr>
<tr>
<td>Exhaust Fan</td>
<td>EF</td>
</tr>
<tr>
<td>Roof Top Unit</td>
<td>RTU</td>
</tr>
<tr>
<td>Variable Air Volume Box</td>
<td>Vx-y x= AHU number, y=box number</td>
</tr>
<tr>
<td>Chiller</td>
<td>CH</td>
</tr>
<tr>
<td>Cooling Tower</td>
<td>CT</td>
</tr>
<tr>
<td>Chilled Water Pump</td>
<td>CWP</td>
</tr>
</tbody>
</table>

MECHANICAL IDENTIFICATION
1.3 PIPING IDENTIFICATION

A. The following schedule shall govern label types for each application:

<table>
<thead>
<tr>
<th>Location</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Other than listed below</td>
<td>I</td>
</tr>
<tr>
<td>Mechanical Rooms</td>
<td>II</td>
</tr>
<tr>
<td>Exterior/Outdoors</td>
<td>III</td>
</tr>
<tr>
<td>Underground – Metallic</td>
<td>IV</td>
</tr>
<tr>
<td>Underground – Non-Metallic</td>
<td>V</td>
</tr>
</tbody>
</table>

1. Type I - Vinyl pressure sensitive tape color coded and lettered for label of service. Flow direction shall be separately labeled with 2” wide pressure sensitive tape. The flow arrow band shall overlap the service label to secure it in place and shall not be less than two complete wraps around the pipe.

2. Type II - Semi-rigid plastic, pre-formed to fit curvature of pipe or pipe insulation, color coded and imprinted with media identification and flow direction. Available in varied sizes for pipe diameter, wording and inclusion of arrow.

3. Type III - Non-vinyl chloride markers specifically design for outdoor use.

4. Type IV - Continuous 6” wide x 0.004” polyethylene film, color coded, and imprinted for type of utility buried below located in the same trench as the piping and/or utility and positioned approximately 12” above the top of the utility.

5. Type V - Continuous 6” wide x 0.035 metallic detection tape, color coded and imprinted for type of utility buried below located in the same trench as the piping and/or utility and positioned approximately 12” above the top of the utility.

B. Markers shall be installed in clear view; located at not more than twenty-five foot (25’) intervals on straight runs at all branch locations; and located on each side of penetrations of the building structure and non-accessible enclosures.
C. The following legend, color, and lettering shall be used for above ground and indoor piping:

<table>
<thead>
<tr>
<th>Service and Legend</th>
<th>Color of Field</th>
<th>Letters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Materials Inherently Hazardous:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Acid Waste</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>High Press. Compressed Air (over 90 psig)</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Boiler Blowdown</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Boiler Feedwater</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Hot Water Supply</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Hot Water Return</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Low Pressure Steam</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Low Pressure Steam Condensate</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Medium Pressure Steam</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Medium Pressure Steam Condensate</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>High Pressure Steam</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>High Pressure Steam Condensate</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Pumped Condensate</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Refrigerant</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Domestic Hot Water</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Domestic Hot Water Return</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Waste</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Vent</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td><strong>Materials of Inherently Low Hazard:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chilled Water Supply</td>
<td>Green</td>
<td>White</td>
</tr>
<tr>
<td>Chilled Water Return</td>
<td>Green</td>
<td>White</td>
</tr>
<tr>
<td>Cold Water</td>
<td>Green</td>
<td>White</td>
</tr>
<tr>
<td>Condenser Water Supply</td>
<td>Green</td>
<td>White</td>
</tr>
<tr>
<td>Condenser Water Return</td>
<td>Green</td>
<td>White</td>
</tr>
<tr>
<td>Drain</td>
<td>Green</td>
<td>White</td>
</tr>
<tr>
<td>Roof Drain</td>
<td>Green</td>
<td>White</td>
</tr>
<tr>
<td><strong>Fire Quenching Materials:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sprinkler – Fire</td>
<td>Red</td>
<td>White</td>
</tr>
</tbody>
</table>

D. The following legend, color, and lettering shall be used for below ground piping:

<table>
<thead>
<tr>
<th>Service</th>
<th>Color</th>
<th>Legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sewer</td>
<td>Green</td>
<td>Caution Buried Sewer</td>
</tr>
<tr>
<td>Potable Water</td>
<td>Blue</td>
<td>Caution Buried Water</td>
</tr>
<tr>
<td>Non-potable Fire (S. 40)</td>
<td>Purple</td>
<td>Caution Buried Reclaimed Water</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Yellow</td>
<td>Caution Buried Gas</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>Yellow</td>
<td>Caution Buried Fuel</td>
</tr>
<tr>
<td>Steam</td>
<td>Yellow</td>
<td>Caution Buried Utility Line</td>
</tr>
<tr>
<td>Chilled Water</td>
<td>Purple</td>
<td>Caution Buried Reclaimed Water</td>
</tr>
<tr>
<td>--------------------</td>
<td>-------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Condenser Water</td>
<td>Purple</td>
<td>Caution Buried Reclaimed Water</td>
</tr>
<tr>
<td>Heating Water</td>
<td>Purple</td>
<td>Caution Buried Reclaimed Water</td>
</tr>
<tr>
<td>Condensate</td>
<td>Purple</td>
<td>Caution Buried Reclaimed Water</td>
</tr>
<tr>
<td>Irrigation Water</td>
<td>Purple</td>
<td>Caution Buried Reclaimed Water</td>
</tr>
</tbody>
</table>

1.4 VALVE IDENTIFICATION

A. All valves exposed or concealed shall be identified with brass valve tags indicating the service of system the valve is in and the number of the valve.

B. Valve tags shall be minimum 1-1/2” diameter brass stock with ¼” legend identifying and ½” valve number both shall be black enamel filled. Legends shall be HVAC, PLBG, SPR, and GAS.

C. Valve tags shall be secured in place with a No. 6 brass bead chain or No. 16 brass jack chain. Chains shall be attached to the valve lever handle or around the valve stem.

D. Valve tags located above lay-in ceilings shall be hung where the valve tag hangs below the level of the piping so that they are easily located.

1.5 DUCTWORK IDENTIFICATION

A. Supply, return and exhaust ductwork uninsulated or insulated, exposed or concealed, shall be identified as specified herein, except for exposed ductwork in finished areas.

B. Markers shall be installed in clear view; installed on both sides of the duct; run parallel to the ductwork; located at not more than twenty-five foot (25’) intervals on straight runs at all branch locations; and located on each side of penetrations of the building structure and non-accessible enclosures.

C. Markers shall be pressure sensitive vinyl tape labeled for service and direction of airflow. Minimum size shall be 2” high x 8” long.

C. Supply, return, exhaust and outdoor air ductwork labels shall be blue with white letters. Outdoor air ductwork labels shall be blue with white letters have an “air” or “outdoor air” legend. Hazardous exhaust air ductwork labels shall be yellow with black letters.

END OF SECTION
<table>
<thead>
<tr>
<th>ID</th>
<th>Service</th>
<th>Sizes</th>
<th>Sched.</th>
<th>Material</th>
<th>Connections</th>
<th>Pressure (PSI)</th>
<th>Temp. (Deg. F)</th>
<th>Service/ Shut-off</th>
<th>Balance/ Throttle</th>
<th>Check Valve</th>
<th>Valve</th>
<th>INSULATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sprinkler Wet Pipe</td>
<td>2&quot; and less</td>
<td>Note 1</td>
<td>Carbon Steel</td>
<td>Threaded -cast iron</td>
<td>175</td>
<td>150</td>
<td>Ball</td>
<td>Swing</td>
<td></td>
<td></td>
<td>Corrosion Resistance Ratio = 1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-1/2&quot; and greater</td>
<td>Note 2</td>
<td>Carbon Steel</td>
<td>Grooved Couplings</td>
<td>175</td>
<td>150</td>
<td>Butterfly</td>
<td>Swing</td>
<td></td>
<td></td>
<td>Cut grooves prohibited</td>
</tr>
<tr>
<td></td>
<td>Dry Pipe</td>
<td>2&quot; and less</td>
<td>Sch. 40</td>
<td>Galvanized Steel</td>
<td>Threaded -cast iron</td>
<td>175</td>
<td>150</td>
<td>Ball</td>
<td>Swing</td>
<td></td>
<td></td>
<td>Cut grooves prohibited</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-1/2&quot; and greater</td>
<td>Sch. 10</td>
<td>Galvanized Steel</td>
<td>Grooved Couplings</td>
<td>175</td>
<td>150</td>
<td>Butterfly</td>
<td>Swing</td>
<td></td>
<td></td>
<td>Cut grooves prohibited</td>
</tr>
<tr>
<td></td>
<td>Under Ground</td>
<td>All</td>
<td>SDR-11</td>
<td>HDPE - FM Labeled</td>
<td>Fusion Welded</td>
<td>160</td>
<td>75</td>
<td>Resilient Seat Gate with curb box</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note 1 - Engineered schedule 40 pipe that UL listed and FM approved with a UL Corrosion Resistance Ratio = 1.0 is acceptable
Note 2 - Engineered schedule 7 pipe that UL listed and FM approved with a rated working pressure of 300 psi is acceptable

CR: Cellular Rubber
GF: Glass Fiber
PT: Poly Iso, (Dow Trymer 2000)
CG: Cellular Glass
<table>
<thead>
<tr>
<th>ID</th>
<th>Service</th>
<th>Sizes</th>
<th>Sched.</th>
<th>Material</th>
<th>Connections</th>
<th>Pressure</th>
<th>Temp. (Deg. F)</th>
<th>Type</th>
<th>Thick.</th>
<th>Jacket</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAN</td>
<td>Sanitary Below Grade inside the Building</td>
<td>All</td>
<td>Service Weight</td>
<td>Cast iron</td>
<td>hub and spigot</td>
<td>0</td>
<td>75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>Vent Below Grade inside the Building</td>
<td>All</td>
<td>Service Weight</td>
<td>Cast iron</td>
<td>hub and spigot</td>
<td>0</td>
<td>75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST</td>
<td>Storm Below Grade inside the Building</td>
<td>All</td>
<td>Service Weight</td>
<td>Cast iron</td>
<td>hub and spigot</td>
<td>0</td>
<td>75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAN</td>
<td>Sanitary Above Grade inside the Building</td>
<td>All</td>
<td>Service Weight</td>
<td>Cast iron*</td>
<td>no hub couplings</td>
<td>0</td>
<td>75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>Vent Above Grade inside the Building</td>
<td>All</td>
<td>Service Weight</td>
<td>Cast iron*</td>
<td>no hub couplings</td>
<td>0</td>
<td>75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST</td>
<td>Storm Above Grade inside the Building</td>
<td>3&quot;-6&quot;</td>
<td>Service Weight</td>
<td>Cast iron</td>
<td>no hub couplings</td>
<td>0</td>
<td>75</td>
<td>CR</td>
<td>3/4&quot;</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10&quot;-15&quot;</td>
<td>Service Weight</td>
<td>Cast iron</td>
<td>no hub couplings</td>
<td>0</td>
<td>75</td>
<td>GF</td>
<td>1&quot;</td>
<td>ASJ</td>
</tr>
<tr>
<td>SAN</td>
<td>Sanitary Below Grade Outside the Building</td>
<td>4&quot;-24&quot;</td>
<td>SCH-40</td>
<td>PVC</td>
<td>hub and spigot</td>
<td>0</td>
<td>75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Concrete</td>
<td></td>
<td>hub and spigot</td>
<td>0</td>
<td>75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST</td>
<td>Storm Below Grade Outside the Building</td>
<td>4&quot;-24&quot;</td>
<td>SCH-40</td>
<td>PVC</td>
<td>hub and spigot</td>
<td>0</td>
<td>75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Concrete</td>
<td></td>
<td>hub and spigot</td>
<td>0</td>
<td>75</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* PVC may be bid as an alternate where not in return air plenums.

Note 1 - Drains used for cooling condensate shall be insulated to prevent sweating.

Note 2 - Drains shall be insulated to prevent sweating and for noise. Insulation shall on all horizontal piping and from the drain body down one floor below the roof.

CR: Cellular Rubber
GF: Glass Fiber
PI: Poly Iso. (Dow Trymer 2000)
CG: Cellular Glass
# Washington University Piping System Schedule

## Vacuum Piping System Schedule

<table>
<thead>
<tr>
<th>ID</th>
<th>Service</th>
<th>Sizes</th>
<th>Sched.</th>
<th>Material</th>
<th>Connections</th>
<th>Pressure (In. Hg)</th>
<th>Temp. (Deg. F)</th>
<th>Valve Type</th>
<th>Balance/Throttle</th>
<th>Check Valve Type</th>
<th>Thick.</th>
<th>Jacket</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAC</td>
<td>Vacuum</td>
<td>1/2&quot;</td>
<td>Type L</td>
<td>Copper</td>
<td>95/5 Solder</td>
<td>-15</td>
<td>75</td>
<td>Ball</td>
<td>Swing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3/4&quot;</td>
<td>Type L</td>
<td>Copper</td>
<td>95/5 Solder</td>
<td>-15</td>
<td>75</td>
<td>Ball</td>
<td>Swing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1&quot;</td>
<td>Type L</td>
<td>Copper</td>
<td>95/5 Solder</td>
<td>-15</td>
<td>75</td>
<td>Ball</td>
<td>Swing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-1/4&quot;</td>
<td>Type L</td>
<td>Copper</td>
<td>95/5 Solder</td>
<td>-15</td>
<td>75</td>
<td>Ball</td>
<td>Swing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-1/2&quot;</td>
<td>Type L</td>
<td>Copper</td>
<td>95/5 Solder</td>
<td>-15</td>
<td>75</td>
<td>Ball</td>
<td>Swing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2&quot;</td>
<td>Type L</td>
<td>Copper</td>
<td>95/5 Solder</td>
<td>-15</td>
<td>75</td>
<td>Ball</td>
<td>Swing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-1/2&quot;</td>
<td>Type L</td>
<td>Copper</td>
<td>95/5 Solder</td>
<td>-15</td>
<td>75</td>
<td>Ball</td>
<td>Swing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3&quot;</td>
<td>Type L</td>
<td>Copper</td>
<td>95/5 Solder</td>
<td>-15</td>
<td>75</td>
<td>Ball</td>
<td>Swing</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### COMPRESSED AIR PIPING SYSTEM SCHEDULE

<table>
<thead>
<tr>
<th>ID</th>
<th>Service</th>
<th>Sizes</th>
<th>Sched.</th>
<th>Material</th>
<th>Connections</th>
<th>Pressure (PSI)</th>
<th>Temp. (Deg. F)</th>
<th>Service/ Shut-off</th>
<th>Balance/ Throttle</th>
<th>Check Valve Type</th>
<th>Insulation Thick</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>Compressed Air</td>
<td>1/2&quot;</td>
<td>Type L</td>
<td>Copper</td>
<td>95/5 Solder</td>
<td>175</td>
<td>150</td>
<td>Ball</td>
<td>Swing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3/4&quot;</td>
<td>Type L</td>
<td>Copper</td>
<td>95/5 Solder</td>
<td>175</td>
<td>150</td>
<td>Ball</td>
<td>Swing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1&quot;</td>
<td>Type L</td>
<td>Copper</td>
<td>95/5 Solder</td>
<td>175</td>
<td>150</td>
<td>Ball</td>
<td>Swing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-1/4&quot;</td>
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<td>Gate</td>
<td>Swing</td>
<td>Pre-insulated mineral wool with air space, coated steel jacket.</td>
<td>Similar to Rovanco class A conduit</td>
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**CR:** Cellular Rubber  
**GF:** Glass Fiber  
**PI:** Poly Iso.  
**CG:** Cellular Glass
# PUMPED CONDENSATE RETURN
## PIPING SYSTEM SCHEDULE

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<th>Jacket</th>
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<td>ASJ</td>
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* a. 316 stainless steel ball stem, and trim, reinforced Teflon (15%) seat

**Remarks:**
- CR: Cellular Rubber
- GF: Glass Fiber
- Pt: Poly Iso
- CG: Cellular Glass
# LOW PRESSURE CONDENSATE RETURN
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a. 316 stainless steel ball stem, and trim, reinforced Teflon (15%) seat

CR: Cellular Rubber
GF: Glass Fiber
PI: Poly Iso.
CG: Cellular Glass
## WASHINGTON UNIVERSITY PIPING SYSTEM SCHEDULE

### HIGH PRESSURE STEAM PIPING SYSTEM SCHEDULE

| ID      | Service                        | Sizes | Sched. | Material       | Connections | Pressure (PSI) | Temp. (Deg. F) | Service/ Shut-off | Balance/ Throttle | Check Valve | Type   | Thick. | Jacket |
|---------|--------------------------------|-------|--------|----------------|-------------|----------------|----------------|-------------------|-------------------|-------------|--------|--------|--------|--------|
| HPS     | Hi Pressure Steam 103 psi and less (HVAC) | 1/2"  | Sch. 40 | Carbon Steel   | Threaded -cast iron | 100            | 350            | Ball (a) Globe   | Swing            | GF          | 1-1/2" | ASJ    |
|         |                                | 3/4"  | Sch. 40 | Carbon Steel   | Threaded -cast iron | 100            | 350            | Ball (a) Globe   | Swing            | GF          | 1-1/2" | ASJ    |
|         |                                | 1"    | Sch. 40 | Carbon Steel   | Threaded -cast iron | 100            | 350            | Ball (a) Globe   | Swing            | GF          | 2-1/2" | ASJ    |
|         |                                | 1-1/4"| Sch. 40 | Carbon Steel   | Threaded -cast iron | 100            | 350            | Ball (a) Globe   | Swing            | GF          | 3"     | ASJ    |
|         |                                | 1-1/2"| Sch. 40 | Carbon Steel   | Threaded -cast iron | 100            | 350            | Ball (a) Globe   | Swing            | GF          | 3"     | ASJ    |
|         |                                | 2     | Sch. 40 | Carbon Steel   | Threaded -cast iron | 100            | 350            | Ball (a) Globe   | Swing            | GF          | 3"     | ASJ    |
|         |                                | 2-1/2"| Sch. 40 | Carbon Steel   | Threaded -cast iron | 100            | 350            | Ball (a) Globe   | Swing            | GF          | 3"     | ASJ    |
|         |                                | 3"    | Sch. 40 | Carbon Steel   | Welded            | 100            | 350            | Gate              | Swing            | GF          | 3"     | ASJ    |
|         |                                | 4"    | Sch. 40 | Carbon Steel   | Welded            | 100            | 350            | Gate              | Swing            | GF          | 3"     | ASJ    |
|         |                                | 5"    | Sch. 40 | Carbon Steel   | Welded            | 100            | 350            | Gate              | Swing            | GF          | 3"     | ASJ    |
|         |                                | 6"    | Sch. 40 | Carbon Steel   | Welded            | 100            | 350            | Gate              | Swing            | GF          | 3"     | ASJ    |
|         |                                | 8"    | Sch. 40 | Carbon Steel   | Welded            | 100            | 350            | Gate              | Swing            | GF          | 3"     | ASJ    |
|         |                                | 10"   | Sch 46  | Carbon Steel   | Welded            | 100            | 350            | Gate              | Swing            | GF          | 3"     | ASJ    |
|         |                                | 12"   | Std. (375") | Carbon Steel   | Welded            | 100            | 350            | Gate              | Swing            | GF          | 3"     | ASJ    |
|         |                                | 14"   | Std. (375") | Carbon Steel   | Welded            | 100            | 350            | Gate              | Swing            | GF          | 3"     | ASJ    |
|         |                                | 16"   | Std. (375") | Carbon Steel   | Welded            | 100            | 350            | Gate              | Swing            | GF          | 3"     | ASJ    |
| Under Ground | All  | Sch. 40 | Carbon Steel | Welded      |                | 100            | 350            |                | Pre-insulated mineral wool with air space, coated steel jacket. | GF          | 350     |        |

**Remarks:**
- CR: Cellular Rubber
- GF: Glass Fiber
- PI: Poly Iso.
- CG: Cellular Glass

**Issue Date:** May 21, 2004

**Revision:** B
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<th>Sched</th>
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<th>Connections</th>
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<td>CR: Cellular Rubber</td>
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* a. 316 stainless steel ball stem, and trim, reinforced Teflon (15%) seat
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- CR: Cellular Rubber
- GF: Glass Fiber
- PI: Poly Iso. (Dow Trymer 2000)
- CG: Cellular Glass

a. Or Cellular Rubber
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a. Not allowed in Residential Halls
b. Insulation not required in Mechanical Room

CR: Cellular Rubber
GF: Glass Fiber
PI: Poly Isoc (Dow Trymer 2000)
CG: Cellular Glass
# WASHINGTON UNIVERSITY PIPING SYSTEM SCHEDULE

## CONDENSER WATER

### PIPING SYSTEM SCHEDULE

<table>
<thead>
<tr>
<th>ID</th>
<th>Service</th>
<th>Sizes</th>
<th>Sched.</th>
<th>Material</th>
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a. Victaulic Fittings and Joints may be bid as an alternate.

CR: Cellular Rubber
GF: Glass Fiber
PI: Poly Iso.
CG: Cellular Glass
## Heating Water Piping System Schedule

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*Date Printed: 6/13/2009*
SECTION 15110 – VALVES

PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 GENERAL

A. When two or more valves of the same type are to be used in the same service, all valves of this type shall be of the same manufacturer.

B. All valves for use with insulated piping shall have stem or neck extensions.

C. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

D. Locate valves for easy access and provide separate support where necessary.

E. Install valves in horizontal piping with stem at or above center of pipe.

F. Install valves in position to allow full stem movement.

G. Butterfly valves larger than 6” shall have gear operators.

H. Butterfly valves and gate valves located above 12'-0” shall have chain wheel operators.

I. Triple duty valves shall not be used.

1.2 VALVE APPLICATIONS

A. Refer to piping Schedules for specific valve applications.

B. Chilled-Water/ Heating-Water/ Condenser Water/ Domestic Cold and Hot Water Piping: Use the following types of valves:

1. Ball Valves: ASTM B584 bronze 2 piece body, 600 psi WOG, quarter turn lever handle, blow-out proof stem, full port 2” and smaller, standard port 2-1/2” and larger, reinforced TFE seats, all stainless steel trim, threaded or soldered ends.

2. Butterfly Valves: ASTM A395 ductile iron body, 1/4 turn, extended neck, geometric drive, EPDM molded-in seat liner, threaded lug type, aluminum bronze disc, 416 SS stem, lubersized bronze or Teflon bushings. Valves shall be rated for 200psi dead end service with out use of a downstream flange.

3. Balance Valves: Valves shall have position indication and calibrated flow curves. Valves shall provide positive shut-off for service and shall have adjustable memory stops to allow returning to original balanced position after servicing. Valves shall have integral pressure tap ports provided with “drip caps”. 2” and smaller bronze body. 2-1/2” and larger iron body.

4. Swing Check Valves: 2” and smaller: Class 125 (125 psi at 400°F, 200 psi at 150°F), bronze, horizontal swing, vertical up-flow, Y pattern, teflon renewable seat and disc in conformance with MSS SP80.

5. Silent Check Valves: 2-1/2” - 10”, Class 125 (125 psi at 400°F, 200 psi at 150°F), flanged, ASTM A-126 Class B, cast iron body, bronze trim, resilient seat.
6. Resilient Seat Gate Valves: 250 psig non-shock cold working pressure (maximum operating temperature 160°F), ASTM A536 ductile iron body, bolted bonnet, non-rising stem, EPDM coated ductile iron wedge, epoxy coated inside and outside per AWWA C550, mechanical joint ends.

C. Low Pressure Steam/High Pressure Steam/Steam Condensate Piping: Use the following types of valves:

1. **Ball Valves**: ASTM B584 bronze 2 piece body, 600 psi WOG, quarter turn lever handle, blow-out proof stem, full port 2" and smaller, standard port 2-1/2" and larger, reinforced TFE seats, all stainless steel trim, threaded ends.

2. **Gate Valves**: 2-1/2" - 12": Class 125 (125 psi at 400°F, 200 psi at 150°F), ASTM A-125 Class B cast iron body, brass mounted, flanged, bolted bonnet, OS & Y, solid wedge, in conformance with MSS SP70.

3. **Gate Valves**: 14" and larger: Class 150 (150 psig at 500°F), ASTM A216 Grade WCB cast steel body, flanged bolted bonnet, OS & Y, flanged end is in accordance with ANSI B16.5 and B16.10, pressure temperature ratings in accordance with ASME/ANSI B16.34.

4. **Globe Valves**: 2" and smaller: Class 125 (125 psi at 400°F, 200 psi at 150°F), bronze, straightway pattern, screw-in bonnet, renewable seat and disc, in conformance with MSS SP80.

5. **Globe Valves**: 2-1/2" and larger: Class 125 (125 psi at 400°F, 200 psi at 150°F), iron body, brass mounted, flanged, straight way pattern, bolted bonnet, renewable seat and disc.

6. **Check Valves**: 2" and smaller: Class 125 (125 psi at 400°F, 200 psi at 150°F), bronze, horizontal swing, vertical up-flow, Y pattern, teflon renewable seat and disc in conformance with MSS SP80.

7. **Check Valves**: 2-1/2" and larger: Class 125 (125 psi at 400°F, 200 psi at 150°F), iron body, flanged, horizontal swing, vertical up-flow, bolted bonnet, renewable seat and disc in conformance with MSS SP71, type 1.

D. Natural Gas Piping: Use the following types of valves:

1. **Ball Valves**: ASTM B584 bronze 2 piece body, 600 psi WOG, quarter turn lever handle, blow-out proof stem, UL listed, full port 1" and smaller, standard port 1-1/4" thru 3", reinforced TFE seats, all stainless steel trim, threaded ends.

2. **Welded Ball Valve**: 4" and larger: welded carbon steel body, butt weld ends, full port, stainless steel ball and stem, teflon seat, 2" square operating nut with locking plate.

3. **Underground Polyethylene**: polyethylene ball valve, PE 2406, SDR-11, 80 psig rating, full port polyethylene ball, nitrile seat, 2" square nut operation.

E. Compressed Air Piping: Use the following types of valves:

1. **Ball Valves**: ASTM B584 bronze 2 piece body, 600 psi WOG, quarter turn lever handle, blow-out proof stem, downstream vent, standard port 2" and smaller, reinforced TFE seats, all stainless steel trim, threaded or soldered ends.

F. Vacuum Piping: Use the following types of valves:

1. **Ball Valves**: ASTM B584 bronze 2 piece body, 600 psi WOG, quarter turn lever handle, blow-out proof stem, full port 2" and smaller, standard port 2-1/2" and larger, reinforced TFE seats, all stainless steel trim, threaded or soldered ends.
PART 2 BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 INSTALLATION

A. Specify that valves are to be installed with the stem above the horizontal.

B. Specify that welded or soldered valves are to have the seats protected from the heat during installation.

END OF SECTION
SECTION 15120 – PIPING SPECIALTIES

PART I PROGRAMMING AND DESIGN GUIDELINES

1.1 THERMOMETERS

A. Liquid-in-Glass Thermometers for Liquid Systems:
   2. Tube: organic-liquid filled, with magnifying lens.
   3. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.
   4. Window: Glass or plastic.
   5. Connector: Adjustable type, 360 degrees in horizontal plane, with locking device
   6. Stem: Metal, for thermowell installation and of length to suit installation.
   7. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

B. Bimetallic-Actuated Dial Thermometers for Air Ducts:
   1. Description: Direct-mounting, bimetallic-actuated dial thermometers complying with ASME B40.3.
   2. Case: Dry type, stainless steel with 5-inch diameter.
   3. Element: Bimetal coil.
   5. Pointer: Red or other dark-color metal.
   6. Window: Glass or plastic
   7. Ring: Stainless steel.
   9. Stem: Metal, for thermowell installation and of length to suit installation.
  10. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

C. Provide the following temperature ranges for thermometers:
   1. Domestic Hot Water: 30 to 180 deg F, with 2-degree scale divisions
   2. Domestic Cold Water: 0 to 100 deg F, with 1-degree scale divisions
   3. Heating Hot Water: 30 to 240 deg F, with 2-degree scale divisions
   4. Condenser Water: 30 to 120 deg F, with 1-degree scale divisions
   5. Chilled Water: 0 to 100 deg F, with 1-degree scale divisions
   6. Steam Condensate: 30 to 240 deg F, with 2-degree scale divisions
   7. Air Ducts:
   8. Outdoor Air - Minus 40 to plus 110 deg F, with 2-degree scale divisions.
   9. Heating - 0 to 160 deg F, with 2-degree scale divisions
  10. All others - 0 to 100 deg F, with 1-degree scale divisions

1.2 PRESSURE GAGES

A. Pressure gauges shall be high quality and high accuracy but shall be used sparingly in the systems. A single pressure gauge shall be piped to both the supply and return to allow calculating differential pressure using the same gauge for both measurements. Pressure gauges shall be installed at major pieces of equipment (boilers, chillers, main system
pumps, water service entrance) but not at air handling units, small circulating pumps, or fan coil units.

B. Provide gauge cocks at other locations not indicated above where gauges would typically be provided. This will allow testing and diagnosis of the equipment.

C. Direct-Mounting, Dial-Type Pressure Gauges

1. Indicating-dial type complying with ASME B40.100.
2. Case: Dry type, stainless steel or cast aluminum 4-1/2-inch diameter.
3. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
4. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Pointer: Red or other dark-color metal.
8. Window: Glass or plastic.
10. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
11. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
12. Range for Fluids under Pressure: Two times operating pressure. Campus chilled water system 0-160 psi range.
13. Pressure-Gauge Fittings:
14. Valves: NPS 1/4 2 piece bronze ball valve, refer to Section 15110.
15. Syphons: Only for steam service - NPS 1/4 coil of brass tubing with threaded ends.
16. Snubbers: ASME B40.5, NPS 1/4 (DN 8) brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure. Snubbers shall be used at all locations.

1.3 FLOW METERS

A. Chilled Water
1. Each building and each loop chiller shall have flow meters.
2. Flow meters shall be insertion turbine type.
3. Meters shall be provided with a local display in gallons per minute.
4. Output shall be 4-20 mA proportional to flow.
5. Flow meters shall be scheduled for system flow x 1.4, then rounded up to the next 50 or 100.
6. Loop chillers flow meters shall be scheduled for 2400 gpm.
7. Meters shall be Onicon dual turbine model F-1210.

B. Domestic Water
1. Each building shall have a flow meter on the domestic water service.
2. Flow meters shall be turbine type.
3. Registers shall be sealed magnetic drive reading in Gallons.
4. Meter shall be Badger Meter model Recordall Turbo Series.
C. Natural Gas  
1. Each building shall have a flow meter on the natural gas service.  
2. Flow meters shall be rotary positive displacement type.  
3. Flow meters shall be scheduled for system flow x 1.4.  
4. Meter shall be Roots series B3 as manufactured by DMD Dresser with a Mercury Instruments model Mini-Max volume corrector.

D. Steam  
1. Only Boiler Plants shall have steam meters.  
2. Flow meters shall be ultrasonic transit time type with wetted transmitters.  
3. Transmitters shall be located in a factory flanged spool piece of the same material as the system piping.  
4. Meters shall be provided with a local display in pounds per hour.  
5. Output shall be 4-20 mA proportional to flow.  
6. Flow meters shall be scheduled for system flow x 1.4, then rounded up to the next 50 or 100.  
7. Meters shall be as Panametrics model GS 868.

E. Steam Condensate  
1. Each building shall have a flow meter on the steam condensate.  
2. Flow meters shall be turbine type hot water meters.  
3. Flow meters shall be installed horizontally in a loop to ensure they remain wetted.  
4. Rate display/Totalizer shall be a Kessler-Ellis model MRTA3A mounted in a Nema 4 enclosure. This is a Johnson Controls N2 compatible device.  
5. Meters shall be Niagara model WPX 210 turbine meter for Hot water.

F. Heating Water  
1. Each building shall have a flow meter on heating water service.  
2. Flow meters shall be ultrasonic transit time type with wetted transmitters.  
3. Transmitters shall be located in a factory flanged spool piece of the same material as the system piping.  
4. Meters shall be provided with a local display in gallons per minute.  
5. Output shall be 4-20 mA proportional to flow.  
6. Flow meters shall be scheduled for system flow x 1.4, then rounded up to the next 50 or 100.  
7. Meters shall be Onicon dual turbine model F-1210.

1.4 AIR SEPARATOR  

A. Centrifugal Type  
1. Chilled Water and Heating Hot Water systems shall have an air separator to remove entrained air from the system.  
2. In chilled water systems the air separator shall be located on in Figure 6-3.  
3. In heating hot water systems the air separator shall be located at the lowest air solubility point, typically on the supply piping upstream of the pumps.  
4. Air separators shall be line size up to 4", larger piping shall have a 2" bypass separator per Figure 6-10.  
5. The installed height of the air separator shall allow ample head room for automatic air vent, piping, and service valve.  
6. The air separator shall have a drain valve.
7. The air separator shall not have a strainer.

1.5 AIR VENTS

A. Automatic High Capacity Type
   1. A high capacity automatic air vent shall be installed at the air separator. Provide a service valve between the air separator and the automatic air vent to allow servicing the air vent.
   2. The discharge of the automatic air vent shall be piped to a floor drain, show the required piping on the drawings.

B. Manual Air Vents
   1. Show manual air vents at high points, potential air “pockets”, and on the high point on the equipment side of service valves.
   2. Specify/detail manual air vents valves with hose end adapter, cap, and chain.

1.6 EXPANSION TANK

A. Bladder Type
   1. Expansion tanks shall be diaphragm or bladder type. Air interface type is not allowed.
   2. Chilled Water systems with chillers shall have a 125 psig ASME stamped expansion tank. Buildings without a chiller shall NOT have an expansion tank, but shall have a 3/4” pressure relief valve.
   3. Open Condenser Water systems shall NOT have an expansion tank. Closed Condenser water systems shall have a 125 psig ASME stamped expansion tank.
   4. Heating Hot Water systems shall have a 125 psig ASME stamped expansion tank.
   5. Domestic Hot Water systems shall have a 125 psig ASME stamped expansion tank, approved for potable water.
   6. Detail at each expansion tank an isolation valve at the tank with a hose end drain valve located between the isolation valve and tank, this is required to recharge the tank.
   7. Floor mounted vertical tanks are preferred.
   8. Indicate on the drawings the design charge pressure. Provide approximately 10 psig of static pressure at the highest point in the system.

1.7 SUCTION DIFFUSER

A. Suction diffusers should be used for end section pumps and inline pumps that are floor mounted where the piping running over head drops to the pump inlet.

B. Fitting shall be 90° angle cast iron body with exit vane, 304 stainless steel strainer with ¼” openings, fine mesh start-up strainer, adjustable support foot, pressure tap, and drain connection. On the drawings show/detail a hose end drain valve on the drain connection and a guage cock on the pressure tap, piped to the pump guage.

C. Fitting shall be coordinated with pump inlet size and system piping, where largest system size available is smaller than the system piping, provide piping reducer at inlet of suction diffuser.
1.8 RELIEF VALVES

A. Pressure Relief
1. Pressure relief valves should be installed on the equipment side of the service valves for chillers, free cooling heat exchangers, and other equipment where thermal expansion would damage the equipment. Relief valves are not required on pumps and coils.
2. One relief valve shall be installed on the main piping of each system: chilled water, condenser water, heating hot water, domestic hot water, domestic cold water, non-potable water systems.
3. Show the relief valve location on the drawings and flow diagrams. Located in the main mechanical rooms where the systems originate. Indicate that the discharges are to be piped to the floor within 10 feet of a floor drain.

B. Temperature Relief
1. Temperature relief valves shall be provided on the domestic hot water systems. It shall be a 3/4" self-contained, reverse acting, with adjustable setpoint. Setpoint shall be not more than 10°F above the system setpoint. The purpose of this valve is relieving some hot water, then cold makeup water will be introduced into the system to bring the temperature down. This is only for an “overshoot” condition. The heater system will be still be protected with an ASME code safety relief valve.
2. Show the relief valve location on the drawings and flow diagrams. Indicate that the discharges are to be piped to the floor within 10 feet of a floor drain.

C. Safety Relief
1. Hydronic systems containing heat exchangers or other unfired heating vessels shall have safety relief valves sized for the rated output of each device at the pressure rating of the lowest pressure device. Valves shall be ASME Code Section VIII rated, bronze body and brass trim.
2. Show the relief valve location on the drawings and flow diagrams. Indicate that the discharges are to be piped to the floor within 10 feet of a floor drain.

1.9 PRESSURE REGULATING VALVE

A. Pressure regulating valves shall be used to regulate the building water pressure.

1.10 PRESSURE REDUCING VALVE

A. Pressure reducing valves shall be used to regulate the fill pressure of mechanical systems. For closed systems the pressure reducing valve and expansion tank shall have same pressure setting and should connect to the system at the same point to provide a constant reference pressure.
PART 2 BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 MANUFACTURERS

A. Thermometers and Gauges:
   1. Marsh Bellofram.
   2. Miljoco Corp.
   3. Trerice, H. O. Co.
   4. Weiss Instruments
   5. Weksler Instruments

B. Air Separator
   1. Bell & Gossett Rolairtrol, Amtrol, Taco, Armstrong VA, Thrush, Spirovent model HV

C. Air Vents
   1. Amtrol Model 720, Armstrong AAE-750, Bell & Gossett 107A, Spirotherm model Spirotop, Thrush model 720

D. Expansion Tank
   1. Diaphragm type expansion tanks shall be Amtrol AX Series, Bell and Gossett Series D, Taco CAX series, Thrush AX series
   2. Bladder type expansion tanks shall be Amtrol L series, Bell and Gossett Series B, Taco CA series, Thrush L series

E. Suction Diffuser
   1. End suction and floor mounted inline pumps - Bell & Gossett, Armstrong, Taco
   2. Double suction pumps - Flow Conditioning Corporation

F. Relief Valve
   1. Pressure Relief - Bell and Gossett, Watts, Kunkle
   2. Temperature Relief – Spence model 2020
   3. Safety Relief, ASME code section IV - Bell and Gossett, Watts, Kunkle

G. Pressure regulating valves
   1. Watts ACV E115-3 AS

H. Pressure reducing valves
   1. Watts U5, Bell and Gossett #7, Taco 335, Armstrong HRD70

END OF SECTION
SECTION 15180 – HEATING AND COOLING PIPING

PART I PROGRAMMING AND DESIGN GUIDELINES

1.1 ABOVE GROUND PIPING

A. Refer to following Pipe Schedules.

1.2 UNDERGROUND DIRECT BURIED PIPING

A. DESIGN

1. Underground piping shall be installed typically at 42" of cover to protect against freezing. If the grade is being modified, then the new grades must be used. This may affect project phasing and should be discussed with FPM and identified in the construction documents.

2. Avoid installing piping at deep depths, as this makes repairs difficult.

3. The routing shall avoid architectural or landscape design features, as this makes repairs difficult. Avoid loading docks, retaining walls, raised planters, decorative concrete plazas, etc.

4. For piping that operates a low velocities consideration shall be given to air movement and air entrapment.

5. The design of all underground utilities shall include a profile that indicates the existing and proposed grades, existing underground utilities, proposed utilities, building elevation.

B. INSTALLATION

1. Piping shall be installed with sand bedding and sand backfill to 6" above the piping.

2. Trench backfill shall be clean earth compacted to 95% modified proctor.

C. CHILLED WATER

1. Piping material: High density polyethylene PE 3408
2. Fittings: molded high density polyethylene PE 3408
3. Joints: Fusion
4. Transitions: Piping shall transition before entering the building. Transitions shall be field constructed per Figure 6-9.
5. Underground Valves: Resilient seat gate valves, mechanical joint, cast iron cast iron curb stop box.
6. Trace wire: Purple #12 AWG solid copper, terminate wire in cathodic test station box anchored in a 12" x 12" x 6" concrete pad.

D. CONDENSER WATER

1. Piping material: High density polyethylene PE 3408
2. Fittings: molded high density polyethylene PE 3408
3. Joints: Fusion
4. Transitions: Piping shall transition before entering the building. Transitions shall be PE to 304 SS. Provide 32 lb. magnesium anode connected to SS piping and to the test station. Provide flange isolation kits for flange inside the building.
5. Underground Valves: Resilient seat gate valves, mechanical joint, curb stop box.
6. Trace wire: Purple #12 AWG solid copper, terminate wire in cathodic test station box anchored in a 12” x 12” x 6” concrete pad.

C. HEATING WATER
   1. Piping material: Preinsulated system, schedule 40 A53 carbon steel carrier pipe, polyurethane insulation, HDPE jacket.
   2. Fittings: standard (schedule 40) carbon steel butt welded
   3. Joints: welded
   4. Underground Valves: in vault or manhole, lugged butterfly valve

D. LOW PRESSURE / HIGH PRESSURE STEAM
   1. Piping material: Preinsulated high temperature conduit system, schedule 40 A53 carbon steel carrier pipe, mineral wool insulation, air space, 10 ga. steel jacket, polyisocyanurate foam insulation, HPDE jacket.
   2. Fittings: standard (schedule 40) carbon steel butt welded
   3. Joints: welded
   4. Underground Valves or Steam traps: in vault or manhole, gate valve

E. STEAM CONDENSATE
   1. Piping material: Preinsulated system, schedule 80 A53 carbon steel carrier pipe, polyurethane insulation, HDPE jacket.
   2. Fittings: extra strong (schedule 80) carbon steel butt welded
   3. Joints: welded
   4. Underground Valves: In vault or manhole, lugged butterfly valve

PART 2 BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 MANUFACTURERS

A. HEATING WATER
   1. Rovanco – Steel System
   2. Thermacor – Ferro-Therm
   3. Perma Pipe – Poly-Therm
   4. Insul-Tek – 250 Steel

B. LOW PRESSURE / HIGH PRESSURE STEAM
   1. Rovanco – Insul-800 High Temp Conduit
   2. Thermacor – DUO-Therm 505
   3. Perma Pipe – Multi-Therm 500
   4. Insul-Tek – Dual-Con

C. STEAM CONDENSATE
   1. Rovanco – Steel System
   2. Thermacor – Ferro-Therm
   3. Perma Pipe – Poly-Therm
   4. Insul-Tek – 250 Steel
2.2 INSTALLATION

A. TRACE WIRES
   1. Trace wires shall be installed on all non-metallic piping. Trace wires shall be
      affixed to the piping on 6 foot intervals. Trace wires shall be #12 AWG solid
      copper and color coded. Trace wires shall terminate on cathodic test station
      terminal boards. The test station shall have a 12" x 12" x 6" concrete pad at
      finished grade.
   2. Trace wires shall be the following colors:
      Service                          Color
      Chilled Water                    Purple
      Condenser Water                  Purple

B. WARNING TAPE
   1. Refer to section 15075 Identification.

C. CURB STOP BOXES
   1. Curb stop boxes and cathodic protection test stations shall be painted the
      following colors.
      Service                          Color
      Chilled Water                    Purple
      Condenser Water                  Purple

D. BACKFILL
   1. Piping shall be installed with sand bedding and sand backfill to 6" above the
      piping.
   2. Trench backfill shall be clean earth compacted to 95% modified proctor.

END OF SECTION
SECTION 15185 – WATER TREATMENT

PART 1 - PROGRAMMING AND DESIGN GUIDELINES

1.1 GENERAL

A. The Owner uses GE Industrial Water as the sole source chemical water treatment vendor.

B. The local water is as follows:
   1. Hardness 6.2 grains/gal
   2. pH 9

1.2 CLOSED LOOP HYDRONIC (CHILLED WATER, HEATING WATER, CONDENSER WATER)

A. Each system should have a pot feeder injecting cleaning chemicals and initial water treatment. Subsystems downstream of a heat exchanger should be treated as a separate system.

B. Systems not connected to the campus system should have a corrosion coupon rack.

1.3 CONDENSER WATER, OPEN SYSTEM

A. Each system should have a corrosion coupon rack.

B. For cooling towers less than 700 tons the chemical system will be a Redi-Feed RF300 solid chemical system consisting of two chemicals, biocide and inhibitor. Refer to drawing Chem-1 for system schematic.

C. For cooling towers greater than 700 tons, consult Owner.

1.4 STEAM HEATING BOILER

A. For Boiler systems less than 150 boiler HP the chemical system will be a Redi-Feed RF202 solid chemical system consisting of a single blended chemical containing molybdate, phosphate, polymer, amine, caustic and antifoam. Refer to drawing Chem-2 for system schematic.

B. For Boiler systems greater than 150 boiler HP the chemical system will consist of an Aqua-Trac controller, three mini-bulk liquid chemical storage tanks, boiler conductivity sensors, automatic top blow down valves, make up water contact meter. Refer to drawing Chem-3 for system schematic.

C. Boiler make up water should be softened.

D. Each boiler shall have a pot feed to allow wet lay up. Refer to drawing Chem-3.

1.5 PROCESS STEAM BOILER
A. For Boiler systems less than 150 boiler HP the chemical system will be a Redi-Feed RF202 solid chemical system consisting of a single blended chemical containing molybdate, phosphate, polymer, amine, caustic and antifoam. Refer to drawing Chem-2 for system schematic.

B. Boiler make up water should be softened.

1.6 DOMESTIC WATER

A. Domestic water is not softened.

1.7 POT FEEDERS

A. Pot feeder size should be proportional to the system volume

1. 0 - 5,000 gal system  5 gal pot feeder
2. 5,000 - 10,000 gal system  12 gal pot feeder
3. above 10,000 gal system  18 gal pot feeder

1.8 PIPE CLEANING

A. All piping must be cleaned before putting into service including additions to existing systems. The Owner will witness and approve pipe cleaning.

B. The Design Professional should assist the Owner in making sure that the pipe cleaning gets scheduled and executed in the construction sequence.

C. Connections of new piping to existing systems should contain high point vents and low point drains in the new piping. These points will allow the contractor to fill, clean, flush, and drain the new section of piping before putting it into service.

D. In new buildings, the piping may be cleaned using the permanent pumps or temporary pumps for un-pumped systems. The new systems shall be isolated from the campus systems.

PART 2 - BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 DRAWINGS

A. For modifications/renovations indicate on the drawings, via keyed notes, the drains and vents to be used for filling, draining, venting, and connecting a temporary circulation pump. Also indicate the connection points for water source and drain discharge.

2.2 MANUFACTURER

A. GE Industrial Water shall be the chemical water treatment vendor, no substitutions allowed
2.3 PIPE CLEANING

A. The Contractor shall clean the respective piping system(s) that are included in his scope of work. All systems shall be flushed with water or air (depending on ultimate use) to relieve any congestion and internally cleanse the respective piping system. The Contractor shall provide all flushing media in sufficient quantity, inlet connections, discharge or drainage outlets and any temporary provisions to protect components, or remove it, to facilitate the flushing. Clean and replace all strainer screens and filters. Flush clean and drain all low points in the piping.

B. Owner’s representative shall be present for flushing, cleaning, and rinsing. Water treatment representative must check water after rinsing to insure all chemical cleaner has been removed and the alkalinity of the rinse water is equal to that of the make-up water. Water treatment representative will also test for iron, oils, and other contaminates. If the water fails the aforesaid test, then subsequent cleaning will be required by the contractor before acceptance by the Owner.

C. All pipe systems for hydronic applications shall be flushed continuously with 100% city water make-up until the water runs clear from all drain locations. Each piping system shall be subsequently cleaned with recommended dosage of an approved pre-cleaning chemical designed to remove deposition such as pipe dope, oils, loose rust, mill scale and other extraneous materials. The cleaning solution shall be circulated throughout the system for a minimum period of twenty-four (24) hours then drained, refilled, and rinsed clean. Flushing before and rinsing after cleaning shall be supplying constant make-up water while draining at all system low points and drains.

D. Condenser/tower water piping shall be flushed continuously with a surfactant cleaning chemical designed to remove deposition such as pipe dope and oils. This chemical shall not be alkaline or aggressive to the system metallurgy. Recommended dosages of a surfactant chemical product shall be added and circulated throughout the water system for a minimum period of twenty-four (24) hours then drained, refilled and rinsed clean.

E. Steam and condensate return piping shall be flushed continuously with 100% city water make-up until the water runs clear from all drain locations. Each piping system shall be subsequently cleaned with recommended dosage of an approved pre-cleaning chemical designed to remove deposition such as pipe dope, oils, loose rust, mill scale and other extraneous materials. The cleaning solution shall be circulated throughout the system for a minimum period of twenty-four (24) hours then drained, refilled, and rinsed clean. Flushing before and rinsing after cleaning shall be by supplying constant make-up water while draining at all system low points and drains.

F. Boilers shall be boiled-out per manufacturer’s recommendations.

G. New or repaired potable water systems shall be purged of deleterious matter and disinfected prior to utilization. The method to be followed shall be that prescribed by the authority having jurisdiction or, in the absence of a prescribed method, the procedure described in either AWWA C651 or AWWA C652. This requirement shall apply to “on-site” or “in-plant” fabrication of a system or to a modular portion of a system.

END OF SECTION

WATER TREATMENT
RadFeed RF300 Complete Kit:
120VAC 50/60 Hz 5 amp
City water inlet ½ in ID NPT
Outlet to chem pump ¾ in OD tube fitting
Drain 3/8 in tube fitting
LMI Chem Pump C121 362SI 100 psi
120 V 22 watts
3/8 in suction/discharge tube fittings
¾ in male NPT injection orific with built-in check valve
½ in blowdown solenoid valve
2 in Carlon contacting head water meter
**LMI pumps controlled by LMI DC4500 - existing

GE Betz
Chemical Feed Schematic
RadFeed
Solid Feeder System
RediFeed RF202 Complete Kit:
120V 50/60 Hz 5 amp. Wall mount 36in H x 31in W x 9in D
Soft water inlet 1/4in ID NPT
Outlet to chem pump 3/8in OD tube fitting
Drain 3/8in OD tube fitting

LMI Chem Pump C121 3625l 100-psl
120V 22 Watts
3/8in OD suction/discharge tube fittings
1/2in NPT male injection quill with built in check valve

**Activate LMI chem. pump based on boiler feedwater flow

CHEM-2
SECTION 15190 – FUEL PIPING

PROGRAMMING AND DESIGN GUIDELINES

1.1 ABOVE GROUND PIPING

A. Refer to following Pipe Schedules.

1.2 UNDERGROUND DIRECT BURIED PIPING

A. NATURAL GAS

1. Piping material: Polyethylene PE 2406
2. Fittings: molded polyethylene PE 2406
3. Joints: Fusion
4. Transitions: Piping shall transition before entering the building or rising out of the ground. Transitions shall be anode-less type (fusion bonded epoxy coated carbon steel).
5. Underground Valves: PE ball valve, with cast iron curb stop box.
6. Trace wire: Yellow #12 AWG solid copper, terminate wire in cathodic test station box anchored in a 12” x 12” x 6” concrete pad.

B. FUEL OIL

1. Piping material: Nylon 12, double wall containment pressure hose
2. Access Pipe: 4” corrugated
3. Fittings: NPT x Clamshell type, manufacturers fittings designed for their hose
4. Accessories: Entry boots, Test boots, Bypass hoses, etc as required for a complete installation
5. Underground Valves: ball valve located in grade level transition sump
6. Trace wire: Yellow #12 AWG solid copper, terminate wire in cathodic test station box anchored in a 12” x 12” x 6” concrete pad.

BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 INSTALLATION

A. TRACE WIRES

1. Specify: Trace wires shall be install on all non-metallic piping. Trace wires shall be affixed to the piping on 6 foot intervals. Trace wires shall be #12 AWG solid copper and color coded. Trace wires shall terminate on cathodic test station terminal boards. The test station shall have a 12” x 12” x 6” concrete pad at finished grade.
2. Trace wires shall be the following colors:

<table>
<thead>
<tr>
<th>Service</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>Yellow</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>White</td>
</tr>
</tbody>
</table>
SECTION 15300 – FIRE PROTECTION

PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 DESIGN REQUIREMENTS

A. DESIGN CRITERIA
1. New buildings shall be fully sprinklered.
2. Existing buildings not fully sprinklered, check with the Owner for the scope of upgrading the building during renovations.
3. Refer to Part 5 to determine Authority having jurisdiction.
4. In general sprinkler and standpipes, where required, shall be wet pipe systems.
5. Dry pipe systems shall be used in parking garages and other special spaces requested by the Owner.
6. Dry pipe pre-action systems shall be used for large computer rooms, animal areas, and other special spaces requested by the Owner.
7. Dry pipe systems shall use hot-dip galvanized piping.
8. Plastic piping shall not be used.
9. Fire pumps are prohibited.

B. WATER FLOW TEST
1. The engineer should request a water flow test from the Owner. The data should be included in the project documents.

C. SYSTEM LAYOUT
1. The drawings shall show the location of the fire water tie-in, exterior pipe routing, double check valve backflow preventer, zone risers, interior pipe main routings, standpipe pipe routings, fire department connection, test/drain piping including point of discharge, and valve cabinets locations. The piping should not be sized, the size will be determined by the hydraulic calculations performed by the contractor.
2. The drawings shall indicate the number of zones and the location of each zone. As a minimum each floor shall be on a separate zone.
3. Head layouts should be shown for special Architectural spaces (i.e. main building lobbies, great rooms, etc.)
4. Head layouts should be shown for repetitive spaces such as dorm rooms, office suites, etc.
5. Heads shall be centered +/-2” on 2 x 2 ceiling tiles, or quarter points on 2 x 4 ceiling tiles.
6. Residential Buildings shall have concealed or sidewall sprinkler heads in finished spaces with drywall or acoustical ceiling tile. Academic Buildings shall have chrome semi-recessed type sprinkler heads in finished spaces with drywall or acoustical ceiling tile. Where sprinkler heads are located in woodwork or special architectural spaces, coordinate with the Owner for the desired type.
7. It is preferred that the fire department connections be located on the building in lieu of free standing. Indicate the location on the plans, including the routing of the ball drip drain.
8. Show properly sized plumbing drains to accept the discharge of test connections, riser drains, backflow preventer, etc.
9. Post indicating valves shall not be used.
10. Where dry type systems or subsystems are used, include on the drawings an electric circuit for the air compressor.
11. Indicate on the drawings the locations of all tamper switches/supervised valves and flow switches. Coordinate with the fire alarm drawings.
12. Alarm bells or water gongs shall not be used.
13. At fire Hydrants provide a shut off valve at the base of the fire hydrant.

PART 2 BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 MANUFACTURERS

A. Fire Hydrants
   1. Mueller
   2. American Foundry

2.2 SPECIFICATIONS

A. Specify that: Sprinkler heads shall be on return bends and centered +/-2” on 2 x 2 ceiling tiles, or quarter points on 2 x 4 ceiling tiles.

B. Specify that: All sets and rises shall be located above ceilings of adjacent spaces of rooms without ceilings as opposed to making the sets and risers in the exposed spaces.

C. Specify that: Inspector test connections and auxiliary drains shall be piped to spaces not occupied by building occupants, i.e., Mechanical Rooms, Storage Rooms, Janitor's Closets, etc.

D. Specify that: Contractor shall locate heads in the field from the final wall locations. It shall be brought to the Architect's attention where the center of tile location exceeds the maximum distance of the sprinkler. Additional heads shall be added and the layout modified as directed by the Architect at no additional cost to the Owner.

E. Specify that: The Contractor shall submit to the Architect/Engineer technical questions to the Authority Having Jurisdiction. The Contractor will be allowed to pursue procedural questions related to the permit process. The Contractor shall file and pay permit cost.

F. Specify that: Preliminary testing, witnessed by the Owner's Representative, shall be conducted to assure proper operation before the final test is scheduled. Prior to this testing, pipes shall be flushed, hydrostatically tested, and all valves and devices shall be operated. All requirements of “System Acceptance” of NFPA 13 shall be met in full. The sprinkler system shall be final Acceptance tested in the presence of the Owner's Representative and the governing agencies having jurisdiction for approval.

G. Specify that: The following are prohibited: Plain end couplings and fittings, Mechanical Saddle tee/cross, Snap-On/Strapless Outlet Fittings, Plastic Piping, and Flexible Connectors.
H. Specify that: Pipe velocities shall not exceed 20 feet per second in any section of the piping system.

I. Specify that: Fire Hydrants shall be painted safety yellow.

J. Refer to the Piping Material Section for materials to be specified.

END OF SECTION
SECTION 15510 – HEATING BOILERS

PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 DESIGN REQUIREMENTS

A. Layout shall be arranged to facilitate boiler maintenance. Piping shall be arranged so that the service valves can be closed and the piping and specialties between the service valves and boiler can be removed for servicing. Where boiler connection sizes are smaller/larger than the line sizes associated with the system piping, a reducer/increaser shall be installed immediately at the boiler flanges to adapt to the indicated line size. All specialties and service valves associated with the boiler shall be line size, and not boiler connection size.

B. The designer shall locate the equipment such that it can be replaced at the end of its life without removing building structural components. (i.e. provide area ways, louvers, removable panels, doors, etc.)

C. Equipment room location shall allow bulk delivery of fuel oil and boiler chemicals.

D. Thermal Plant low pressure steam heating boilers shall meet the following criteria:
   1. Scotch Marine/Fire Tube
   2. FM gas train
   3. Dual Fuel – Natural gas and No. 2 Fuel oil
   4. 15 psig relief valves
   5. Fisher modulating feedwater control valve
   6. Modulating VFD forced draft burner
   7. Linkage-less actuators
   8. O2 trim

E. Hot water heating boilers shall meet the following criteria:
   1. Flex tube or cast iron sectional
   2. FM gas train
   3. Dual Fuel – Natural gas and No. 2 Fuel oil
   4. 50 psig relief valves minimum
   5. Modulating forced draft burner

F. Steam process boilers shall meet the following criteria:
   1. Vertical Tubeless
   2. FM gas train
   3. Natural gas only
   4. Modulating forced draft burner

G. Boiler pad shall be reinforced and dowelled to the floor to withstand seismic forces. Boiler attachment to the pad shall withstand seismic forces. The drawings shall indicate the specific requirements, including anchor bolt size, embedment depths, edge distance requirements, anchor spacing requirements.
H. Individual boiler flues are preferred. The designer shall pay close attention to flue layout and flue calculations. Flue draft fans are not acceptable.

I. Gas vents and steam vents shall be piped outdoors to a safe location. Gas vents shall be vented separately. Steam relief vents may be combined for multiple boilers where long runs are required.

J. Show on the drawings: drains, relief valve piping, drip pan elbows, gas vents, blow down, drain lines, and other contractor installed piping.

K. Multiple hot water boilers or process steam boilers shall be sequenced with Heat Timer model Multi-MOD. On the drawings show the panel location, power wiring, and control wiring.

L. Thermal Plant steam boilers shall have a Cleaver Brooks Hawk ICS sequence panel. On the drawings show the panel location, power wiring, and control wiring.

PART 2 BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 MANUFACTURERS

A. Thermal Plant steam boilers shall be Cleaver Brooks model CB.

B. Flex Tube hot water boilers shall be Bryan Steam, Cleaver Brooks, Unilux.

C. Cast iron sectional hot water boilers shall be Burnham Corp., HB Smith, Peerless, Weil McClain.

D. Vertical Tubeless process steam boilers shall be Fulton Boiler Works model ICS, Hurst model 4VT.

END OF SECTION
SECTION 15550 – BREECHINGS, CHIMNEYS, AND STACKS

PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 DESIGN REQUIREMENTS

A. GENERAL
1. Stacks should be shown on the drawings using the standard fittings and pieces cataloged from the manufacturer. Stacks shall be drawn double line with joint lines drawn for each fitting or component.
2. Coordinate with the architect to maintain the required clearance to combustible materials.
3. Coordinate with the architect to maintain the required space to support the vertical stack in the chase using the cataloged supports.
4. Locate stack discharge such that the discharge is not drawn into fresh air intakes for the building or adjacent buildings. Prevailing winds and obstructions shall be considered.
5. Individual boiler flues are preferred. The designer shall pay close attention to flue layout and flue calculations. Flue draft fans are not acceptable.
6. Coordinate with Architect to conceal stacks.

B. B VENT
1. B Vent shall be double wall type. The vent shall have an inner wall constructed of a minimum of .018” thick aluminum alloy. The outer wall shall be a minimum of .020” of G-90 galvanized steel.

C. POSITIVE PRESSURE
1. The double wall stack shall have an outer jacket of a minimum of .025” thick aluminum coated steel. The inner gas carrying pipe shall be a minimum of .035” thick type 316 stainless steel.
2. The engineer shall determine the required insulation value based on the application and what is adjacent to the stack.

D. CONDENSING
1. Flue shall have AL29-4C stainless steel wall.
PART 2 BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 MANUFACTURERS

   A. B Vent and Positive Pressure
      1. AMPCO
      2. Metalbestos
      3. Metal-Fab
      4. Schebler
      5. Van-Packer

   B. Condensing
      1. Heat Fab, ProTech Systems, or equivalent

2.2 SPECIFICATIONS

   A. Specify that the vendor provide flue calculations with shop drawing submittal.

END OF SECTION
PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 DESIGN REQUIREMENTS

A. Layout shall be arranged to facilitate chiller maintenance. Piping shall be arranged so that the service valves can be closed and the piping and specialties between the service valves and chiller can be removed for servicing and to allow clear access to the water boxes for removal as required. Flanges or Victaulic couplings shall be located to allow removal of a minimal amount of piping to clean the chiller tubes. Where chiller connection sizes are smaller/larger than the line sizes associated with the system piping, a reducer/increaser shall be installed immediately at the chiller flanges to adapt to the indicated line size. All specialties and service valves associated with the chiller shall be line size, and not chiller connection size.

B. Chillers shall be located at grade or basement level on an exterior wall for easy replacement without disassembling the chiller or without removing ductwork or piping. Chillers located at grade shall have an overhead door, removable louver, or removable panel. Chillers located below grade shall have an area way.

C. Head room and piping layout shall allow removal of the chiller compressor and motor with an A frame hoist.

D. Loop Chiller selections shall meet the following criteria:
   1. Centrifugal compressor.
   2. High Efficiency.
   3. HCFC-123 or HFC-134a refrigerant.
   4. 44°F leaving water temperature, fouling factor 0.00025.
   5. 85°F entering condenser water, fouling factor 0.0005.
   6. Evaporator flow 1900 gpm for Hilltop Campus, or 2000 gpm for East Campus.
   7. Refrigerant rupture disk and refrigerant relief valve in series to minimize charge loss on an over pressure condition. A pressure switch shall be located between the two devices to indicate a ruptured disk.

E. Process Chiller selections shall meet the following criteria:
   1. Scroll or screw compressor.
   2. HFC-134a, HCFC-22 or HFC-407c refrigerant.
   3. Evaporator fouling factor 0.00025.
   4. Air cooled condensers selected at 105°F ambient for summer operation.
   5. Air cooled condensers selected at 0°F ambient for winter operation.
   6. 85°F entering condenser water, fouling factor 0.0005.

F. Chillers installed at slab on grade shall be installed on a neoprene pad. Vibration isolation shall only be used where the designer demonstrates the need.

G. Chiller pad shall be reinforced and doweled to the floor to withstand seismic forces. Chiller attachment to the pad shall withstand seismic forces. The
drawings shall indicate the specific requirements, including snubber size, anchor bolt size, embedment depths, edge distance requirements, anchor spacing requirements.

H. Refrigerant relief piping shall be copper or steal with a braided flexible connector at the chiller connection.

I. In general the chiller should be metered at the 5 kV load switch in lieu of the chiller starter.

J. Loop chillers shall be Johnson Controls N2 compatible or the manufacturer shall provide a gateway to the Johnson Controls system. If a gateway is to be provided show the gateway panel location, power wiring to the panel, and communication wiring between the gateway and the chiller.

PART 2 BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 MANUFACTURERS

A. Centrifugal Loop Chillers shall be Trane, York, and Carrier.

B. Process Chillers shall be Trane, York, Carrier, and McQuay.

C. Electronic Flow Switches shall be Ameritrol, Inc. model FM-0750-voltage-02-S.

2.2 SPECIFICATIONS

A. Specify that chiller be Johnson Controls N2 compatible or the manufacturer shall provide a gateway to the Johnson Controls system. The manufacturer shall include the cost of field programming and mapping the gateway points.

B. Include temperature control point to monitor the pressure switch between the refrigerant rupture disk and relief valve.

C. Specify that the chiller condenser water tubes be Eddy Current tested, at the job site after installation, and that the test data be submitted to the Owner.

D. Specify that the chiller warranty be five (5) years from Substantial Completion.

E. Specify Contractor to adjust set point for electronic flow switches.

F. Life cycle bidding is the preferred method of purchasing Loop chillers.

END OF SECTION
SECTION 15630 – REFRIGERANT MONITORING SYSTEMS

PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 DESIGN REQUIREMENTS

A. Each chiller equipment room shall be provided with a refrigerant monitor system, refrigerant exhaust system, and a self contained breathing apparatus (SCBA).

B. Refrigerant monitors shall be infrared (IR) sensor technology. It shall accurately provide sensing down to 1 part per million (ppm).

C. Provide a refrigerant sensor on each side of the chiller. Chillers next to each other may share a common sensor if the refrigerants are the same.

D. Exhaust shall be ducted down to 12 inches above the mechanical room floor. The exhaust duct and makeup air inlet shall be located to “sweep” the room across the chiller.

E. An interposing relay shall be provided on the high alarm contact. The relay shall: start the exhaust fan, output to the DDC, and shut down any boilers in the same equipment room. These functions shall be hardwired and shall be shown on the electrical drawings.

F. The DDC shall monitor the following: low alarm level contact and high alarm level contact.

G. A self contained breathing apparatus shall be located outside of the machinery room door. The University’s maintenance staff carry a SCBA in their vehicle, therefore it is not necessary to provide a second unit.

PART 2 BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 MANUFACTURERS


2.2 SPECIFICATIONS

A. Specify the following alarm levels: The first level of alarm shall be set at 100 ppm (except for R-123, it shall be 20). The second level of alarm shall be set at the TLA-TWA level of 1000 ppm (except for R-123 which is 30 ppm).

B. Specify only one (1) self contained breathing apparatus.

END OF SECTION
SECTION 15640 – PACKAGED COOLING TOWERS

PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 DESIGN REQUIREMENTS

A. Layout shall be arranged to facilitate cooling tower maintenance and good airflow. Where cooling tower connection sizes are smaller/larger than the line sizes associated with the system piping, a reducer/inincreaser shall be installed immediately at the cooling tower flanges to adapt to the indicated line size. All specialties and service valves associated with the cooling tower shall be line size, and not cooling tower connection size.

B. Cooling Towers shall be located on building roofs and shall be architecturally screened, including safety rails and headers, in the design of the building. The location of the cooling towers shall not be located above spaces sensitive to noise or vibration.

C. Cooling Tower selections shall meet the following criteria/options:
1. High Efficiency.
2. Low noise, maximum 65 dBA at the ground level. On the South 40 Campus 60 dBA at the ground level and 50 dBA at the property line.
3. 79°F Ambient wet bulb.
4. 85°F leaving condenser water.
5. Stainless steel or FRP hot and cold basins.
7. TEFC motor outside of the air stream with a gear drive.
8. Service platforms, plenum walkways, ladders and guardrails.
9. Vibration switch
10. Without makeup water valve and float assembly.

D. Cooling towers shall be directly attached to galvanized steel supports. Vibration isolation shall only be used where the designer demonstrates the need.

E. Inverters shall be used on cooling tower fans. Motors shall be inverter duty per NEMA MG-1, Part 31 (1600 volt peak, 0.1 microsecond rise time).

F. Cooling towers shall be designed with freeze protection. Consult Planning Facilities and Management to determine if heating will be by electric basin heaters and electric heat trace or by a side stream heat exchanger.

G. Condenser water shall have a modulating bypass valves (i.e. one butterfly valve in the bypass and another butterfly valve in supply line to the tower, each with their own actuator) located in the mechanical room. This bypass is to facilitate cold weather starting.

H. One cooling tower cell shall serve a maximum of one chiller. It is acceptable to use more than one cooling tower cell to serve a single chiller.
I. Multi-cell towers shall be piped with an external equalizer line with valves in lieu of basin weir plate. Equalizer lines shall have a maximum pressure drop of 3 in. w.c. under worst case operating condition. Multi-cell towers shall have a magnetostrictive type water level sensor located in the equalizer piping.

J. The DDC shall control/monitor the following: fan speed control, water level sensor, modulating makeup water valve and vibration alarm switch.

K. Provide freezeless hose bibs near the cooling towers to allow cleaning.

PART 2 BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 MANUFACTURERS

A. Cooling Towers shall be Baltimore Air Coil or Marley.

2.2 SPECIFICATIONS

A. Specify that the contractor is responsible for installing all components shipped loose with the cooling tower.

B. Specify that the tower manufacturer shall provide a representative during start-up to program/lockout of tower natural frequencies.

C. Life cycle bidding is the preferred method of purchasing Loop cooling towers.

END OF SECTION
SECTION 15710 – HEAT EXCHANGERS

PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 DESIGN REQUIREMENTS

A. Layout shall be arranged to facilitate heat exchanger maintenance including tube cleaning and tube replacement. Where heat exchanger connection sizes are smaller/larger than the line sizes associated with the system piping, a reducer/increaser shall be installed immediately at the heat exchanger flanges to adapt to the indicated line size. All specialties and service valves associated with the heat exchanger shall be line size, and not heat exchanger connection size.

B. On the drawings indicate the required service clearance.

C. When steam to water heat exchangers are used for building heating, a single plate and frame type shall be used.

D. Condenser water cooling economizer heat exchangers shall be plate and frame type.

E. Other heat exchangers shall be shell and tube type. Preference should be given for straight tube type for cleaning.

F. Systems using a single steam to water heat exchanger shall be provided with a minimum of two steam traps, each steam trap sized for 50% of the load.

G. Heat exchangers shall be installed on steel supports to support them at working height, and for steam heat exchangers to provide proper condensate drainage.

H. Hot surfaces above 120°F shall be insulated for personnel protection. Cold surfaces below 55°F shall be insulated with a continuous vapor barrier.

PART 2 BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 MANUFACTURERS

A. Plate Frame – Alfa-Laval, APV, Bell and Gossett

B. Shell and Tube – Armstrong, Bell and Gossett, Taco

2.1 SPECIFICATIONS

A. Plate frame Heat exchangers shall have the following construction:

1. Capacity – ARI 400 certified ratings
2. Frame – Steel, epoxy coated
3. Carrying Bar – Stainless Steel
4. Tightening Bolts – Steel with rolled threads and double width hex nuts
5. Plates – 316 Stainless Steel
6. Gaskets – Nitrile, glue-free
7. Connections – Carbon Steel, all pipe connections on frame plate
8. OSHA protective shroud on plate pack
9. Frame size should allow approximately 20% excess capacity
10. Stainless steel drip pan

END OF SECTION
SECTIO\n
AIR HANDLING UNITS

PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 DESIGN REQUIREMENTS

A. Layout shall be arranged to facilitate air handling maintenance including coil cleaning, coil replacement and filter replacement. Where coil connection sizes are smaller/larger than the line sizes associated with the system piping, a reducer/increaser shall be installed immediately at the coil flanges to adapt to the indicated line size. All specialties and service valves associated with the coil piping shall be line size, and not coil connection size.

B. On the drawings indicate the required service clearance, including coil replacement pull space, filter replacement pull space, fan/motor replacement pull space, and access to all inspection doors and maintenance points.

C. The designer shall locate the equipment such that it can be replaced at the end of its life without removing building structural components. (i.e. provide area ways, louvers, removable panels, doors, etc.)

D. Each coil shall have upstream and down stream access for inspection and cleaning.

E. Piping design shall locate flanges/unions and service valves to allow removing the coil by removing a minimal amount of piping.

F. Humidifiers are to be used only when requested by the Owner. When a humidifier coil is used it shall be located in an access section with a drain pan located up stream of the cooling coil. Trim humidifiers located in the ductwork shall have drain pans installed 2 times the absorption distance downstream of the humidifier.

G. Units shall be draw through arrangement.

H. Cooling coil face velocity shall not exceed 500 fpm.

I. 24" x 24" Filter sizes are preferred, use external filter section when necessary. Filter face velocity shall not exceed 400 fpm. Filtration for Academic, Office, and Residential buildings shall be 30% efficient (MERV 7) on ASHRAE Test Standard 52, unless otherwise directed by the Owner.

J. Designer shall calculate the condensate trap height for each unit, indicate additional supporting steel where condensate trap height is greater than the height available from the unit base rails and housekeeping pad.

K. Energy Recovery wheels shall have the following minimum characteristics:
   1. Aluminum substrate
   2. Aluminum support system
   3. Modular Media sections
   4. 3Angstrom molecular sieve desiccant
   5. External pillow block bearings
6. Non-wearing seals  
7. Tested in accordance with ASHRAE 84

L. Units shall have the following minimum characteristics:
   1. Double Wall, insulated, galvanized steel  
   2. Air foil or backward inclined fans  
   3. Internally seismic isolated fans  
   4. Coils – ½” diameter x .020” wall thickness copper tubes and .0075”  
      aluminum or copper fins spaced not closer than 10 per inch  
   5. Chilled water coils shall not be less than 6 rows  
   6. Stainless steel cooling coil casing  
   7. Stainless steel drain pans, IAQ double pitched  
   8. Intermediate drain pans for stacked cooling coils  
   9. Stacked coils shall have independent coil frames  
  10. Extended lube lines through the unit casing  
  11. Hinged access doors with quarter turn handles  
  12. NEMA premium efficiency motor  
  13. Inverter rated motor when used with VSD  
  14. NEMA starters, if furnished with unit.  
  15. Marine lights with 1 hour timer switch in units larger than 15,000 cfm  
  16. Stainless steel fan shafts in units larger than 15,000 cfm

M. Large roof mounted equipment shall have the following additional characteristics:
   1. Walk-in sections or service vestibule  
   2. Marine lights with 1 hour timer switch  
   3. Rain gutters  
   4. Electrical receptacles

PART 2 BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 MANUFACTURERS

A. Packaged – Trane, York, Carrier, McQuay

B. Custom – Air Enterprise, Buffalo, Webco, Marcraft

2.2 SPECIFICATIONS

A. Specify that the manufacturer shall use the most energy efficient fan option within  
   the manufacturer's line for the unit size but in no case will the wheel be smaller than  
   the diameters scheduled.

B. Specify that water coil connections are copper or brass.

C. Specify that energy recovery wheels be manufactured by SEMCO.

END OF SECTION
SECTION 15810 – DUCTS

PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 DESIGN REQUIREMENTS

A. Refer to Duct System Schedule.

B. Ductwork shall be designed for low pressure loss and energy conservation.

C. Branch take offs and any flexible duct for VAV boxes shall be sized at the same friction factor as the trunk duct then reduce to the size of VAV box inlet and provide a minimum of 3’ of straight hard duct at the inlet of VAV boxes.

D. All rectangular ducts shall be “Pittsburgh Lock” longitudinal joints. Snaplock is not acceptable.

E. All round ducts and flat oval ducts shall have spiral seams or continuously welded longitudinal seams.

F. All transverse joints in rectangular ductwork 48” and larger shall be Ductmate, SMACNA T-25, or approved equivalent. All flanged ductwork, regardless of pressure class, shall use gaskets, corner closures, and be TEK screwed or riveted on 10” centers with a minimum of two (2) per side. Transverse joints in rectangular ductwork smaller than 48” shall be made in accordance with SMACNA suitable with the pressure class.

G. All transverse joints in round and oval ductwork 24” and larger shall be Ductmate, or approved equivalent. Transverse joints in round and overall ductwork smaller than 24” shall be beaded sleeve joints.

END OF SECTION
<table>
<thead>
<tr>
<th>ID</th>
<th>Service</th>
<th>Application</th>
<th>Duct Type</th>
<th>Material</th>
<th>Pressure Class</th>
<th>Seal Class</th>
<th>Insulation Type</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Outdoor Air - Unconditioned</td>
<td></td>
<td>(Rectangular)</td>
<td>Galvanized Steel</td>
<td>2&quot; w.c.</td>
<td>A</td>
<td>GF-1</td>
<td></td>
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<td>Galvanized Steel</td>
<td>2&quot; w.c.</td>
<td>A</td>
<td>GF-1</td>
<td></td>
</tr>
<tr>
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<td>High Pressure</td>
<td>(Rectangular)</td>
<td>Galvanized Steel</td>
<td>4&quot; w.c.</td>
<td>A</td>
<td>GF-1 or GF-3</td>
<td></td>
</tr>
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<td>(Round)</td>
<td>Galvanized Steel</td>
<td>4&quot; w.c.</td>
<td>A</td>
<td>GF-2 or GF-3</td>
<td></td>
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<td>Low Pressure</td>
<td>(Rectangular)</td>
<td>Galvanized Steel</td>
<td>2&quot; w.c.</td>
<td>C</td>
<td>GF-1 or GF-3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Supply Air - Downstream of VAV or recirculation with room</td>
<td>Low Pressure</td>
<td>(Round)</td>
<td>Galvanized Steel</td>
<td>2&quot; w.c.</td>
<td>C</td>
<td>GF-2 or GF-3</td>
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<td>Transfer Air</td>
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<td>None</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Transfer Air</td>
<td>Sound Boots</td>
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<td>GF-3</td>
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<td>GF-1</td>
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<tr>
<td></td>
<td>Return</td>
<td>General Service</td>
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<td>GF-2</td>
<td></td>
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<tr>
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<td>A</td>
<td>GF-1</td>
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</tr>
<tr>
<td></td>
<td>Return upstream of VAV boxes</td>
<td>High Pressure</td>
<td>(Round)</td>
<td>Galvanized Steel</td>
<td>4&quot; w.c.</td>
<td>A</td>
<td>GF-2</td>
<td></td>
</tr>
<tr>
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<td>Aluminum</td>
<td>2&quot; w.c.</td>
<td>B</td>
<td>GF-1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Return</td>
<td>High Moisture</td>
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<td>Aluminum</td>
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<td></td>
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<tr>
<td></td>
<td>Exhaust</td>
<td>General Service</td>
<td>(Round)</td>
<td>Galvanized Steel</td>
<td>2&quot; w.c.</td>
<td>B</td>
<td>None</td>
<td></td>
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<tr>
<td></td>
<td>Exhaust</td>
<td>High Moisture</td>
<td>(Rectangular)</td>
<td>Aluminum</td>
<td>2&quot; w.c.</td>
<td>B</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exhaust</td>
<td>High Moisture</td>
<td>(Round)</td>
<td>Aluminum</td>
<td>2&quot; w.c.</td>
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<tr>
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<td>Fume Hood Exhaust w/ individual fan</td>
<td>Acid Fumes</td>
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<tr>
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<td>Fume Hood Exhaust w/ common fan</td>
<td>Acid Fumes</td>
<td>(Round)</td>
<td>316 Stainless Steel or PVC Coated Galvanized</td>
<td>4&quot; w.c.</td>
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<td>None</td>
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</tr>
<tr>
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<td>Fume Hood Exhaust common riser</td>
<td>Diluted Fumes</td>
<td>(Rectangular)</td>
<td>Galvanized Steel</td>
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<tr>
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<td>Fume Hood Exhaust common riser</td>
<td>Diluted Fumes</td>
<td>(Round)</td>
<td>Galvanized Steel</td>
<td>4&quot; w.c.</td>
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<td>None</td>
<td></td>
</tr>
<tr>
<td></td>
<td>General Lab Exhaust downstream of VAV boxes</td>
<td>Low Pressure</td>
<td>(Rectangular)</td>
<td>Galvanized Steel</td>
<td>2&quot; w.c.</td>
<td>B</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td></td>
<td>General Lab Exhaust downstream of VAV boxes</td>
<td>Low Pressure</td>
<td>(Round)</td>
<td>Galvanized Steel</td>
<td>2&quot; w.c.</td>
<td>B</td>
<td>None</td>
<td></td>
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<tr>
<td></td>
<td>General Lab Exhaust upstream of VAV boxes</td>
<td>High Pressure</td>
<td>(Rectangular)</td>
<td>Galvanized Steel</td>
<td>4&quot; w.c.</td>
<td>A</td>
<td>None</td>
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<tr>
<td></td>
<td>General Lab Exhaust upstream of VAV boxes</td>
<td>High Pressure</td>
<td>(Round)</td>
<td>Galvanized Steel</td>
<td>4&quot; w.c.</td>
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<td></td>
<td>Kitchen Exhaust</td>
<td>Grease Hoods</td>
<td>(Rectangular)</td>
<td>Welded Steel</td>
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<tr>
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<td>Kitchen Exhaust</td>
<td>Grease Hoods</td>
<td>(Round)</td>
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<td>Listed Grease Duct</td>
<td></td>
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</tbody>
</table>

* Exterior: GF-1: Glass Fiber Board ducts seal GF-2: Glass Fiber Blanket class A GF-3: Acoustical Duct Liner
# Ductwork Insulation Schedule

<table>
<thead>
<tr>
<th>ID</th>
<th>Service</th>
<th>Conditioned spaces and return air plenums</th>
<th>Unconditioned spaces, including Mechanical Rooms</th>
<th>Exterior</th>
<th>Ventilated Attic</th>
<th>Unventilated Attic with insulation at the ceiling</th>
<th>Unventilated Attic with insulation at the roof</th>
<th>REMARKS</th>
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</thead>
<tbody>
<tr>
<td>Outdoor Air</td>
<td>Unconditioned</td>
<td>1&quot;</td>
<td>1&quot;</td>
<td>None</td>
<td>None</td>
<td>2&quot;</td>
<td>1&quot;</td>
<td>None</td>
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<tr>
<td>Heating Only Ducts</td>
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<td>None</td>
<td>None</td>
<td>1&quot;</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Cooling Only Ducts</td>
<td>1&quot;</td>
<td>1&quot;</td>
<td>1&quot;</td>
<td>1&quot;</td>
<td>1&quot;</td>
<td>2&quot;</td>
<td>1&quot;</td>
<td>None</td>
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<tr>
<td>Heating &amp; Cooling Ducts</td>
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<td>2&quot;</td>
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<td>2&quot;</td>
<td>1&quot;</td>
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<tr>
<td>Return Ducts</td>
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<td>1&quot;</td>
<td>1&quot;</td>
<td>1&quot;</td>
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</tbody>
</table>
PART I PROGRAMMING AND DESIGN GUIDELINES

1.1 DESIGN REQUIREMENTS

A. AIR FILTRATION

1. Filter housings shall use only 24" x 24" size filters.
2. Face velocity not to exceed 400 fpm
3. Academic, Office, and Residential buildings shall be 30% efficient (MERV 7) on ASHRAE Test Standard 52, unless otherwise directed by the Owner
4. Drawings shall indicate filter change out pressures allowed in the design. It is recommended that 30% filters be changed at 0.5" and pre-filter high efficiency combination be changed at 1.3".
5. Each filter assembly shall have a gauge arranged to measure pressure across each filter bank in housings containing more than one stage of filters. Gauges shall be Dwyer Model 2001 or equivalent (0-1" range for single stage 30% filters) (0-2" range for 65% or greater filters or multiple stages).
6. Each filter assembly shall have an engraved plastic plate indicating what the final change-out pressure is for each type of filter.

B. BALANCE DAMPERS

1. Show on the drawings volume dampers at each main branch take-off and in such other locations where required to properly balance the air distribution systems. Dampers shall not be provided at a take-off to a VAV box inlet.
2. All dampers, except those located downstream from terminal units used to adjust individual grilles, shall have frames and bearings and shall have quadrant lock regulators with thread screw to allow damper to be securely locked into place.
3. Balancing dampers downstream from terminal units that are contractor fabricated or a part of manufactured branch fittings shall be a minimum of 18-ga. Plate, 3/8" continuous shaft with locking quadrant handle equal to Duro Dyne model Quadline.

C. FIRE DAMPERS

1. Show on the drawings locations of all required fire dampers.
2. Each fire damper shall have a unique number and be scheduled on the drawings.
3. Fire dampers shall have the damper blades out of the air stream, Style B for rectangular ductwork and Style C for round/oval ductwork.
4. At each fire damper location show on the drawings the location and size of access doors.

D. FIRE/SMOKE DAMPERS

1. Show on the drawings locations of all required fire/smoke dampers.
2. Each fire/smoke damper shall have a unique number and be scheduled on the drawings.
3. Fire/smoke dampers shall have direct coupled actuators with the damper blades and actuator outside of the wall, but within the length of the sleeve.
4. At each fire/smoke damper location show on the drawings the location and size of access doors.
5. Coordinate with Division 16 to show the power requirements and fire alarm control modules.
6. Coordinate with Division 16 to specify how the fire/smoke dampers are to be controlled (i.e. all close on any general fire alarm; all close on any smoke detector initiation; AHU serving the third and fourth floor only close on smoke detector initiation on the third or fourth floor; floor by floor pressurization)

E. ACCESS DOORS
   1. Show at all fire dampers, control dampers, airflow stations, entering side of duct mounted coils, leaving side of duct mounted trim humidifiers, etc. Minimum size shall be 6" x 6", show largest size the duct will allow.

F. ACCESS PANELS
   1. Show at all plenum boxes at any location requiring personnel access. Minimum size shall be 18" x 36".

G. TURNING VANES
   1. Air turning vanes shall be used for all 90° change in direction for supply, return, relief, and exhaust duct.
   2. Turning vanes shall be single thickness, 2" radius, spaced on 1.5" centers.

H. FLEXIBLE DUCT
   1. Flexible duct length shall not exceed 8’ for diffusers and 3’ at VAV box inlets.
   2. Support flexible duct on 4’ centers maximum.
   3. Flexible duct shall be attached with zinc plated or stainless steel worm drive duct hose clamps.
   4. Flexible duct used for cooling shall have a metallic vapor barrier.

I. INTAKE AND RELIEF HOODS
   1. Intake hoods and relief hoods shall be located so cross contamination does not occur. Intake hoods shall be located 15’ away from exhaust, plumbing vents, etc.
   2. Intake hoods and relief hoods shall be located away from walls or parapets where snow drift can form.
   3. Curb height shall be a minimum of 18 inches.

J. LOUVERS
   1. Intake louvers and relief louvers shall be located so cross contamination does not occur. Intake louvers shall be located 15’ away from exhaust air, relief air, generator exhaust, loading docks, delivery/service points.
   2. Intake louvers shall be selected below the rated point for water penetration.
   3. Louvers located in area wells shall be located a minimum of 12 inches above the bottom of the area well.
4. Louvers connected to duct work shall have a 18” minimum deep plenum box with access doors to allow inspection/cleaning. Duct connections allow a minimum of 6” from the bottom of the duct to the bottom of the plenum.
5. Louvers shall be provided with bird screens, insect screens shall not be used.
6. Coordinate size, locations, and mounting details with the Architect.
7. Louvers that are used for mechanical systems shall be specified by Division 15.

PART 2 BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 MANUFACTURERS

A. Filter Housings
   1. 4” Filter – Camfil-Farr Filter model 4P Glide/Pack, Flanders/Air Seal model FL4, American Air Filter model Polyseal
   2. 2” Pre-Filter, 12” Second Filter - Camfil-Farr Filter model 3P Glide/Pack, Flanders/Air Seal model SD-HF

B. Filters, 30% efficient (MERV 7) - Camfil-Farr Filter model 30/30, American Air Filter model 300X

C. Filters, High Efficiency - Camfil-Farr Filter model Riga-Flow, American Air Filter model Vari-Plus

D. Balance Dampers - Ruskin, Nailor, Arrow, Air Balance, NCA,

E. Fire Dampers - Ruskin, Nailor, Air Balance, Greenheck

F. Access Doors and Panels - Ruskin, Nailor

G. Intake and Relief Hoods – Greenheck, Ruskin, Penn Ventilation, United Enertech

H. Louvers – Ruskin, Greenheck, Air Balance, Arrow, NCA, United Enertech

2.2 SPECIFICATIONS

A. Specify that: Each filter assembly shall have an engraved plastic plate indicating what the final change-out pressure is for each type of filter.

B. Specify that: Fire Dampers are to be tested by the Contractor and witnessed by the Owner. The Contractor shall remove the fusible link and demonstrate that the damper closes freely. After acceptance by the Owner, the Contractor shall reset the damper and replace the fusible link.

END OF SECTION
PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 DESIGN REQUIREMENTS

A. Layout shall be arranged to facilitate fan maintenance including changing belts and motor replacement.

B. On the drawings indicate the required service clearance.

C. Motors shall be NEMA premium efficiency. Motors used with variable speed drives shall be inverter duty per NEMA MG-1, Part 31 (1600 volt peak, 0.1 microsecond rise time).

D. Fans shall be installed with seismic vibration isolators.

E. The fan rpm shall not be within 15% of the maximum or minimum allowable rpm, Where selection point is within 15% of the maximum allowable rpm of the fan class, provide a higher fan class.

F. Fans shall be belt driven to allow matching the performance to the system requirements.

G. Fan selections shall meet the following criteria:
   1. High Efficiency.
   2. Quiet Operation.
   3. Stable Operation, selected to the right of the surge line, typically one or two wheel diameters smaller than optimal.
   4. Non-overloading motor size anywhere along the rpm curve.

PART 2 BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 MANUFACTURERS

A. Centrifugal Fans and Vent Sets – Cook, Geenheck, Penn Ventilation, Twin City, Barry, Buffalo

B. Lab Exhaust, Variable Volume - MK Plastics, Greenheck, Strobic Air

2.2 SPECIFICATIONS

A. Specify that: All fans shall be licensed to bear the AMCA Performance Air and Sound Certified Ratings Seal. Fan air performance ratings shall be based on test conducted in an AMCA registered laboratory in accordance with AMCA 210 Air Performance Testing and AMCA 300 Sound Performance Testing. Fan curve families (tables will not be accepted) and octave band sound data shall be furnished with submittal data.
B. Specify that: In addition to the above, fans with induced air outlets shall have performance ratings based on test conducted in an AMCA registered laboratory in accordance with AMCA 260-07 Laboratory Methods of Testing Induced Flow Fans for Rating.

C. Specify the following:

Where fans are not the scheduled make and model the following criteria shall apply:

1. High Fan Efficiency. Selections with fan efficiencies 5% less than the scheduled fan may be rejected.
2. Stable Operation. Selections too close to the surge line may be rejected.
3. Quiet Operation. Selections with greater sound power levels may be rejected.
4. Non-overloading motor size for the fan selection point. Selections with overloading motors may be rejected.

D. Specify that: Motors shall be NEMA premium efficiency. Motors used with variable speed drives shall be inverter duty per NEMA MG-1, Part 31 (1600 volt peak, 0.1 microsecond rise time).

E. Specify that: The fan rpm shall not be within 15% of the maximum or minimum allowable rpm, Where selection point is within 15% of the maximum allowable rpm of the fan class, provide a higher fan class.

F. For roof exhausters specify: Contractor shall install a vinyl coated steel cable from the motor cover to the base to allow the motor cover to be removed for service but will not permit the cover to be blown away. Cable shall have eyelet or swagged ends with aluminum or galvanized fasteners.

END OF SECTION
SECTION 15990 – COMMISSIONING

PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 PURPOSE

A. This document defines the different types of commissioning that may be used on a project and the roles of each person in the process.

B. The Owner shall instruct the design team if commissioning, and at what level, will be included in the project.

1.2 DEFINITIONS

A. Commissioning: The process of ensuring that systems are designed, installed, functionally tested, and capable of being operated and maintained to perform in conformity with the design intent.

B. Commissioning Authority: The designated person, company, or agent who implements the overall commissioning process.

C. Design Intent: A detailed explanation of the ideas, concepts, and criteria that are defined by the owner to be important. This typically is an expansion of the information provided in the Owner’s program.

D. Field Installation Verification (FIV): The process of determining that equipment and systems have been installed properly and in accordance with the construction documents.

E. Functional Performance Test (FPT): The process of determining the ability of the equipment and systems to deliver performance, accordance with the final design intent.

1.3 TYPES OF COMMISSIONING

A. Fundamental: Design Professionals develop design intent. Near the end of construction the Commissioning Authority develops and completes FIV forms, and FPT forms. All major pieces of MEP equipment will be commissioned. Twenty-five percent of HVAC terminal equipment will be commissioned.

B. Enhanced: Starting at the beginning of the project the Commissioning Authority works with the Design Team and Owner. All major pieces of MEP equipment will be commissioned. All HVAC terminal equipment will be commissioned. Commissioning Authority can not be a member of the design firm.

1.4 OUTLINE OF THE COMMISSIONING PROCESS

A. Fundamental Commissioning
1. Commission Authority works for the Owner. Develops commission plan, develops commissioning forms, verify sequences of operation, witnesses all testing and completes commissioning forms, prepares commissioning report.

2. Design Professionals develop design intent.

3. Testing and Balancing Contractor works for Prime Contractor.

4. Trade Contractors assist the Commissioning Authority by providing labor to operate equipment, take measurements, and correct installation defects and equipment defects identified by the commissioning process.

B. Enhanced Commissioning

1. Commission Authority works for the Owner. Attends design meetings, reviews design, develops commission plan, develops commissioning forms, reviews shop drawings, conducts construction site visits, attends construction meetings, witnesses all testing and completes commissioning forms, prepares commissioning report, reviews O&M manuals, reviews As-built drawings.

2. Design Professionals develop design intent.

3. Testing and Balancing Contractor works for Commission Authority.

4. Trade Contractors assist the Commissioning Authority by providing labor to operate equipment, take measurements, and correct installation defects and equipment defects identified by the commissioning process.

PART 2 CONSTRUCTION DOCUMENTS

2.1 SPECIFICATIONS

A. Fundamental Commissioning

1. The Design Professional will edit the commissioning specifications Section 01810 for the Project Manual.

B. Enhanced Commissioning

1. The Commissioning Authority will edit the commissioning specifications Section 01810 for the Project Manual.

END OF SECTION
SECTION 16060 – GROUNDING AND BONDING

PART 1 - PROGRAMMING AND DESIGN GUIDELINES

1.1 GENERAL

A. The grounding system shall be designed in accordance to the National Electrical Code.

B. The system grounding electrode conductor shall be connected to the neutral bar inside the main panel.

C. The equipment grounding system shall consist of a continuous green insulated equipment grounding conductor. This grounding conductor shall be installed in every conduit or raceway with the feeder or branch circuit conductors. This grounding conductor shall be extended from the housing of every electrical load, through panelboard equipment grounding busses, to the equipment grounding bus in the main panel. The grounding bus shall be bonded to the grounded neutral bar inside the main panel using a Main Bonding Jumper.

D. When transformers are used to provide a separately derived system, the Contractor shall connect the grounding electrode conductor to the neutral bar inside the secondary system panel or service rated disconnect switch. Do not connect the grounding electrode conductor to the neutral lug inside the transformer.

E. Grounding of the service entrance and bonding of systems shall terminate on a wall mounted copper grounding bar.

F. The engineer shall show on the drawings the grounding bar, grounding electrode conductor, grounding electrodes, and all bonding of other systems.

PART 2 - BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 SPECIFICATIONS

A. Specify that the record drawing indicate the location and wire routing of the grounding electrode conductor, grounding electrodes, and all bonding of other systems.

B. Specify that the grounding is witnessed by Owner’s Representative.

END OF SECTION
SECTION 16120 – CONDUCTORS AND CABLES

PART 1 - PROGRAMMING AND DESIGN GUIDELINES

1.1 5 kV

A. Cables should be the following:
   1. Cable Type – MV-105
   2. Conductor – Copper
   3. Conductor Stranding – Compact round, concentric lay, Class B
   4. Conductor Insulation – Ethylene-propylene rubber complying with AEIC CS8
      a. Voltage rating – 5 kV
      b. Insulation Thickness – 133 percent insulation level
   5. Shielding – Copper tape, helically applied over semi-conducting insulation shield
   6. Cable Jacket – Sunlight-resistant PVC
   7. Bending Radius – The cables shall not be bent more than the 12x the cable diameter including shipping reels, pulling operation, junction boxes, and terminations.

B. Splices should be the following:
   1. Kit with stress-relief tube, non-tracking insulator tube, shield ground strap with constant force spring, 5 kV compression-type connector, end seal, cold shrink rubber sleeve or hot shrink plastic sleeve.

C. Terminations should be the following:
   1. IEEE 48 - Class 1
   2. Kit with stress-relief tube, non-tracking insulator tube, shield ground strap with constant force spring, 5 kV compression-type terminal lug, end seal, cold shrink rubber sleeve or hot shrink plastic sleeve.

D. Separable Insulated Connections should be the following:
   1. Modular system, complying with IEEE 386
   2. Load-Break – Elbow type with 200 Amp load make/break and continuous current rating, designed for energized disconnecting. Include test point on terminator body that is capacitance coupled.
   3. Dead-Break – Elbow type with 600 Amp continuous current rating, not designed for energized disconnecting. Include test point on terminator body that is capacitance coupled.
   4. Dead-Front Terminal Junctions: Modular bracket mounted groups of dead-front stationary terminals that mate and match with above cable terminators.

E. Indicate to scale on the drawings the conduit bending radius and pull box sizes. It is important that the designer show the elevation that the conduits are entering the building and design the entrance pull box accordingly.

1.2 600 Volt and less

A. Wire should be the following:
   1. Conductor – Copper, solid conductor for No. 10 AWG and smaller, stranded for No. 8 AWG and larger.
   2. Insulation – 90°C, THHN, THWN, XHHW for wiring in conduits
B. Applications
1. Service Entrance – THHN, THWN, XHHW, wiring in raceway
2. Feeders exposed, concealed, or below grade – THHN, THWN, XHHW, wiring in raceway
3. Branch Circuits “homeruns” exposed, concealed – THHN, THWN, XHHW, wiring in raceway
4. Branch Circuits “whips” exposed to view, or concealed in masonry/concrete walls, or inaccessible – THHN, THWN, XHHW, wiring in raceway
5. Branch Circuits “whips” not exposed to view, not concealed in masonry/concrete walls, not inaccessible – Metal Clad cable, Type MC with insulated copper equipment ground conductor.
7. Outdoors - THWN, XHHW, wiring in raceway
8. Underground Branch Circuits – USC/RHW, wiring in raceway

PART 2 - BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 ACCEPTABLE MANUFACTURERS

A. 5 kV
1. Cable: Pirelli Cables & Systems, Okonite Company, Southwire Company, Aetna Insulated Wire Company
   a. Specify that cable be shipped on reels that are 12x the cable diameter
2. Splices and Terminations: 3M Company, Raychem Corporation
3. Separable Connectors: Thomas & Betts/Elastimold, Cooper Power Systems

B. 600 Volt
1. Wire- General Cable Company, Carol, Anaconda, Rome Cable Corporation, ITT Royal, or Southwire Company.

2.2 INSTALLATION

A. 5 kV
1. The minimum cable bending radius required by the NEC and the cable manufacturer shall be maintained at all times during the installation. The larger of the two bending radius shall be used. Bending cables to less than the minimum radius shall be reason for not accepting the cable.

2.3 TESTING

A. 5 kV
1. Contractor shall test, witnessed by Owners representative, the insulation values of all cables, terminations and slices using a DC High Potential Test in accordance with ICEA S-68-516/NEMA WC-8. A controlled voltage source shall be used between the test equipment and the power source. Testing shall reach a voltage of 25kV (for 5 kV operating) and held there for 15 minutes. Submit a written record of the test. Remove defective cables, replace with new cable and retest.
2. Contractor shall test, witnessed by Owners representative, phasing of cables at loop switches prior to closing the switch and shall test each time the switch is to be closed.
Correct phasing as required to match existing phasing and rotation. At the completion of the project the loop switch shall be closed.

3. When connecting new cable to existing cable, the new cable shall be tested per the above prior to connecting to the existing cable. After the final connections are made, both the new and the existing cable shall be tested with a Megohm meter at 5,000 volts.

END OF SECTION
SECTION 16130 – RACEWAYS AND BOXES

PART 1 - PROGRAMMING AND DESIGN GUIDELINES

1.1 RACEWAY APPLICATION

A. Indoor should be the following:
   1. Rigid Steel, in all mechanical rooms where not supported directly to walls or ceilings. Threaded rigid steel conduit fittings and threaded cast aluminum boxes.
   2. Rigid Steel or Rigid Aluminum for medium voltage cable. Threaded rigid conduit fittings and painted steel or galvanized pull boxes.
   3. EMT, all work concealed in partitions or in concrete block walls, for all conduits run in ceiling plenums and exposed runs, and in all mechanical rooms where supported directly to walls or ceilings. Set-screw or compression type connectors and stamped steel boxes.
   4. MC cable will be allowed for the final connection to devices and fixtures where accessible and within drywall partitions. The maximum length for lighting whips, or outside of drywall partitions shall be 10 feet.

B. Connections to rotating or vibrating equipment should be the following:
   1. Flexible liquid-tight metal conduit (FLMC), all connects to HVAC equipment, in damp or wet locations.
   2. Flexible metal conduit (FMC), galvanized, all transformers and uninterruptible power systems.

C. Outdoors, above grade should be the following:
   1. Rigid Steel, except at cooling towers. Threaded rigid steel conduit fittings and threaded cast aluminum boxes.
   2. Rigid Aluminum at cooling towers. Threaded rigid aluminum conduit fittings and threaded cast aluminum boxes.

D. Outdoors, below grade should be the following:
   1. Medium Voltage, Communication duct banks, Pad Mount Transformer secondary shall be concrete encased duct banks. Conduit shall be schedule 40 PVC with
   2. Lighting circuits, blue phones, etc. direct buried schedule 40 PVC conduit with polymer hand holes.

E. Sizes
   1. Minimum conduit size shall be 3/4” trade size for branch circuits, except for switch legs which may be 1/2” trade size.

F. Do not install aluminum conduits embedded in or in contact with concrete.

G. Raceways shall not be embedded in slabs; except within the main electrical room, or in parking garages, where approved by the Owner.

1.2 DUCTBANK

A. Conduit: Electrical grade, rigid, nonmetallic, Schedule 40 PVC conduit in a 4” diameter size only, shall be installed. It shall be 90° C rated PVC and meet the latest revision of
NEMA Standard TC6. Lengths of either 10' or 20', with belled or coupled ends. Bends shall be a minimum of 24” radius at 90°, 45°, 22.5°, or 11.25°.

B. Spacers: The conduits in the duct bank shall be arranged in the trench in a tight, orderly matrix arrangement with the use of spacers. Spacers shall be 3” separation.

C. Encasement: Provide #3 rebar with 6” overlap splices in each corner. Provide 2500 psi concrete. After the concrete has been poured and leveled sprinkle dye on top of the concrete for future identification during excavation. Electric ductbanks the dye shall be “red”, Telecommunication ductbanks the dye shall be “orange”. Provide locator tape 12” above the ductank.

D. Provide a 200 lb tensile strength polypropylene pull string in each conduit.

1.3 MANHOLES

A. The manhole shall be a 12’ x 6’ x 7’ conventional precast concrete manhole constructed for H2O traffic rating.

B. The manhole shall include the following hardware and accessories:

36” diameter cast iron frame and cover marked “ELECTRIC” / “TELEPHONE”
6” concrete collar grade ring
6" concrete collar with a ladder anchor
Ladder with hook hangers
12-cable racks, 70 inches long, furnished by manufacturer and installed by contractor
24-14" long cable hooks
Pulling irons
4” terminators, (24) on each end, (48) on each side
Sump with round perforated cover
Joint sealant compound for manholes, collars, and cover frame
Grounding ribbon

C. Manhole shall be set on a level bed of 6” thick ¾” minus.

D. Reasonable effort shall be made to drain all manholes. Provide a Tideflex backwater valves in the storm/sanitary manhole.

E. When designing the ductbank indicate that the top row of terminators shall be left available for future in the event that additional conduits would be added to a ductbank in the future.

1.4 INNERDUCT

A. Provide three (3) 1-¼ inch innerducts inside of 4 inch Data conduits. Within each conduit the each innerduct shall be a different color.

B. Provide a 200 lb tensile strength polypropylene pull string in each innerduct. Secure the string on each end.
PART 2 - BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 SPECIFICATIONS

   A. Specify the applications per the above.

END OF SECTION
SECTION 16270 – TRANSFORMERS

PROGRAMMING AND DESIGN GUIDELINES

1.1 DESIGN REQUIREMENTS

A. DANFORTH CAMPUS
   1. It is preferred that the building transformer be contained in a dedicated electrical room with the main switchboard. The room shall be located such that conduit access in/out is not limited by the building architecture (i.e. not located under the building lobby, etc.). Electric rooms shall be void of other utilities unless they serve the electric room.

B. S40 CAMPUS
   1. Both indoor dry type and oil filled pad mounted transformers have been utilized. The preference is indoor dry type with the same requirements as above.

C. 5kV DRY TYPE

D. 600V DRY TYPE
   1. Three phase transformers shall be 480 delta primary and 208Y/120 secondary. Transformer shall have a minimum of 4 - 2-1/2% full current below normal and 2 - 2-1/2% full current above normal taps.

   2. Transformers shall be ANSI Class AA (Self-Cooled), as defined by ANSI-C57.12.01. Transformers shall be 115°C-temperature rise above 40°C ambient. 115°C rise transformers shall be capable of carrying a 15% continuous overload without exceeding a 150°C rise in a 40°C ambient. All insulating materials to be in accordance with NEMA St20-1992 standards for a 220°C UL component recognized insulation system.

BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 SPECIFICATIONS

A. Where Pad Mounted Transformers are utilized the following requirements shall be included in the project specification.

   Size: 45 through 750 KVA Three phase Dead Front
   Voltage: 4160VΔ - 208Y/120 or 4160VΔ - 480Y/277
   Taps: Two ½% above and two ½% below with hot-stick operated tap changers.
Options:

a) Furnish transformers with the following options:

**Fusing**
Three Bay-o-net oil immersed in series with ELS-P current limiting type fuses with 50,000A interrupting capacity.

b) **Switching**
Two individual two position 3 Pole 400A loop and one individual two position 3 Pole 200A transformer two position internal oil immersed load break switches shall be installed to allow the following switching selections. Switching shall not cause a momentary de-energizing of the transformer. ‘V’ and ‘T’ blade switching will not be acceptable.

1. Switch A closed, switch B closed, transformer switch closed.
2. Switch A closed, switch B closed, transformer switch open.
3. Switch A closed, switch B open, transformer switch closed.
4. Switch A open, switch B open, transformer switch closed.
5. Switch A open, switch B closed, transformer switch open (or closed).

c) **Terminations**
Provide six primary Elastimold 600 Series Deadbreak internal bushing to accept Elastimold 600 Series elbow connectors and provide six parking stands and six insulated parking bushings #K650SOP. Cooper/RTE devices are acceptable.

The low voltage bushings shall be tinned spade type. Transformers rated 500KVA shall have four 9/16” holes and the 750KVA shall have six 9/16” holes. Use ANSI requirements for other sizes and voltages.

d) **Accessories Group**

- One inch drain valve.
- Separate ½ inch oil sampler device.
- Dial type thermometer mounted in a well with resettable high temperature slave hand indicator.
- Oil filling fitting.
- Liquid Level gauge.
- Self-actuating pressure release device to vent pressure at 10 psig.
- Provisions for a Vacuum/Pressure gauge (1/4” NPT).

e) **Surge Arrestor**
Furnish in the transformer oil tank a 3KV surge arrestor.
f) **Vacuum/Pressure Gauge**
Furnish on the transformer a vacuum/pressure gauge with a range of -10 psig vacuum to +10 psig pressure.

2.2 MANUFACTURERS

A. 5kV Dry Type Transformers: Cutler-Hammer, General Electric, Siemens, or Square D Company.
B. Pad Mounted Transformers: ABB, Cooper, and General Electric.
C. 600V Dry Type Transformers: Cutler-Hammer, General Electric, Hevi-duty, Siemens, or Square D Company.

END OF SECTION
SECTION 16490 – COMPONENTS AND ACCESSORIES

PART 1 - PROGRAMMING AND DESIGN GUIDELINES

1.1 GENERAL

A. Fuses shall have a minimum 2:1 coordination.

1.2 FUSES – 600 VOLT and under

A. Fuses for motor loads and all other loads up to 600 A and up to 600 V shall be Bussmann “Low-Peak” or Ferraz Shawmut Amptrap 2000 dual element fuses, having a minimum interrupting capacity of 200,000 A RMS symmetrical. The fuses shall be UL Class RK1.

B. Fuses for all loads above 600 A and up to 600 V shall be Bussmann “Low-Peak” or Ferraz Shawmut Amptrap 2000 current limiting, time delay fuses, with a minimum interrupting capacity of 200,000 A RMS symmetrical. The fuses shall be UL Class L.

1.3 FUSES – 5KV

A.

PART 2 - BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 ACCEPTABLE MANUFACTURERS

A. 600 Volt - Bussmann Company, Ferraz Shawmut

B. 5KV – Cutler-Hammer, S&C

2.2 EQUIPMENT

A. Specify fuses from only one manufacturer shall be installed.

B. Specify that the contractor shall furnish and install in a spare fuse cabinet a complete set of three spare fuses for each size and type used. For 5KV fuses specify that the fuse refills be provided.

C. Specify that the contractor furnish and install a spare fuse cabinet.

END OF SECTION
SECTION 16075 – ELECTRICAL IDENTIFICATION

PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 GENERAL

A. Equipment identification and branch circuit information is required on “as-built” drawing submittals.

B. Designer shall include an electrical label schedule on the drawings or include a label column in the electrical schedules.

1.2 EQUIPMENT IDENTIFICATION

A. All major equipment items (i.e., transformers, panel boards, starters, variable speed drives, generators, lighting inverters, etc.) shall be identified with appropriately sized nameplates permanently attached to the respective equipment.

B. Interior equipment nameplates shall be 1/16” thick two-ply acrylic plastic 2-1/2” x 1” size minimum with white letters on a black background. Tag size shall be appropriate for equipment name, letters shall be a minimum of ½” high.

C. Exterior equipment shall be identified with nameplates suitable for exterior use or shall be engraved aluminum plates .020” thick, minimum size shall be 4” x 1-1/2” plates.

D. Nameplates shall be attached with corrosion-resistant No. 3 round head or No. 4 sheetmetal screws.

E. The following legend shall be used:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformers</td>
<td>T</td>
</tr>
<tr>
<td>Main Panel</td>
<td>MP</td>
</tr>
<tr>
<td>Distribution Panel</td>
<td>DP</td>
</tr>
<tr>
<td>Lighting Panel Boards</td>
<td>see below</td>
</tr>
<tr>
<td>Motor Control Center</td>
<td>MCC</td>
</tr>
<tr>
<td>Stand-by Generators</td>
<td>GEN</td>
</tr>
<tr>
<td>Automatic Transfer Switch</td>
<td>ATS</td>
</tr>
<tr>
<td>uninterruptible Power Supply</td>
<td>UPS</td>
</tr>
<tr>
<td>Unit Substation</td>
<td>SUB</td>
</tr>
<tr>
<td>Pad Mounted Switch</td>
<td>PMS</td>
</tr>
</tbody>
</table>

F. Loop Switches shall have the following labels:

1. Each switch shall have a 6” x 2” label with white letters on a red background that shall read:

   “WARNING
   SWITCH MAY BE ENERGIZED
   BY BACKFEED”
2. A 6" x 1-1/4" label with white letters on a black background shall identify the loop name on the first line and the next building served on the second line. Loop names will be given from the WU project manager. Example: “LOOP C2  TO CUPPLES I” “LOOP C2  TO WHITACRE”

G. Load Switches shall be labeled with description and include equipment designation such as "EAST WING TRANSFORMER T-1” or “UNIT SUBSTATION SUB-1” or “CHILLER CH-1”.

H. Unit substations, switchgear, and distribution panelboards shall be labeled with equipment labels as defined above. Load breaker/fusible switches shall be labeled with ½” wide, black text on white label maker tape.

1. When there is only one voltage in the building or the system is small the equipment can be simply labeled SUB-1, SWBD-1, DP-1, DP-2, etc.
2. When there is equipment of different voltages within the building, they should be further identified as SUB-H1, SUB-L1, DP-H1, DP-H2, DP-L1, or in the case of a very large distribution system 3-DP-L2 (indicating 3rd floor, distribution panel, 208 V, second panel)

I. Starters, disconnects, and variable speed drives shall be labeled with description and include equipment designation and where it is feed from such as “CONDENSER WATER PUMP CP-1, Fed from DP-2” or “WEST COOLING TOWER CT-1, Fed from DP-4” or “TOILET EXHAUST EF-12, Fed from 3-NHP-2”

J. Lighting panel boards as a class of equipment shall be labeled as follows regardless of what loads they serve.

1. Panels with a voltage of 480 shall be designated as ‘HP’.
2. Panels with a voltage less than 480 shall be designated ‘LP’.
3. If the building contains a stand-by generator; panels with emergency/life safety loads shall be designated as ‘EHP’ or ‘ELP’, panels with non-life loads shall be designated as ‘SHP’ or ‘SLP’, panels not connected to the stand-by generator shall be designated as ‘NHP’ or ‘NLP’.
4. Buildings with larger distribution systems may add number before the panel designating the floor and a number after the panel designation indicating the panel number on that floor. Example 1-HP-1 for first floor, 480 volt, first panel, or 3-NLP-2 for third floor, normal 208 volt, second panel.

K. The following legend, color, and lettering shall be used for below ground utilities:

<table>
<thead>
<tr>
<th>Service</th>
<th>Color</th>
<th>Legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric 4160 V</td>
<td>Red</td>
<td>Caution Buried High Voltage Electric</td>
</tr>
<tr>
<td>Electric</td>
<td>Red</td>
<td>Caution Buried Electric</td>
</tr>
<tr>
<td>Fiber Optic</td>
<td>Orange</td>
<td>Caution Buried Fiber Optic</td>
</tr>
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<td>Caution Buried CATV</td>
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</table>
PART 2 BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 CIRCUIT IDENTIFICATION

A. Specify that the contractor is to write the panel and circuit number on junction boxes covers and on the back of device covers.

1.2 EQUIPMENT IDENTIFICATION

A. Specify that the contractor is to submit a label list for approval.

END OF SECTION
SECTION 16210 – ELECTRICAL UTILITY SERVICES

PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 DESIGN REQUIREMENTS

A. CAMPUS DISTRIBUTION

1. Electric service on campus is available from the campus distribution system at a primary voltage of 4160 volt 3 wire wye, effectively grounded. The distribution system is a ‘Loop’ configuration. Each loop is protected by a pair of Cutler-Hammer 400E boric acid expulsion fuses. The building design shall coordinate with the 400E fuses. Service to new buildings shall be provided through (2) 600 Amp non-fused loop switches, fused main switches, and transformation to utilization voltage. Fused 4160 V main switches shall use current limiting type fuses for most applications. For existing facilities, service for modifications or additions shall be integrated with existing building service. The available campus short circuit capacity from the utility company is 20,000 Amps. Each building is to be provided with an electric meter.

B. LOOP CHILLERS AND THERMAL PLANTS

1. Where practical use separate distribution panels from the general building power distribution for loop chiller, thermal plants, and their auxiliary loads to allow sub-metering from the building electric usage.

C. METERS

1. Meters shall be provided on the utilization voltage side of each building transformer, for all 4160 volt loads (i.e. Loop Chillers), and sub-meters where directed by the Owner for accounting purposes. Where multiple meters exist on a project they shall be networked together via RS-485 network. One meter shall have an ethernet communication card and shall be wired to the building data system.

D. STANDBY POWER

1. Loads that can not tolerate any power interruptions, including 15 second automatic switching shall be provided with an uninterruptable power supply.

2. Loads that can not tolerate extended (24 hour) power outages shall be provided with engine generator back-up as approved by the Owner.

3. Loads that require standby power per a code requirement shall be discussed with the Owner.
4. Power quality is that as supplied by the Utility Company. Loads that require higher power quality shall be provided with a power conditioning unit.

5. In general, Emergency lighting shall be battery backup unless there is an Engine Generator provided for other purposes.

E. ENGINE GENERATOR

1. The need for an engine generator should be discussed at the earliest stages of design and programming as it has a large impact on the architectural, mechanical, and electric designs.

2. When an engine generator is provided the loads shall be segregated with automatic transfer switches as required by code for Level 1/Life Safety, Level 2/Legally Required, and Optional with separate transfer switches with separate power feeds/conduit/junction box paths to each.

PART 2 BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 MANUFACTURERS

A. BUILDING METERS

1. Each building meter shall be a Square D – CM3350 Circuit Monitor, with CMDVF Vacuum Florescent Display. One meter shall be furnished with an ethernet communication card (ECC). NO SUBSTITUTIONS ALLOWED

B. LOOP CHILLER METERS

1. Each chiller meter shall be a Square D – PM820 Power Meter. NO SUBSTITUTIONS ALLOWED

2.2 DRAWINGS

A. METER NETWORKING

1. On the drawings indicate conduit, wire, and terminations to network the meter with the ethernet communication card to a data closet.

2. On the drawings indicate conduit, wire, and terminations to daisy chain RS-485 communications between meters.

END OF SECTION
SECTION 16230 – GENERATOR ASSEMBLIES

PART 1 - PROGRAMMING AND DESIGN GUIDELINES

1.1 GENERAL

A. Loads that can not tolerate extended (24 hour) power outages shall be provided with engine generator back-up as approved by the Owner.

B. Loads that require standby power per a code requirement shall be discussed with the Owner.

C. The need for an engine generator should be discussed at the earliest stages of design and programming as it has a large impact on the architectural, mechanical, and electric designs.

D. When an engine generator is provided the loads shall be segregated with automatic transfer switches as required by code (Building Code, NFPA 110, National Electrical Code, etc.) for Level 1/Emergency/Life Safety, Level 2/Legally Required, and Optional with separate transfer switches with separate power feeds/conduit/junction box paths to each. A single generator feeding transfer switches of different classes shall either have multiple breakers on the engine generator, or the power distributed with a switchboard (panelboards are not allowed).

1. The following are typical examples of Level 1/Emergency/Life Safety Loads, refer to the applicable codes. (Level 1/Emergency/Life Safety Transfer Switches are not permitted in the main electrical room if the service in several cases)

   Emergency Lighting
   Elevator
   Fire Alarm System (still provide full battery backup)
   Smoke exhaust/control system

2. The following are typical examples of Level 2/Legally Required Loads, refer to the applicable codes.

   Smoke Removal Systems
   Sewage Ejectors
   Communication Systems

3. The following are typical examples of Optional Standby Power Loads, refer to the applicable codes.

   Security System
   Temperature Control System
   Uninterruptable Power Supplies
   Sump Pumps
   Condensate Pumps
   Heating Water pump for perimeter fin tube and preheat coil pumps
   Process cooling/heating for special spaces
Fume hood exhaust and makeup air
Critical lab equipment

4. When an engine generator is provided the following loads, if applicable, shall NOT be connected to the engine generator.

Loop Chillers
Comfort HVAC Equipment
General Lab Equipment.

1.2 DESIGN

A. The generator location should be selected per the following:

1. Muffler discharge is not located near outdoor air intakes.
2. Radiator discharge will not recirculate and is not located near outdoor air intakes.
3. Sound levels are met at the property line.
4. Fuel delivery can be made easily.

B. Points to be monitored by Campus EMS: 1) Generator run status, 2) common fault relay and circuit breaker auxiliary contact.

C. Coordinate with Owner on who should supply the fuel. In general, for generators connected to fuel oil storage tank, the owner will supply the fuel. In general, for generators with stand alone tanks, the contractor will supply the fuel.

D. Where generators are exposed to view, discuss with the Owner if the equipment should be specified with a custom paint color (typically tan).

E. Load Banks for testing shall not be permanently installed.

1.3 EQUIPMENT

A. Generators shall be packaged assemblies meeting the following:

1. Comply with NFPA 110 requirements for emergency and standby power supply systems.

2. Output Connections: Three phase generators should be wye connected for maximum flexibility.

3. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
   a. Ambient Temperature: Minus 10°F to 122°F.
   b. Relative Humidity: 0 to 100 percent.
   c. Altitude: Sea level to 700 feet.

4. Generator: Brushless, self exciting, Class H insulation, 130°C temperature rise, with strip heater
5. Voltage Regulator: Solid state, +/- 2%, 3-phase sensing

6. Governor: Isochronous governor, +/- 0.25%

7. Circuit Breaker: Line circuit breaker with shunt trip and auxiliary contact indicating breaker position

8. Battery Charger: Equalizer/Float type

9. Air Cleaner: Restriction indicator

10. Cooling System: Forced air, closed loop, self contained radiator, anti-freeze, block heater

11. Controller: Minimum features per NFPA 110, remote audio/visual alarm with silence, common fault relay kit, remote emergency stop kit

B. Transfer switches generally should be 3-pole, open transition type, with maintenance bypass. Buildings with double ended substations or multiple transformers should be 4-pole to eliminate parallel paths on the neutral/ground. Generators with 4-pole transfer switches are considered separately derived systems and need to be grounded in accordance with the NEC.

1.4 IDENTIFICATION

A. Refer to section 16075.

PART 2 - BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 ACCEPTABLE MANUFACTURERS

A. Generators: Caterpillar, Kohler Company, Onan Corporation

B. Transfer Switches: Asco Power Technologies, Caterpillar, Kohler Company, Onan Corporation

2.2 EQUIPMENT

A. Specify the above features and options, plus the following:
1. After installation, field acceptance test per NFPA 110, under full load and that the AHJ shall be notified to witness the test.
2. Specify for belly tank applications that the Contractor is to provide the fuel and it shall include: initial filling, fuel for testing, and filling the tank after acceptance.

END OF SECTION

GENERATOR ASSEMBLIES
SECTION 16440 – SWITCHBOARDS, PANELBOARDS, AND CONTROL CENTERS

PART 1 - PROGRAMMING AND DESIGN GUIDELINES

1.1 GENERAL

A. It is preferred that the electrical service be contained in a dedicated electrical room. The room shall be located such that conduit access in/out is not limited by the building architecture (i.e. not located under the building lobby, etc.). Electric rooms shall be void of other utilities unless they serve the electric room.

B. It is preferred that circuit breaker panelboards be located in an electrical closet or in a 24” recess with doors in the corridors. Recessed panelboards are discouraged due to the difficulty in adding circuits in the future and damage to the finishes from removing the cover.

C. Show on the drawings the required electrical clearance in front of each panel.

D. Show on the drawings the location of the spare fuse cabinet, if the project has fuses.

E. The campus available short circuit capacity from the utility company is 20,000 Amps at 4160 Volts. The Engineer shall perform and submit a short circuit analysis to determine minimum requirements for building panels.

F. The Engineer shall perform and submit a coordination study.

G. Panels shall have approximately 20% spare capacity for both load and buss space.

1.2 SWITCHBOARDS

A. Switchboards shall be dead front requiring only front access.

B. Fusible switches are preferred.

C. Fusible switches shall be Class R fuses up to 600A, Class L fuses above 600A.

   1. High Pressure Contact Switches are acceptable. Bolted pressure switches are not acceptable.

D. Circuit breakers shall be molded case type. Draw-out breakers shall not be used unless specifically requested by the Owner.

   1. Breaker trip settings shall be indicated on the contract drawings and as-built drawings.

E. Switchboards where used in lieu of a unit substation shall include customer metering, refer to section 16210 Electrical Utility Services.

F. Buss shall be plated copper.
G. Equipment grounding bar shall be copper.

H. The smallest switch should not be less than 25% of the main switch size for good design practices. Smaller switches should be located in the next tier of the distribution system.

1.3 DISTRIBUTION PANELBOARDS

A. Fusible switches are preferred for their high current interrupting capacity.

C. Fusible switches shall be Class R fuses up to 600A, Class L fuses above 600A.

D. Circuit breakers when used are preferred to be modular type allowing breaker mounting independent of adjacent breaker positions.

E. Buss shall be plated copper.

F. Equipment grounding bar shall be copper.

G. Door in a door hinged trim when available.

1.4 CIRCUIT BREAKER PANELBOARDS

A. Circuit breakers shall be of the molded case, bolt-on type.

B. Buss shall be plated copper.

C. Equipment grounding bar shall be copper.

D. Door in a door hinged trim.

E. Avoid feed through panels. Where a feed through design would be utilized, tap the feeder using mechanical lug power blocks and branch to the panelboard. Provide a main circuit breaker for the panelboard. This allows replacing or working on a panel with less interruption to the rest of the panels.

1.5 CONTROL CENTERS

A.

1.6 IDENTIFICATION

A. Refer to section 16075.

PART 2 - BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 ACCEPTABLE MANUFACTURERS

A. Square D, Cutler-Hammer, General Electric, Siemens
2.2 INSTALLATION

A. Flush mounted panelboards shall have spare 1" conduits stubbed out of the panelboard and extended to above the ceiling in an accessible location. Panels on interior walls shall have conduits on each side of the wall. Panels on exterior walls shall have conduits only on the interior side. Provide a minimum of 3 conduits per panel board section, provide additional conduits based upon the number of unused circuits.

2.3 IDENTIFICATION

A. Specify that the contractor furnish and install labels in accordance with the Identification Section of the specification.

B. Specify that panel board directories be typed. Actual room numbers shall be used in lieu of plan room numbers.

2.4 HOUSEKEEPING PAD

A. Specify that floor mounted equipment be installed on a housekeeping pad. On the lowest level specify that housekeeping pads be 12 inches high to prevent water damage in the event of minor flooding.

END OF SECTION
SECTION 16510 – INTERIOR LIGHTING

PART 1 - PROGRAMMING AND DESIGN GUIDELINES

1.1 GENERAL

A. Illumination shall generally be designed to attain the recommendations of IES while not exceeding the Unit Power Density energy requirement limitations as defined in the latest ASHRAE/IES 90.1 standard.

B. The following are recommended minimum maintained illuminance levels for specific spaces. All other areas should be reviewed with the University.
   - Offices: 30 footcandles on work surface
   - Classrooms: 30 footcandles on reading surface
   - Laboratories: 55 footcandles on work surface
   - Corridors: 10 footcandles
   - Dorm Rooms: 20 footcandles

C. Control of light fixtures shall be designed to meet the requirements of ASHRAE/IES 90.1 standard. The preferred method of achieving the automatic lighting shutoff requirements is via the use of local occupancy sensors versus a centralized building relay system. The building design should be evaluated to determine if perimeter day lighting control would be appropriate.

D. Classroom lighting shall be designed per the University Managed Classroom Standards guidelines.

1.2 EQUIPMENT

A. Specification grade light fixtures should be specified.

B. Aesthetically styled light fixtures such as recessed direct/indirect type light fixtures are preferred in public areas. Economical light fixtures may be used in non-public areas.

C. High frequency electronic ballasts should be specified.

D. Spaces with occupancy sensors shall have manual off override capability. Dual technology (passive infrared and ultrasonic) occupancy sensors shall be used in classrooms and conference rooms.

PART 2 - BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 EQUIPMENT

A. The preferred fluorescent lamp size is T8. The color temperature shall generally be 3500 Kelvin with a high color rendering index.

END OF SECTION
SECTION 16900 – FIRE ALARM SYSTEM

PART 1 - PROGRAMMING AND DESIGN GUIDELINES

1.1 GENERAL

A. Fire alarm system shall be installed in all buildings. System shall be Simplex Series 4100, microprocessor based, addressable system.

B. Panel will be networked with a network card via the building telephone copper. Provide a telephone drop at the main fire alarm panel location.

C. Generally, the main panel will be located in a mechanical or electrical room but not in telecommunication room. The remote annunciator should be located at the main entrance of the building. Review the proposed locations of the panels with the Owner.

D. Simplex bids to the General Contractor/Construction Manger. Simplex obtains a minimum of three bids for the installation labor. Simplex includes material and labor for the fire alarm system. Simplex does not include smoke dampers, door hold opens, security, etc. nor does it include power for them. Simplex provides the control for the equipment furnished by other trade contractors.

E. Provide a spare 20 amp circuit breaker for the main fire alarm panel. Provide a spare 20 amp circuit breaker for fire alarm remote power supplies. A remote power supply is required for approximately 40 visual/audible devices.

1.2 DETECTORS

A. Smoke detector shall be installed every 30 feet in public corridors and in public restrooms, even though they may not be required by code in a fully sprinklered building.

B. Smoke detectors shall be Photoelectric type.

C. Dorm rooms shall have a local audible pre-alarm via a sounder base. At a lower threshold a local audible alarms sounds and the campus police are notified. At a higher threshold results in a general alarm and the fire department is notified.

D. Duct detector locations shall be indicated on the drawings, coordinate with the mechanical design to provide required upstream and downstream space requirements.

1.3 PULL STATIONS

A. Pull station type shall be double action, key reset.

B. Pull stations shall be located at all exits, even though they may not be required by code in Business occupancy.
1.4 VISUAL/AUDIBLE DEVICES

A. Circuit shall be designed with 20% excess capacity. The 20% spare capacity shall be in addition to any capacity for planned expansion or voltage drop.

1.5 CONTROL AND MONITOR MODULES

A. A control module is required to shunt trip power to kitchen equipment located under commercial cooking hoods with fire protection.

B. Elevator interface typically requires four (4) control modules: Fire fighter; Shunt trip; Primary recall; and Alternate recall; and one (1) monitor module of the shunt trip. Coordinate with the Architect if fire rated doors are being provided at the elevator doors; if so then two (2) additional control modules are required for the primary recall and alternate recall.

PART 2 - BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 ACCEPTABLE MANUFACTURERS

A. Simplex, Series 4100, no substitutions allowed. The supplier shall be the St. Louis, Missouri, Simplex/Grinnell factory authorized representative.

2.2 EQUIPMENT

A. Specify a network card.

B. Specify smoke detectors to be Photoelectric type. Dorm rooms shall have a local audible pre-alarm via a sounder base

C. Specify pull stations to be double action, key reset type.

D. Specify 20% spare capacity shall in addition to any capacity for planned expansion or voltage drop. Do not specify the maximum number of devices on the circuit.

2.3 SUBMITTALS

A. Specify that battery calculations be submitted with the shop drawings.

B. Specify that the programming matrix be submitted with the shop drawings.

2.4 INSTALLATION

A. No conduit or raceway system will include Class I or non-power limited fire protection signaling circuits with Class II or power limited fire protection signaling circuits in accordance with N.E.C. Article 725 or 760.

B. Specify that the fire alarm panel be programmed with the actual room numbers in lieu of the plan room numbers.

END OF SECTION

FIRE ALARM SYSTEM
APPENDIX I

SAMPLE OF SCHEMATIC DESIGN PHASE INFORMATION

The schematic design phase submittal package shall contain the appropriate drawings to indicate equipment room location, sizes and access, building geometry and materials, equipment locations, service access, routing of ducts, pipes and conduits, air, water and thermal quantities and flow quantities (cfm, gpm, mbh, etc.) The purpose of the drawings shall be to demonstrate the system design in graphic form.

Additionally, the following data shall be submitted with the Schematic Design package where applicable, as required by the guidelines. The purpose of this appendix is to demonstrate the format of the data described in the text. The examples presented are not for the same project but rather, are intended to demonstrate the extent of the information required on various different types of projects.

The use of specific manufacturers, trade names or materials in the following examples is not intended to imply a preference for that manufacturer, trade name, or material.

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<td>I-B</td>
<td>Example of heating water flow diagram in ladder format</td>
<td>IB-1</td>
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<td>I-C</td>
<td>Example of chilled water flow diagram in ladder format</td>
<td>IC-1</td>
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<td>ID-1</td>
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<td>IF-1 to IF-4</td>
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<td>I-H</td>
<td>Example of electrical load schedule</td>
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I-1
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<td>Example of electrical power riser diagram (one line)</td>
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<td>I-R</td>
<td>Example of steam &amp; condensate system flow diagram</td>
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APPENDIX I
ATTACHMENT A

Example of Schematic Design Budget Estimate & Construction Cost Estimates

Washington University
West Campus - Bldg. 414
First Floor East Retail
W.U. Project No. 95-120

January 18, 1995

Budgets

The following cost estimates have been developed based on this schematic diagram.

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Total MEP: $222,000.00

See attached sheets for documentation.
# COstell Estimate

**Project:** Retail Area - First Floor  
**Location:** West Campus - Bldg 414

**Comments:** HVAC

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**Notes:** 25% LEED credit, 94.000
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- Copper Pipes 1" 100 LF 10.95 $1100
- Ball Valves 1" 6 EA 82.1 20.0 $1342
- 15 62.0 480 15734.0 $2512

TOTALS

2000
<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>DESCRIPTION OF ITEM</th>
<th>QUANTITY</th>
<th>MATERIAL</th>
<th>LABOR</th>
<th>TOTAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>NC. UNITS</td>
<td>UNIT</td>
<td>PER UNIT</td>
<td>TOTAL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UNIT MEAS.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sprinklers-</td>
<td></td>
<td>5500</td>
<td>EF</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Common Area</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>Pipe changes</td>
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<td>10</td>
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<td>5,000</td>
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<tr>
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<td></td>
<td></td>
<td></td>
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</table>

**Basis for Estimate:**
- ☑️ Means Cost Guide
- ☐ Dodge Cost Guide
- ☐ Manufacturers Quotes
- ☐ Other (Specify)
## Cost Estimate

**Project:** Retail Area - First Floor  
**Location:** West Campus - Bldg 414

**Comments:** Fire Alarm

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>DESCRIPTION OF ITEM</th>
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<th>MATERIAL</th>
<th>LABOR</th>
<th>TOTAL COST</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>250 Volt, 2 Wire, Single Phase, 5 A</td>
<td>2</td>
<td>EA</td>
<td></td>
<td>30</td>
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<tr>
<td></td>
<td>250 Volt, 2 Wire, Single Phase, 25 A</td>
<td>2</td>
<td>EA</td>
<td></td>
<td>60</td>
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<tr>
<td></td>
<td>Pull, Panel, Strobe</td>
<td>25</td>
<td>PRS</td>
<td>100</td>
<td>2500</td>
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<td></td>
<td>Warning</td>
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<td>1000</td>
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<td></td>
<td>Conspency</td>
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<td>%</td>
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**Totals:** $5000
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<th>TOTAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>NO. UNITS</td>
<td>UNIT MEAS.</td>
<td>PER UNIT</td>
<td>TOTAL PER UNIT</td>
</tr>
<tr>
<td>200 A panel</td>
<td>3</td>
<td>EA</td>
<td>2005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>200 A dist. Panel</td>
<td>1</td>
<td>EA</td>
<td>5500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>600 A panel</td>
<td>2</td>
<td>EA</td>
<td>500</td>
<td></td>
<td></td>
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<tr>
<td>600 A Switch</td>
<td>1</td>
<td>EA</td>
<td>500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cabling/Conduit:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4&quot; 8/0, 1/2 &amp; 2&quot;</td>
<td></td>
<td>40</td>
<td>UF</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>1/2&quot; 8/0 mcm</td>
<td></td>
<td>8</td>
<td>EA</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>2&quot; 10/0 UF</td>
<td></td>
<td>100</td>
<td>UF</td>
<td>25.92</td>
<td></td>
</tr>
<tr>
<td>3&quot; 300</td>
<td></td>
<td>100</td>
<td>UF</td>
<td>30.12</td>
<td></td>
</tr>
<tr>
<td>Ins. Wire</td>
<td></td>
<td>2</td>
<td>EA</td>
<td>1200</td>
<td></td>
</tr>
<tr>
<td>15 A Disc.</td>
<td></td>
<td>2</td>
<td>EA</td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>Corridor lighting</td>
<td></td>
<td>550</td>
<td>SF</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Corridor Power</td>
<td></td>
<td>550</td>
<td>SF</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Exit Foyer</td>
<td></td>
<td>3</td>
<td>EA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Contingency</td>
<td></td>
<td>20</td>
<td></td>
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</tr>
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</table>

**TOTALS: 107,300**
## COST ESTIMATE

**Project:** Retail Area - First Floor  
**Location:** West Campus - Bldg 414  
**Basis for Estimate:** Manufacturers Quotes  
**Comments:**

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>DESCRIPTION OF ITEM</th>
<th>QUANTITY MATERIAL</th>
<th>LABOR</th>
<th>TOTAL COST</th>
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<tbody>
<tr>
<td></td>
<td><strong>Budget Recap</strong></td>
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<td>HVAC</td>
<td>25.000</td>
<td></td>
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<td>Plumbing</td>
<td>2.000</td>
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<tr>
<td>Fire Protection</td>
<td>17.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire Alarm</td>
<td>5.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural</td>
<td>19.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total Project:</strong></td>
<td></td>
<td></td>
<td>$224,000</td>
</tr>
</tbody>
</table>

**Totals:**
APPENDIX I
ATTACHMENT B

Example of Heating Water Flow Diagram in Ladder Format
Example of Chilled Water Flow Diagram in Ladder Format
Example of Air System Balance Diagram
APPENDIX I
ATTACHMENT E

Example of Schematic Design Description of Specification Data

Boilers: Two - Cast iron, natural draft, gas designed boilers, each with a capacity of 1,158 mbh water heating capacity when burning 1,430 cubic feet per hour of natural gas. Similar to Weil McLain, LGB-12.

Chillers: Two - 125 ton electric centrifugal chillers each designed for 250 gpm of water from 57°F ewt to 45°F lwt with 375 gpm of condenser water at 85°F. Full load power consumption 75 kW maximum, 480 volt similar to McQuay Corporation Series PEH with R-134a refrigerant.

Cooling Tower: Two independent cells which will operate hydraulically in parallel; but fans can be independently operated and each unit can be serviced and maintained while the other is in service. Each cell to have a capacity to cool 375 gpm of water from 95°F to 85°F at 78°F w.b. They will be reinforced fiberglass and stainless steel construction similar to Marley Series NC1001 with 5 H.P. motors.

Winter Chiller: One - 50 ton electric reciprocating chiller with a remote air cooled condenser and head pressure control allowing the unit to operate down to 85 °F reduced head pressure when the ambient temperature permits. Unit to be designed for 100 gpm from 57°F to 45°F with up to 115°F head pressure. Similar to McQuay Corporation Series WHR with Condenser Series APD.

Circulating Pumps: All circulating pumps for hydraulic and condenser water service are to be base mounted or close coupled pipe mounted units with mechanical shaft seals and 480 volt 3 phase motors similar to Bell & Gossett Model 1510 or Series 60. Sizes and service approximately as follows:

<table>
<thead>
<tr>
<th>No.</th>
<th>Use</th>
<th>Flow GPM</th>
<th>Motor Head</th>
<th>Motor HP</th>
<th>Speed RPM</th>
<th>B&amp;G Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-1</td>
<td>Chiller</td>
<td>250</td>
<td>20</td>
<td>2</td>
<td>1150</td>
<td>1510 4AC</td>
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<tr>
<td>P-2</td>
<td>Chiller</td>
<td>250</td>
<td>20</td>
<td>2</td>
<td>1150</td>
<td>1510 4AC</td>
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<tr>
<td>P-3</td>
<td>Chilled Water</td>
<td>250</td>
<td>60</td>
<td>7.5</td>
<td>1750</td>
<td>1510 2-1/2BB</td>
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<tr>
<td></td>
<td>System Pump</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>P-4</td>
<td>Chilled Water</td>
<td>250</td>
<td>60</td>
<td>7.5</td>
<td>1750</td>
<td>1510 2-1/2BB</td>
</tr>
<tr>
<td></td>
<td>System Pump</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Use</td>
<td>Flow GPM</td>
<td>Head</td>
<td>Motor HP</td>
<td>Speed RPM</td>
<td>B&amp;G Model</td>
</tr>
<tr>
<td>-----</td>
<td>----------------------</td>
<td>----------</td>
<td>------</td>
<td>----------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>P-5</td>
<td>Boiler</td>
<td>120</td>
<td>15</td>
<td>1</td>
<td>1150</td>
<td>1510 3AB</td>
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<tr>
<td>P-6</td>
<td>Boiler</td>
<td>120</td>
<td>15</td>
<td>1</td>
<td>1150</td>
<td>1510 3AB</td>
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<tr>
<td>P-7</td>
<td>Heating Water</td>
<td>67</td>
<td>50</td>
<td>2</td>
<td>1750</td>
<td>1510 1-1/2AB</td>
</tr>
<tr>
<td>P-8</td>
<td>Heating Water</td>
<td>67</td>
<td>50</td>
<td>2</td>
<td>1750</td>
<td>1510 1-1/2AB</td>
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<tr>
<td>P-9</td>
<td>Unit Preheat Coil</td>
<td>54</td>
<td>15</td>
<td>1/2</td>
<td>1150</td>
<td>1510 2BC</td>
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<tr>
<td>P-10</td>
<td>Condenser Water</td>
<td>375</td>
<td>50</td>
<td>7-1/2</td>
<td>1750</td>
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<tr>
<td>P-11</td>
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<td>50</td>
<td>7-1/2</td>
<td>1750</td>
<td>1510 3BB</td>
</tr>
</tbody>
</table>

**Air Handling**

Units: Six recirculating air handling units (Numbers 2 through 7) and one 100% outdoor air, controlled ventilation unit. The recirculating units are to be institutional grade, insulated casings with centrifugal fans, stainless steel insulated drain pans, cooling coils with no more than 8 fins per inch, heating coils (as applicable) and unit controls. 100% outdoor air unit to be insulated, double-wall casing with intake dampers, integrated face and bypass preheat coil, sprayed coil humidifier/dehumidifier chilled water coil, and reheat coil. All units to have solid state inverter variable speed drives. Sizes and capacities to be as follows:

<table>
<thead>
<tr>
<th>No.</th>
<th>Location</th>
<th>Type</th>
<th>CFM</th>
<th>Ap in w.c.</th>
<th>Motor HP</th>
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</thead>
<tbody>
<tr>
<td>S-1</td>
<td>MER-1</td>
<td>OA, Vent</td>
<td>6,667</td>
<td>3.5</td>
<td>7-1/2</td>
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<tr>
<td>S-2</td>
<td>MER-2</td>
<td>Recirc.</td>
<td>10,000</td>
<td>3.5</td>
<td>10</td>
</tr>
<tr>
<td>S-3</td>
<td>MER-2</td>
<td>Recirc.</td>
<td>25,000</td>
<td>4.0</td>
<td>25</td>
</tr>
<tr>
<td>S-4</td>
<td>MER-3</td>
<td>Recirc.</td>
<td>20,000</td>
<td>4.2</td>
<td>20</td>
</tr>
<tr>
<td>S-5</td>
<td>MER-3</td>
<td>Recirc.</td>
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<td>3.7</td>
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<tr>
<td>S-6</td>
<td>MER-4</td>
<td>Recirc.</td>
<td>19,000</td>
<td>4.1</td>
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<tr>
<td>S-7</td>
<td>MER-4</td>
<td>Recirc.</td>
<td>12,000</td>
<td>3.2</td>
<td>10</td>
</tr>
</tbody>
</table>

**Temperature Control:**

The temperature control system is to be a programmable, direct digital system, with distributed intelligence for each air handling system or system groups and a P.C. driven head end station connected into the campus central monitoring system for monitoring and operational override as required.

**Electric Switchgear:**

The main switch board is to be a dead front with front accessibility only in a NEMA 1 enclosure, with plated copper busses, sized in accordance with UL891, shall have a short circuit rating of 50,000 RMS symmetrical amperes, and shall include surge arrestors sized in accordance with NEC Article 280. It will include fusible switches and a metering compartment which will include potential transformers, and current transformers for a
solid state monitor with a display which will include kilowatt hours, kilowatt demand, instantaneous kilowatts, voltages, amperages, and power factor. The main panel board will be similar to Square D Type QED1.

The distribution panelboards will be dead front with fusible switches, and fuses or circuit breakers. The main buses will be silver or tin plated copper sized to limit the temperature rise to 65°C and the panels will have a short circuit rating of no less than 10,000 amperes.

Circuit breaker panelboards (lighting panels) will be dead front, copper bus, with equipment grounding bus, hinged door with framed directory card similar to Square D, GE, or Westinghouse.
APPENDIX I
ATTACHMENT F

Example of Temperature Control Diagrams and Data

SEQUENCE OF OPERATION AND SOFTWARE, AHU-1

The successful control contractor will be required to submit engineered control drawings, wiring diagrams, equipment schedules, etc., as required for a complete system. The successful control contractor will be expected to work out the details of controller action, control loop tuning, normally open/normally closed connections, exact equipment requirements, etc., to provide a working control system performing the functions described in the written sequence of operation. The written sequence of operation will be the criterion used to judge the final performance of the control system. All functions described in the sequence will be required even if the required equipment and connections are not depicted on the drawings.

FAN SYSTEM SEQUENCE OF OPERATION

A hand-off-auto switch located in remote control panel shall energize outdoor air damper EP switch EP-1 and time delay relay in the Hand or Auto position. Fans will start when outdoor air damper is open as signaled by 5 second time delay (adjustable). In the auto position, the outdoor air damper will return to its normally closed position whenever fan start circuits are open or proof of operation DPs are open. Regardless of the above conditions, in the auto mode both fans will shutdown and not restart if the safety circuit components indicated below are open, indicating an unsafe condition.

Motor overloads shall shut down and lock out both fans if excessive motor current is drawn by either fan. The motor overloads shall require manual reset.

A freezestat located at the discharge of the cooling coil shall shut down both fans whenever the coil discharge air falls below 35°F (adjustable). The freezestat shall require a manual reset.

A smoke detector located in each final filter discharge plenum shall shutdown both fans and require manual reset whenever an unsafe condition exists.

WINTER CYCLE

The winter cycle is initiated whenever the outside air falls below 55°F as determined by outside air thermostat OA-1. Whenever the outside air is below 55°F but above 35°F, the face and bypass dampers shall remain in the full face position, and the steam preheat control valve shall modulate to maintain coil discharge air temperature at 55°F (adjustable) as sensed by coil discharge air sensor (HD-1).
The cooling coil control valve shall remain closed. Below 35°F (adjustable) the preheat coil control valve shall be open. The face and bypass dampers shall modulate to maintain coil discharge air temperature at 55°F (adjustable) as determined by coil discharge air stat HD-1.

Zone reheat control valves RH-1 and RH-2 shall modulate to maintain zone supply air temperature at 70°F (adjustable) as determined by its respective duct mounted zone stat DS-1 and DS-2.

SUMMER CYCLE

The summer cycle shall be initiated whenever the outside air is 55°F (adjustable) or above as determined by outdoor air stat OA-1 located in the outdoor intake plenum. The face and bypass dampers shall remain in the full face position and the preheat coil control valve shall be closed. The chilled water control valve CW-1 shall modulate to maintain a chilled water coil discharge air temperature of 55°F (adjustable). Reheat coil control valves RH-1 and RH-2 shall modulate to maintain zones discharge air temperature as sensed by its respective duct mounted discharge air thermostat setpoint DS-1 and DS-2.

HUMIDIFIERS

Humidifiers H-1 and H-2 shall be energized whenever fan proof-of-operation differential pressure sensors indicate its respective zone fan H-1A or H-1B is in operation through normally closed humidifier shutoff control valve HS-1 or HS-2. Humidifier shall modulate to control discharge air humidity as sensed by its respective humidistat HT-1 and HT-2.

SAFETY CIRCUITS

All safety circuits shall be hard wired circuits using standard snap acting electric or pneumatic switches as required by the function and shall be totally independent of the DDC system controllers. This includes interlocks that return dampers and valves to some normal, fail-safe position when the system they are associated with shuts down. It is the intent of this paragraph that the systems have the capability to be operated manually complete with safeties and fail-safe interlocks even if the DDC system is off-line. Software safeties will not be accepted.
FIGURE IF-1

TEMPERATURE CONTROL POINTS LIST
FIGURE IF-2
TEMPERATURE CONTROL SCHEMATIC DIAGRAM
APPENDIX 1
ATTACHMENT G

Example of Material List

Following is a list of the materials to be specified on the various major systems and components of the mechanical and electrical portion of the project.

**HVAC:**
- Chilled and Heating Water Above 2"
  - Schedule 40-Black Steel
- Chilled and Heating Water 2" and below
  - Type L Copper
- Condenser Water Piping
  - Schedule 40-Steel
- Steel Piping Fittings
  - Welded Steel with flanged unions and connections
- Copper Piping Fittings
  - Wrought copper with 95/5 or silver solder joints. Threaded adapters to ground joint unions or equipment connections.
- Air System Ductwork
  - Galvanized steel, shop fabricated in accordance with SMACNA/ASHRAE recommendations for low or medium pressure systems.
  - Neoprene faced acoustical lining in supply ductwork.
- Flexible Connection to Diffusers
  - Corrosion resistant steel spiral reinforcing with fabric covering - limited to 6' in length.
- Intake and Exhaust Louvers
  - Anodized aluminum or coated aluminum or steel as applicable.

**Plumbing:**
- Domestic Hot and Cold Water Piping
  - Type L copper with wrought copper sweat fittings joined with 95/5 soft solder.
- Drain Waste & Vent Piping Above Ground
  - Cast Iron "No-hub" with Neoprene couplings and stainless steel clamp bands.
Drain Waste & Vent Piping Below Grade
Cast iron hub & spigot with neoprene gaskets.

Electric:
Conduits concealed in or behind walls, chases, above ceilings, etc.
EMT (thinwall) with compression fittings.
Conduits exposed in equipment rooms or buried in concrete pour
Schedule 40 galvanized (heavywall) with threaded fittings.

Wire and Cable
(Power Conductors)
Minimum No. 12. Copper, THHN type; sizes 14 thru No. 10 shall be solid, above No. 10 shall be stranded.

Wire and Cable
(Control)
Minimum No. 12, stranded or solid, but stranded if it is to flex or be in a wiring harness.

Fire Protection:
Sprinkler Piping
Schedule 40 PVC with cement joints.
Standpipes and Fire Service Piping
Schedule 10 steel with Victaulic clamp type fittings for 3" and above and threaded cast iron fittings for 2-1/2" and below.
## APPENDIX I
ATTACHMENT H

### Example of Electrical Load Schedule

#### Electrical Load Schedule

**Project Name**  
80,000 Square Foot

<table>
<thead>
<tr>
<th>Description</th>
<th>Design</th>
<th>KW</th>
<th>Wtr KWD</th>
<th>Sum KWD</th>
</tr>
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<tbody>
<tr>
<td>Lighting</td>
<td>2.0 w/Sq. ft.</td>
<td>160</td>
<td>160</td>
<td>160</td>
</tr>
<tr>
<td>General Purpose Receptacles</td>
<td>1.0 w/Sq. ft.</td>
<td>80</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Misc. Bldg Pwr (EWC, Small HVAC, Copiers, Microwave, etc.)</td>
<td>1.5 w/Sq. ft.</td>
<td>120</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>Air Conditioning</td>
<td>300 Sq. ft./Ton</td>
<td>250</td>
<td>---</td>
<td>250</td>
</tr>
<tr>
<td>Electric Heating</td>
<td>50 KW</td>
<td>50</td>
<td>50</td>
<td>---</td>
</tr>
<tr>
<td>Elevator</td>
<td>30 HP</td>
<td>30</td>
<td>30</td>
<td>30</td>
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<tr>
<td>Kitchen</td>
<td>60 KW</td>
<td>60</td>
<td>25</td>
<td>25</td>
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<tr>
<td><strong>Total</strong></td>
<td></td>
<td>750</td>
<td>500</td>
<td>700</td>
</tr>
</tbody>
</table>
APPENDIX I
ATTACHMENT I

Example of Electrical Power Riser Diagram (One Line)

TO CAMPUS DISTRIBUTION SYSTEM

800 AMP MAIN PANEL "MP"

400 AMP DISTRIBUTION PANEL "DP1"

20 HP ELEV

20 HP SUPPLY FAN

10 HP RETURN FAN

50 TON COND UNIT

ONE LINE DIAGRAM
3 PHASE 4 WIRE 208Y/120 VOLT

II-1
# APPENDIX I  
## ATTACHMENT J

## Example of Logic Diagram of Fire Alarm System

### FIRE ALARM ADDRESSEEABLE POINT LIST

<table>
<thead>
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**NOTE:** SIGNALING LINE CIRCUITS SHALL BE #18 SHIELDED TWISTED PAIR.
FIRE ALARM SIGNAL CIRCUIT RISER DIAGRAM

LEGEND

\[ \text{#14 UNTWISTED PAIR ALARM SIGNALING CKT.} \quad \text{FK} \quad \text{- HORN} \quad \text{CMX} \quad \text{- CONTROL MODULE} \]

\[ \text{2 #14 THHN - ALARM INITIATING CIRCUIT} \quad \text{V} \quad \text{- STROBE} \quad \text{DH} \quad \text{- DOOR HOLDER} \]

I-2
APPENDIX I
ATTACHMENT K

Example of Block Load Calculations and Preliminary Energy Analysis

Preliminary Energy Analysis and Annual Energy Cost Estimate

The schematic design architectural design and mechanical/electrical systems were analyzed to determine the energy impact of the systems and the anticipated annual energy costs. The results are as follows:

Building Area 239,875 square feet
Electric Demand 1,314 kW (5.48 watts/sq.ft.)
Annual Electrical Consumption 4,528,618 kWh
Annual Electric Operating Cost $271,717

Cost per square foot $1.13/sq.ft
Average cost per kWh 6.0¢/kWh
Annual electric load factor 39%

Gas Demand 6,526 Cubic feet per hour
Annual gas consumption 38,680 therms
Annual gas cost $10,444
Cost per square foot $0.044
Average cost per therm 27¢
Annual gas load factor 6.7%.

A month by month usage and cost was calculated as well as a pro forma of the energy use categories. These results together with all of the input sheets and computer calculation summaries and output data are included in the following pages.

Block Load Input Data Pages IK-2 thru IK-5
Block Load Output Data Pages IK-6 thru IK-9
Energy Analysis Printout Pages IK-10 thru IK-17
Input Units: 2 (English)  Output Units: 2 (English)

Month for Cooling Solar Gain: 7 (July)

Latitude (Degrees North): 38

Altitude: 535 ft

Weight of Room Construction: 1 (Light - 30 lb/sq ft)

Summer Conditions:

Outdoor Drybulb Temperature: 95 deg F
Outdoor Wetbulb Temperature: 78 deg F
Outdoor Temperature Range: 21 deg F
Indoor Drybulb Temperature: 75 deg F
Indoor Relative Humidity: 50 percent

Winter Conditions:

Outdoor Drybulb Temperature: 0 deg F
Outdoor Wetbulb Temperature: 0 deg F
Outdoor Temperature Range: 0 deg F
Indoor Drybulb Temperature: 75 deg F
Indoor Relative Humidity: 40 percent
APPENDIX I
ATTACHMENT K

Example of Block Load Calculations and Preliminary Energy Analysis

Preliminary Energy Analysis and Annual Energy Cost Estimate

The schematic design architectural design and mechanical/electrical systems were analyzed to determine the energy impact of the systems and the anticipated annual energy costs. The results are as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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<tr>
<td>Building Area</td>
<td>239,875 square feet</td>
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<tr>
<td>Electric Demand</td>
<td>1,314 kW (5.48 watts/sq.ft.)</td>
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<tr>
<td>Annual Electrical Consumption</td>
<td>4,546,791 kWh</td>
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<tr>
<td>Annual Electric Operating Cost</td>
<td>$272,807</td>
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<tr>
<td>Cost per square foot</td>
<td>$1.13/sq.ft</td>
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<tr>
<td>Average cost per kWh</td>
<td>6.0¢/kWh</td>
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<td>Annual electric load factor</td>
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<tr>
<td>Gas Demand</td>
<td>5,730 Cubic feet per hour</td>
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<tr>
<td>Annual gas consumption</td>
<td>38,680 therms</td>
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<tr>
<td>Annual gas cost</td>
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<td>Cost per square foot</td>
<td>$0.044</td>
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<tr>
<td>Average cost per therm</td>
<td>27¢</td>
</tr>
<tr>
<td>Annual gas load factor</td>
<td>7.7%</td>
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</tbody>
</table>

A month by month usage and cost was calculated as well as a pro forma of the energy use categories. These results together with all of the input sheets and computer calculation summaries and output data are included in the following pages.

Block Load Input Data                  Pages IK-2 thru IK-5
Block Load Output Data                 Pages IK-6 thru IK-9
Energy Analysis Printout               Pages IK-10 thru IK-17
Input Units: 2 (English)        Output Units: 2 (English)
Month for Cooling Solar Gain: 7 (July)
Latitude (Degrees North): 38
Altitude: 535 ft
Weight of Room Construction: 1 (Light - 30 lb/sq ft)

Summer Conditions:
Outdoor Drybulb Temperature: 95 deg F
Outdoor Wetbulb Temperature: 78 deg F
Outdoor Temperature Range: 21 deg F
Indoor Drybulb Temperature: 75 deg F
Indoor Relative Humidity: 50 percent

Winter Conditions:
Outdoor Drybulb Temperature: 0 deg F
Outdoor Wetbulb Temperature: 0 deg F
Outdoor Temperature Range: 0 deg F
Indoor Drybulb Temperature: 75 deg F
Indoor Relative Humidity: 40 percent
WALL-TYPE DEFINITIONS:

Wall Type: 1
- U factor: 0.250 Btu/hr ft^-2 deg F
- Color: 2 (Dark)
- Weight of Wall Construction: 2 (Medium - ASHRAE Wall 44)

ROOF/FLOOR-TYPE DEFINITIONS

Roof/Floor Type: 1
- U factor: 0.106 Btu/hr ft^-2 deg F
- Color: 2 (Dark)
- Weight of Roof/Floor Construction: 1 (Light - ASHRAE Roof 17)

Roof/Floor Type: 2
- U factor: 0.300 Btu/hr ft^-2 deg F
- Color: 2 (Dark)
- Weight of Roof/Floor Construction: 3 (Heavy - ASHRAE Roof 29)

WINDOW-TYPE DEFINITIONS

Window Type: 1
- U factor: 0.560 Btu/hr ft^-2 deg F
- Shading Coefficient: 0.85

PEOPLE-TYPE DEFINITIONS

People Type: 1
- Sensible Load: 255 Btu/hr
- Latent Load: 255 Btu/hr
Zone: 1  No Additional Identical Spaces.

VENTILATION & INFILTRATION

Ventilation: 21273 ft^3/min  Summer Schedule: 1  Winter Schedule: 1
Infiltaration: 0 ft^3/min  Summer Schedule: 0  Winter Schedule: 0

PEOPLE

Number of People: 1164  Gain-Type of People: 1
Summer Schedule: 1  Winter Schedule: 0

LIGHTING

490.3 kW,  Dec. Fract. Ret.: 0.000
Summer Schedule: 1  Winter Schedule: 0

WALLS & WINDOWS

Wall Type: 1  Wall Area: 12514 ft^2  Dec. Fract. Ret.: 0.000
Window Type: 1  Window Area: 1152 ft^2  Exterior Shading Type: 0
Direction of Wall: 0 Degrees

Wall Type: 1  Wall Area: 12694 ft^2  Dec. Fract. Ret.: 0.000
Window Type: 1  Window Area: 1712 ft^2  Exterior Shading Type: 0
Direction of Wall: 90 Degrees

Wall Type: 1  Wall Area: 12983 ft^2  Dec. Fract. Ret.: 0.000
Window Type: 1  Window Area: 2314 ft^2  Exterior Shading Type: 0
Direction of Wall: 180 Degrees

Wall Type: 1  Wall Area: 10600 ft^2  Dec. Fract. Ret.: 0.000
Window Type: 1  Window Area: 1680 ft^2  Exterior Shading Type: 0
Direction of Wall: 270 Degrees

ROOFS

Roof Type: 1  Roof Area: 51046 ft^2  Dec. Fract. Ret.: 0.000
Skylite Type: 0  Skylight Area: 0 ft^2  Exterior Shading Type: 0
Direction of Skylight Shading: 0 Degrees

Roof Type: 2  Roof Area: 24046 ft^2  Dec. Fract. Ret.: 0.000
Skylite Type: 0  Skylight Area: 0 ft^2  Exterior Shading Type: 0
Direction of Skylight Shading: 0 Degrees
AREA AND HEIGHT

Space Area: 239875 ft^2
Space Height: 11 ft
BLOCK LOAD

Area = 239875 Square Feet
Volume = 2686600 Cubic Feet

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<th>Winter 100 Hrs</th>
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**Area = 239875 Square Feet**  
**Volume = 2686600 Cubic Feet**

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Area = 239875 Square Feet  
Volume = 2686600 Cubic Feet

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Max Load (at 1600 Hrs) = 5071818 Btu/HR = 422.65 Tons

Sum of Peaks = 5075153 Btu/HR
Building Summary

Area = 239875 Square Feet
Volume = 2686600 Cubic Feet

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Sum of Peaks = -4583660 Btu/HR
Latitude, Degrees (North) 38.0

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Solar Gains, Maximum in July (For Input to MEDI Programs)

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573257 Btu/Hr at 20 Deg F Temp Diff
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INT- 1.000 OF HEAT LOSS; 1.000 OF LIGHT APPLICABLE
RET- .000 OF HEAT LOSS; .000 OF LIGHT APPLICABLE
DECIMAL OF HORIZONTAL SOLAR GAIN TO RETURN AIR .000
DECIMAL OF TRANSMISSION GAIN TO RETURN AIR .000
SUPPLY FAN HEAT IN BTUH 385670.
RETURN FAN HEAT IN BTUH 0.
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ENTER WEATHER FILE NAME:  

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DO YOU WANT LFILE (1=YES, 2=NO): 2

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WHAT IS THE MBH OF BOILER: 8000.00

WHAT IS THE UNOCCUPIED WINTER ROOM TEMP SET BACK: 10.00

IS THERE AN ECONOMISER CYCLE (1=YES, 2=NO): 2

IS SYSTEM OFF IN UNOCCUPIED HOURS WHEN OUTDOOR DRYBULB IS ABOVE ROOM DRYBULB (1=YES, 2=NO): 1

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ANNUAL TOTAL

IK-14
WASHINGTON UNIVERSITY  
FAMOUS BARR BUILDING  
ENTIRE BUILDING  
RUN WUBBBL2M 2/27/95  
HEAT-COOL-OFF SYSTEM  

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|     | 283139 | 966719 | 5513510 |

IK-17
Example of Flow Diagram of Fire Protection Piping System

TO SPRINKLER SYSTEM (TYP)
2 1/2" F.D.V. (TYP)

ZONE VALVE (TYP)

FLOW SWITCH (TYP)

Siamese

FIRE PUMP ASSEMBLY
BACKFLOW PREVENTER ASSEMBLY

WATER SUPPLY FROM FIRE MAIN

IL-1
Example of Domestic Cold Water Flow Diagram
Example of Domestic Hot Water Flow Diagram
Example of Hydraulic Analysis of Fire Protection Piping

FLOW TEST:
- STATIC - 90 PSI
- RESIDUAL - 60 PSI @ 1000 GPM FLOW

SYSTEM DEMAND - 278 GPM @ 74 PSI
HOSE STREAM REQUIREMENT - 250 GPM
HOSE STREAM AVAILABLE - 450 GPM
Example of Domestic Water System Pressure Analysis

Domestic Water System Pressure Analysis

Net Domestic Water Quantity = 90 Fixture Units (Plumbing)
- 65 gpm
- 2" Cu → 6.5 fps
  8.9 ft/100' ΔP
- 2½" Cu → 4.2 fps
  3.0 ft/100' ΔP

Use 2" Cu Connections

Main Pressure: 95 psi @ h = 105'
Three Story Bldg. + Basement
Height of Highest Flush Valve = 141'
Pressure Required at Highest Flush Valve
Sloan Siphon Jet Wall Hung → 20 psi

ΔP @ 65 gpm:
- 2" Tap = 0.5 psi
- 2" Meter = 3.1 psi
- 2" BFP = 10.9 psi

Piping System
- 195 ft @ 8.9 ft/100' = 7.5 psi
- Fittings
  - 125 ft @ 8.9 ft/100' = 4.8 psi
- Elevation Loss
  - 141-105' = 15.6 psi

Minimum Inlet Pressure Required

20 + 0.5 + 3.1 + 10.9 + 7.5 + 4.8 + 15.6 = 62.4 psi

Street Pressure acceptable; no booster required

Provide Pressure Regulator at inlet for improved controllability:
Reduced Pressure Setpoint = 70 psi
APPENDIX I  
ATTACHMENT Q  

Example of Utility System Requirements Summary

Water:

Potable Cold Water Supply  60 GPM demand  gallons per day consumption

Fire Protection  750 GPM peak flow @ 75 psi

Sewer:

Storm Sewer  46,000 sq.ft. pavement & building  20,000 sq.ft. landscaped

Sanitary Sewer  8"

Electric:

480Y277 volt service,  500 kW demand  2,628,000 kWh consumption

Gas:

200 cubic feet/hour demand  7,000 therms per year consumption

Steam Service:

2,200 #/hr

Chilled Water:

250 Tons
Example of Steam & Condensate System Flow Diagram.